



CHENNAI METROPOLITAN WATER SUPPLY & SEWERAGE BOARD



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FOR

**PROJECT FOR CONSTRUCTION OF CHENNAI
SEAWATER DESALINATION PLANT (I)**

PART-II

(EMPLOYER'S REQUIREMENTS)

(VOLUME 2 OF 3)

**PROCUREMENT OF DESIGN/ENGINEERING, CONSTRUCTION,
COMMISSIONING OF 400 MLD SEAWATER REVERSE OSMOSIS (SWRO)
DESALINATION PLANT AT PERUR, CHENNAI WITH 20 YEARS OF
OPERATION AND MAINTENANCE (DBO BASIS)**

INTERNATIONAL COMPETITIVE BIDDING

PROJECT MANAGEMENT CONSULTANTS

SMEC International Pty Ltd.
NJS Engineers India Pvt. Ltd.
Tata Consulting Engineers Ltd.
SMEC India Pvt. Ltd.

SUPERINTENDING ENGINEER

(CONTRACTS & MONITORING)
CHENNAI METROPOLITAN
WATER SUPPLY & SEWERAGE
BOARD

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CHAPTER - 5

5. PARTICULAR CIVIL REQUIREMENTS

5.1 Introduction

The Standard Basic Specifications (SWRO Desalination Works Contract) issued by CMWSSB, set out the specifications that shall be followed for construction of general Works under the 400 MLD Chennai SWRO Desalination Project. In the event of any discrepancy between the provisions of the General Specifications and the Particular Specifications, the provisions of the Particular Specifications shall prevail over general specifications.

Contractor is responsible for the supply of all civil materials, machinery, marine equipment, supervision, labour, safety personnel and all expenses necessary for the installation of the structures that are part of the Contract. Nothing contained herein or missing shall be construed as relieving the Contractor of his obligation to provide a structure capable of performing its intended service for a submerged life as defined in the Contract. The Contractor shall provide necessary method of statement and Procedures that will be followed for execution of the work in sequential step by step activities, and he will use the necessary float days for proactive work during zero float days of critical works in the Planning program. The Employer or its representatives reserve the right to inspect and reject at all stages of the Works when the Contractor is found not in compliance with the specification. Contractor shall give the Engineer and Employer's Representative full and unrestricted access to all areas of the work. The Contractor shall invite the Engineer and Employer's representatives for inspection after completion of the tasks prior to covering, coating/painting operations. They reserve the right to use still photography or video cameras to document visual inspection at any stage of work by the Contractor.

If any inspection or testing defined by or referenced in this Specification reveals that the work is non-compliant, then the entire preparation and application procedure shall be redone from the point where the Contractor can demonstrate compliance to the satisfaction of the Engineer. All remedial work shall be at the Contractor's expense to the satisfaction of the Engineer. In general all the works shall be carried out by the Contractor to the satisfaction of the Engineer abiding along with the satisfaction of the Quality Control Engineer apart from IS codes of minimum requirements and also abide OSHAS standards to the utmost satisfaction of the Safety Engineer at project site.

The Contractor shall be in possession of the current revisions and addenda of all codes, standards and specifications required for the Works. All such documents shall be made readily available to the Engineer or the Employer's Representatives upon request. Contractor shall employ only qualified and experienced personnel for the work. The Engineer/ Employer's Representatives shall determine the competence of personnel and shall retain the right to have replaced any Contractor's personnel if in their opinion, the proposed personnel are not working in accordance with Contract, approved procedures or plans.

The Contractor shall maintain all equipment in good conditions at all times and where necessary fully calibrated. The Employer shall inspect equipment and all deficiencies shall be corrected

by Contractor at his sole expense and to the satisfaction of the Employer. Contractor shall maintain the identification of every component and/or section of the pipe constituting the Intake and Outfall. These marks shall be recorded by the Contractor and the daily logs provided to the Engineer or Employer's site representative as requested.

All tests performed by the Contractor or his suppliers to prove materials characteristics shall be in accordance with the listed codes, standards and specifications or tests referenced herein and general civil requirements. In all cases, the Contractor is to get Engineer's written approval prior to the testing.

At the Employer's discretion, the Contractor shall be required to carry out tests to prove compliance of materials. All such tests shall be to Contractor's account. Contractor shall clearly state every exception to the requirements of this specification prior to Contract award, if no exceptions are stated full compliance should be confirmed.

After award of contract and before start of work, the Contractor shall submit a detailed written description of the procedures, materials, personnel, tests and safety measures for Engineer's approval. The description shall be accompanied by full details of the test results on similar works performed by the Contractor. The Contractor shall submit to the Engineer for review and approval of the following procedures:

- i) Construction and Project Management Plan
- ii) Site Organization Chart
- iii) Work Schedule and Progress Monitoring Plan
- iv) Quality Manual and Project Quality Plan
- v) Safety Execution Plan and Procedures
- vi) Installation Procedure and Manual
- vii) Utilization of Construction Equipment
- viii) Marine Operation Manual
- ix) Mooring Arrangements Procedure and Marine Spread Anchor Pattern
- x) Critical Lift study
- xi) Emergency and Medical Evacuation Plan

5.2 Scope of Civil Works

The scope under Civil Works includes complete structural designing, construction, procurement, installation, commissioning and 20 years operation and maintenance of the 400 MLD SWRO desalination plant on Design, Build and Operate (DBO) basis. The Works include all civil and all associated works required for construction of the plant with sludge treatment and water recovery facility.

The following buildings/structures are part of the Works in scope along with all other civil works required to construct the 400 MLD SWRO desalination plant fully functioning as per the contract specifications and guarantees.

- (i) Construction of complete Intake and Outfall works including intake/outfall

pipeline, intake heads, intake well, pumping station etc. The scope includes the supply of all material, machinery, plant site, supervision, labour, safety personnel and all expenses necessary for the installation, testing and commissioning of the Intake and the Outfall system with all onshore and offshore works.

- (ii) RCC Clear Water Reservoir of 9ML capacity.
- (iii) RCC Outfall Tank of about 4.5 ML capacity for wastewater discharge to the sea through diffusers.
- (iv) Construction of RCC Sludge Balance Tank with pumping arrangement
- (v) Construction of two Gravity Thickeners & Thickened Sludge Holding tanks with all associated structures.
- (vi) Construction of Sludge treatment building (Belt Filter Press (BFP) building) with all associated structures.
- (vii) Construction of Substation building including Switchyard & Transformer area
- (viii) Construction of Administrative Building with all associated works.
- (ix) Construction of Laboratory and Plant Central Control building with Record room
- (x) Construction of large Workshop and Warehouse
- (xi) Construction of all main and connecting roads and landscaping of the plant site area.
- (xii) Construction of Retaining wall all around the site and filling of soil up to the required level.
- (xiii) Construction of RR masonry Boundary wall all around the project site.
- (xiv) Construction of multiple short dyke walls perpendicular to coastline near the plant area to prevent soil erosion and disruption to “Nemmeli Kuppam” Boat landing centre.
- (xv) Construction of clear water tank
- (xvi) Construction of the main gate
- (xvii) The following units/items shall be constructed separately for each plant stream of 200 MLD.
 - a) Construction of inlet chambers and channel with baffles, flash mixing chamber, distribution chamber with weirs, walkway etc.
 - b) Construction of Flocculators & Tube Settlers tanks along with walkway etc.
 - c) Construction of Chemical Building with RCC solution preparation Tanks for coagulant and Polymer, Storage area, Bunds to collect splash chemicals, etc. and other features.
 - d) Construction of covered area for chlorination, acid and any other chemical storage tanks and dosing system.

- e) Construction of DAF (Dissolved Air Flotation) tanks covered along with walkway etc.
- f) Construction of Gravity Dual Media Filters (GDMF) under Filter Building along with pumps, blowers areas and walkway etc.
- g) Construction of RO (Reverse Osmosis) Feed Tanks and other associated structures.
- h) Construction of RO building along with CIP area, storage/maintenance areas and other allied structures etc.
- i) Construction of Chemical Building for RO system to accommodate all chemical tanks and dosing system.
- j) Construction of Permeate Tank and other associated structures.
- k) Construction of Limestone Filters along with the Filtrate area, CO₂ generation area, online Limestone makeup system and other associated structures.
- l) Construction of Product water tank of capacity 2 x 7.5ML along with other associated structures and piping.
- m) Construction of covered Chambers for all valves, dismantling joints and flowmeters along with laying of all yard piping.
- n) Construction of all MCC buildings
- o) Any other civil construction to fulfil the requirements for the proposed plant as per the Contract.

5.3 Intake and Outfall Works

The intake system will be designed to have a hydraulic capacity of 1040 MLD. The intake conduit shall be of two number 2500 mm OD @ >6.5 bar HDPE pipe (SDR≤26) and the outlet conduit shall be one number of 2500 mm OD 6.5 bar HDPE pipe (SDR≤26) to produce net 400 MLD product water capacity. The waste seawater with high salinity will be discharge to the sea through nozzles to allow fast dispersion and less environmental impact.

Conventional dredging/trenching method or as approved by the Engineer is proposed to be employed for laying of Intake and Outfall conduits in the sea with minimum 1.5m cover over the pipe. The backfilling of the trench shall be done with the same excavated earth/material. The Spoil would be removed and returned to shore. The pipe would be prefabricated and floated over the trench or dragged along the trench. A safety boat shall be deployed in the vicinity to warn other craft to keep clear of the working area. Pipe shall be handled with care so as not to cause any deformation or out-of-roundness of the pipe, damage to the ends, bending of the pipe etc. Excavation of the trench at the shoreline shall be executed in such a way to prevent damages to the shore structures. The trench shall be dredged to a depth from the sea bottom in order to give a vertical distance of 1.5 m (pipe top cover) between the top of the respective intake/ outfall pipelines and the surrounding natural undisturbed seabed level. The bottom of the trench shall be filled with a levelling fine sand bed having a minimum thickness of 200 mm to avoid any dent or puncture of the pipe due to hard pointed rock surface.

During excavation of the trench as per approved drawings, all efforts shall be made by providing supports to protect the lateral walls from collapsing. Walls shall have a slope with a minimum inclination of 1:1 to maintain safety and to avoid any mishap. The trench shall be graded such that the minimum vertical radius of curvature of the pipeline does not generate excessive stresses in the pipeline. Any trench transitions for the pipelines (at spool pieces) shall be smoothly profiled back to the undisturbed natural seabed level so as to ensure that the pipeline is not subjected to over-stress while exiting or entering the trench. The bottom of the trench in a transition zone shall be at a constant smooth gradient providing a gentle continuous surface to support the pipeline.

Before start of the sinking process, the route shall be marked properly by buoys floating at sea surface. The Sinking of the pipeline shall be mainly carried out by nature's own forces i.e. gravity, buoyancy and air pressure while sinking of the diffuser, involves use of cranes. The sinking speed shall not exceed 0.3m/s. The compressor required for air filling in pipeline shall work up to 10 bar. The sinking shall be carried out in a continuous basis. The pipelines shall be equipped with blind flanges fully checked for tightness at each end. At the outmost end the blind flange is equipped with pipes and valves for air evacuation and air filling. The inmost blind end of the pipeline is also connected with valve and pipe for controlled water pumping inside the pipeline through pump during the sinking. The air pressure inside the pipe shall be adjusted depending on the depth through the air valve and compressor to prevent any "run way". The sinking shall start by opening of the air valve in the outmost end carefully and controlling the inside pressure by a manometer if required to charge the pipe with compressed air and in no case the sinking speed shall be greater than 0.3 m/s. The sinking operation shall be continuous process. If for any reason, there is an interruption in the sinking operations, the reverse sinking process should start immediately by starting the compressor and must be completed within 15 minutes.

The sand backfilling can start when pipelines are laid and it is ensured that the extremities of the line at the intake chamber and spool piece end respectively remains free for the future connection to the onshore equipment and to the offshore intake screen installation. Backfilling shall be carried out using the native sand, restoring to the original situation. The backfilling shall be carried out in subsequent stages in order to allow the sand to be deposited duly compacted and to give, as final result, the original sea bottom configuration and water depth. The intake head and outfall diffuser section shall be connected to the main HDPE pipelines by means of appropriate pipe expansion spool pieces to be installed after the final positioning of the intake to suite levels. The seabed characteristics of the area surrounding the Seawater Intake and the Outfall is generally constituted by loose sand with some areas of compact sand and some clay patches. The report comprising of the data & results w.r.t to offshore studies are enclosed with the Tender, Part-2 Site Data for reference. However, these studies are only indicative, and the detailed investigations shall be carried out by the selected bidder (Contractor), as required before execution of works to confirm the data and to meet the contractual requirements.

The scope of the Contractor for intake and outfall system includes but is not limited to:

- Contractor will be responsible of the supply of material, machinery, marine equipment,

supervision, labour, safety personnel, video monitoring system and all expenses necessary for the installation of the structures and inspection by approved third party as part of the Contract.

- Carryout all the onshore and offshore studies and surveys of the area including bore logs to verify the nature of the sea bottom for construction of marine works. and get all works checked and inspected and approved by the Safety Engineer, Quality Control Engineer, and the Engineer.
- Excavation of the appropriate trench in the sea bottom with appropriate equipment and supply and receive the HDPE pipes along with associated accessories constituting the intake and the outfall.
- Backfilling of the trench, supply and installation of the various materials in the areas for construction of sea water intake and outfall along with pipe conduits.
- Supply, welding, laying and connection of two PE 100 High Density Polyethylene (HDPE) intake pipes > 6.5 bar (IS 4984) and one HDPE outfall pipe 6.5 bar in the submarine trench in accordance with the specifications.
- Prefabrication and installation of concrete/anchor blocks for the anchorage of the pipes. The blocks shall be manufactured with Portland Slag cement.
- Prefabrication and installation of the concrete blocks for the system towards protection against trawling fishing and other possible causes of damage.
- Fabrication and installation of the intake heads and GRP or Duplex Steel intake screens (as per the consent of the Engineer) at the extremity of the sea water intake pipeline and connection of the pipeline with special expansion spool piece joint as required.
- Provision for pigging to clean the pipelines and pig launching station and landing (collection) point suitable for the purpose shall be provided.
- Fabrication and installation of the HDPE reject outfall diffusers section and connection with special expansion spool piece joint as required.
- Supply and installation of the necessary Navigational Aids like buoy with red lantern marks to mark the position of the structures as per drawings.

The decoded and validated digital data shall be supplied by the Contractor to the Employer through email transfer and also on Compact disk/ USB. The information shall be on the Longitudinal profile and Event data. The Longitudinal profile shall include the key parameter (KP) along the theoretical design route, sea bottom depth along the pipe axis, Pipe depth, Easting and Northing coordinate and any other related information. The Event data shall include the KP along the theoretical design route, Event code and event description. These files shall be delivered before post trenching activities survey.

5.3.1 System Description

5.3.1.1 Seawater Intake

The sea water intake facilities cover two seawater intake heads with screen offshore and two intake pipes to bring water to intake well and pumping station onshore. The offshore units comprise of sea water intake system comprising of intake suction head fitted with 100 mm c/c GRP screen along with ring provision of Hypo dosing and air bursting arrangement along the periphery of the offshore intake screen. Nylon net, two concrete intake head and associated pipelines. The net shall be properly anchored and shall have provision for easy replacement. The intake structure (Head) shall be prefabricated in one single piece and shall be installed using the preapproved procedure.

The seabed conditions are one of the primary factors in determining the location of seawater intake and outfall conduits. A 100 mm c/c opening screen in GRP/ Duplex steel construction shall be provided at the intake to exclude larger marine life. The said screen shall be designed with an approach velocity of ≤ 0.12 m/s to minimise the entrapment of marine species. A fish net will be provided to minimise the ingress of jelly fish to the intake. The fish net will be required to be inspected and replaced from time to time, as the same is likely to be damaged by marine lives. The head loss through the intake system will also be monitored, and in any increase in system losses indicating fouling at the intake, or the growth of biomass within the intake conduit, the same shall be cleaned through divers. The Hypo dosing lines and compressed air line shall be of HDPE material per IS 4984 with possibly GRP cover to protect the pipe and shall be laid along the intake pipe properly clipped at the crown of the pipe. The preliminary study proposed that the intake pipes should be laid up to approximately 1150 m offshore, the depth at the intake would be >10 metres at low tide. The bidder should cost the intake system based on this length and carry out bathymetric and brine diffusion study. The two intake pipe shall be laid in one trench to avoid movement of heavy machinery and repetition of the works.

5.3.1.2 Reject Outfall

An outfall shall be one 2500 mm OD 6.5 bar HDPE pipe conduits. Coastal currents flow from south to north from August to October and from north to south from November to March each year. The currents from the South to the North are stronger than the currents from the North to the South. For this reason, the outfall will be located to the North of the intake, same as in the existing Nemmeli plants. Since the near shore currents in this region are predominantly directed towards North, it is preferred to locate the outfall on the Northern side, so that the plume spread would be mostly oriented towards North and there would not be any re-circuit to the intake. Sea water outfall pipe shall be High density polyethylene pipe (black). As per the study the outfall pipe should be laid at 750m offshore. However, a brine diffusion analysis can be carried out by the Contractor.

5.3.1.3 HDPE Pipes

Contractor shall supply the HDPE pipes (PN 21) as per IS 4984, shall keep them in custody in a safe and protected area, shall check all pipes for damage, dents, out of roundness, gouges and flat ends etc. All damage and other defects noted shall be recorded by the Contractor and witnessed by the Engineer/ Employer's representatives. Damage caused to pipe whilst in the custody of the Contractor shall be reported to the Engineer and replaced or repaired by the Contractor to the satisfaction of the Engineer. The cost of replacement or such repair work and

the cost of any material lost shall be at the Contractor expense. The history and details of each pipe, including the pipe identification number shall be recorded by the Contractor before the commencement of installation and a unique cross reference number shall be painted by the Contractor on the inside and outside of the pipe on both the ends. All documents related to the pipes shall be preserved by the Contractor for inclusion into the final certification documents.

5.3.1.4 Pipe Handling

HDPE pipes shall be handled at all times in a manner, which avoids damages. All pipes shall be lifted clear and moved without being dragged over the ground or any obstructions. Alternate lifting equipment or specially manufactured lifting hooks may be permitted after approval has been given by the Engineer and under the supervision of the pipe manufacturer. Pipes shall not be rolled or dropped. Line pipe shall be positioned with care so as not to cause out-of-roundness of the pipe, damage to the ends, bending of the pipe etc. Any pipe suffering impact damage during handling shall be immediately quarantined and the Engineer/ Employer's representative be advised for their inspection and eventual subsequent acceptance and/or repairs. Excess damage beyond the repair will be assessed by the Engineer/ Employer's representative and shall be rejected. The rejected pipe shall be removed from the site by the Contractor immediately. Lifting equipment shall be approved by the Engineer. Wire ropes alone shall not be used to lift pipes. Where forklift trucks are to be used to transport the pipe, they shall be suitably padded to prevent damage. All pipe handling equipment and procedures shall be subject to the approval of the Engineer prior to their use.

5.3.1.5 Pipe Stacking

Bare pipe shall not be stacked more than two layers high. The pipe shall be stacked, either on properly constructed and maintained pipe racks, inspected and approved by the Employer, or on a minimum of two coal tar enamel covered loose graded sand windrows. The sand windrows shall at least be 15 cm deep and not less than 2 m wide (each), approximately 7 m apart, and shall not be separated by bearers. Contractor shall submit proposed stacking arrangement by detailed shop drawings, including stacking heights pipe end supports and stacking surface to the Employer for approval, prior to use and installation. If the Contractor requires to stack the pipes in a different number of layers, he shall submit to the Employer all relevant calculations certifying the new proposed configuration.

End supports need to be placed at either end of the stack to prevent to pipe joints from rolling. If pipes are to be stored for an extended period, precautions shall be taken to prevent damage of pipe ends and interiors. The pipe shall be carefully lowered to prevent impact damage and stacked in such a way that water and mud cannot accumulate within the pipe.

5.3.1.6 Concrete

Cement, sand, aggregate for concrete works shall be as per the enclosed General Civil specifications of the bid document and in case of conflict between the General Civil specifications and the guidelines mentioned in Particular Civil works, the Particular Civil specifications shall prevail. The concrete blocks to be installed for the support and ballast of the Outfall diffusers and Intake screen, for the cast in situ inside the prefabricated caisson at the

elbow of the Intake pipeline and for the anti-trawl fishing protections, anti- buoyancy saddles for intake and outfall pipeline as per the span & load mentioned in the respective intake and outfall pipeline construction drawings shall be of the type for underwater marine seawater environment construction and shall be dense concrete not less than M40 / IS code shall be referred and approved by the Engineer based on Soil test report and trial mix design for the special case to Sea shore Structures. The concrete shall be suitable for marine installations and cement used shall be resistant to sulphate and chloride attack under submerged seawater conditions.

5.3.1.7 Cement

Sulphate resisting Portland cement conforming to BS-4027 or as per IS 12330:1988 specification for sulphate resisting Cement Portland cement or better shall be used. Cement shall be suitable for use for seawater and shall have a Tri-Calcium Aluminate (C3A) content of not more than 3.5% and an alkali content of less than 0.6%. All cement batches shall be covered by manufacturer's test certificates which shall be submitted to the Engineer. These shall cover the physical and performance characteristics of the cement. Cement shall be stored in such a way that provides satisfactory protection from ambient elements. Cement that has hardened, become partially set or has become lumpy shall be rejected and removed from the site by the Contractor. A Special Consideration shall be considered for the Sea water Structures by the Contractor in choosing the type of cement, Quick setting, Sulphate resisting, etc. based on site soil condition and the pile foundations to be considered if required. However final recommendations will be followed with consent of the Engineer.

5.3.1.8 Sand

Sand used for concrete coating mix shall be silica type conforming to BS EN 12620 or IS 2116 - 1960 and shall be well graded from fine to coarse grains. As a part of general Instruction Contractor shall follow Indian code standard and any other code for reference shall be with compliance statement matching to the Indian standards and to the satisfaction of the Engineer. As an emergency scarcity option M-sand (manufactured Sand) from crushing Quarry stone to sand (in line with IS:383 – 1970 or latest version) shall be used with the consent of the Engineer and with Compliance statement to IS codes for Ordinary river Sand.

5.3.1.9 Crushed Stone

Crushed stone shall be clean and free from any chemicals or soils or organic material that could impair the concrete strength or as per IS 383 1970 or as specified by the Engineer's approval.

5.3.1.10 Aggregate

Mix Grading Aggregate mix shall be clean and free from injurious amount of clay, salt and alkali, organic or other deleterious material or as per IS 383 1970 or as specified. Alkali compatibility is essential for aggregate. The Contractor shall maintain a material traceability system to record properly the receipt, return or disposal of all materials supplied and their location within the coating yard on a real-time basis. The Contractor shall permit inspection of these records by the Engineer/ Employer's representatives at any time.

5.3.2 Installation Specification

5.3.2.1 Shore Approach Preparation

Contractor shall reclaim and prepare the Site where he intends to constitute the yard for the assembly and preparation of the structures. He is responsible for the construction of the required access roads and the installation of all services relevant to the Works. The start of the excavation of the trench at the shoreline shall be executed in such a way to prevent damages to the shore structures and appropriate sheet pile walls shall be installed (if necessary) to avoid that the action of the waves can cause difficulties to the works carried out by others onshore. The pipeline trench would be dredged using an air lift pump, dragline or clamshell, or excavated with a long armed back hoe from a jack up barge. If rock is present, underwater drilling / rock cutting may be required. Spoil would be removed and returned to shore. This activity would create significant stirred sediments and may require the use of temporary curtains to contain the turbidity plume. Stone bedding material would be imported and placed at the bottom of the trench. The pipe would be prefabricated and floated over the trench or dragged along the trench with neutral buoyancy before being sunk progressively into position by the release of air. Stone pipe surround would then be placed from a barge using chutes and divers and rock protection lowered and placed as trench backfill. The size of the rock protection shall be decided upon the wave climate and depth and the seabed to its original profile and allows longshore drift to remain unaffected in the long term.

5.3.2.2 Pre-Work and Pre-Lay Site Survey

The Contractor shall carry out a pre-works survey to confirm that the site conditions, including sea bottom profile, are the conditions described as per the bathymetry report and side scan supplied by the Employer. Contractor is responsible to highlight to the Engineer any eventual discrepancy with the original data and all eventual variations due to a lack in the execution of this survey and communication to the Employer shall not constitute origin for any claim whatsoever. Prior to trenching operations, Contractor shall ensure that the pipeline is not subjected to excessive spanning as per the requirements of specific Standards. For that purpose, Contractor shall conduct a post-lay survey using divers and/or ROV depending on the work area. Accordingly, Contractor shall propose procedures with all supporting documents along with method of statement for the trenching equipment to negotiate areas of pipeline spanning (if any) such that the pipeline is not over-stressed. Prior to mobilizing for the trenching activities, the Contractor shall review soils data along the pipeline route to ensure the adequacy of the proposed trenching method and that no adverse conditions, which could affect the trenching operations efficiency, are anticipated well in advance.

5.3.2.3 Trenching Method

The Contractor shall propose its preferred method(s) for trenching the pipeline taking into consideration the involved soils and seabed features along the proposed offshore route. A preliminary study of the bathymetric survey has been included in the tender Part-2 D-Site Data. The proposed method shall include procedures for negotiating seabed features, the direction of trenching, trenching sequence and split and the entire trenching methodology shall be established by the Contractor in conjunction with the Engineer/ Employer's representative to

guarantee the efficient operation of the trenching spread.

5.3.2.4 Trenching Requirements

The Contractor shall proceed with the excavation of the trench of the 2500 mm OD, subsea pipeline taking into consideration the following:

Contractor shall dredge the trench to the required depth from the sea bottom in order to give a vertical distance of 1.5 m (pipe top cover) between the top of the respective intake and outfall pipes and the surrounding natural undisturbed seabed level. The top shall be accounted from the crown of the pipe.

- Lateral walls of excavation shall have a minimum slope characteristic of the sea bed to prevent collapse of trench.
- Contractor shall maintain a maximum trench out-of-straightness “OOS” of 0.25 m all over the route in order to mitigate upheaval buckling in case of natural backfilling.
- Pipe should not be lowered until the trench is of the desired width. Any pipeline portions not satisfying the above mentioned “OOS” value shall be adequately corrected in accordance with Contractor procedures and at his sole expense.
- The bottom of the trench shall be compacted and filled with a levelling fine sand bed having a minimum thickness of 0.2 m. Eventual material protruding out of this layer shall be duly recorded and the Engineer shall be informed to agree with the Contractor for the necessary remedies.
- The shape of the trench shall be always in control of the Contractor and designed section shall be restored when and if necessary, at the sole expense of the Contractor.

If, during trenching operations, Contractor encounters obstacles (not likely), he shall at his own expense and to the satisfaction of the Engineer, immediately cease trenching operations on that portion of the pipeline and report to the Engineer the details of the obstructions along with his recommended solution. Any obstacles such as boulders or wrecks, preventing trenching the line shall be removed by the Contractor.

5.3.2.5 Trench-Out of Straightness- Survey (OOS)

As soon as possible after completion of trenching operations, Contractor shall conduct a post-trenching survey to determine the out-of-straightness of the pipeline and ensure that it does not exceed 0.25 m for the entire route. Contractor shall acquire, record and map all necessary data required to determine the “Astrenched” position. Contractor shall perform imperfection out of straightness “OOS” surveys, which shall constitute the basis for “OOS” Assessment, to ensure that the required cover depths for the two intake and one outfall pipelines are maintained along their route. The required “OOS” survey should accurately define the pipeline profile after completion of trenching operations. Prior to the “OOS” survey, repeatability trials should be undertaken to assess the accuracy of the OOS measurements.

5.3.2.6 Trench Grading and Profile

The trench shall be graded such that the minimum vertical radius of curvature of the pipeline does not generate excessive stresses in the pipeline. Any trench transitions for the pipelines (at spool pieces) shall be smoothly profiled back to the undisturbed natural seabed level so as to ensure that the pipeline is not subjected to over-stress while exiting or entering the trench. The bottom of the trench in a transition zone shall be at a constant smooth gradient providing a gentle continuous surface to support the pipeline. Unsupported pipe spans caused by trenching (despite being unlikely) shall not be in excess of the maximum allowable free span lengths given in the relevant standards. Unsupported pipeline spans greater than the allowable span lengths shall be corrected by the Contractor. The Contractor is required to adjust the bottom profile of the excavation in the eventuality that the onshore civil works contractor has to modify the elevation of the Intake chamber of the desalination plant. In this case the slope of the trench shall smoothly be modified in accordance with the final defined elevation. For the Outfall line there is no necessity to modify the sea bed profile during trenching but only make the necessary adjustment to the spool piece at tie-in point.

5.3.2.7 Levelling Sand Bed

The Contractor shall describe in detail the method he intends to use for the distribution of the fine sand in the bottom of the trench in order to have a perfectly levelled and smooth surface. Contractor shall provide, at his own expense, to the correction of any eventual differences in level of the fine sand bottom trench bed. All the profile of the Bed shall be Fully Inspected and Approved by the Engineer.

5.3.2.8 Sinking of Submarine HDPE Pipeline

The specifications below deals with the sinking process and necessary precautions to be taken to secure a safe installation of pipeline at the bottom. Sinking of the pipeline is mainly carried out by nature's own forces i.e. gravity, buoyancy and air pressure.

During sinking of the intake and outfall pipeline, the following factors shall be taken into consideration:

- a) Detailed sinking procedure must be worked out including technical parameters, necessary resources, communication systems and emergency procedures.
- b) Detailed calculations of the sinking curvatures must be carried out by computer programs.
- c) The pulling force in the end shall be calculated and minimum shall be 40 tons. Necessary equipment should be arranged for the same.
- d) The sinking speed shall not exceed 0.3m/s.
- e) The compressor required for air filling in pipeline shall work up to 10 bar. Air pressure curve as a function of depth shall be calculated.
- f) The critical radius of curvature is to be determined for outfall and intake pipeline.
- g) The sinking shall be carried out in a continuous basis.

- h) Concrete weights must be fixed securely.
- i) The weather conditions must be satisfactory and favourable.
- j) The diffuser and intake head must be installed as a beam system by use of cranes.
- k) The static system during lowering of the intake head and diffuser must be calculated.
- l) The intake screen head and diffuser must be ‘mated’/ connected to the main pipeline at sea bottom (in the trench) with the special spool joint.
- m) The sinking shall be carried out under assistance of well certified and experienced personnel in this field.
- n) Use of divers shall be minimised and minimum possible work related to installation must be carried inside the sea.
- o) The pipe string will be towed from the production area by tugboats to the installation site. The Contractor shall prepare a detailed sinking procedure before installation.

The concrete weights shall be fixed to the pipeline at the prescribed centre to centre distance. The weights can be installed onshore or offshore. The concrete weights shall be fixed properly to prevent sliding during installation. To increase the co-efficient of friction and to avoid scratches in the surface of pipe, an EPDM (ethylene propylene diene monomer) rubber gasket between the pipe and concrete weights shall be fixed. When all the pipe sections are fitted together, the pipeline is ready for sinking process. The pipeline is equipped with blind flanges in each end. At the outmost end, the blind flange is also equipped with pipes and valves for air evacuation and air filling.

Before start of the sinking process, the route shall be marked properly by buoys floating at sea surface. Particular care should be taken for the weather forecast as very little wind and waves should exist during the sinking process. The entire pipeline shall be positioned in the correct route by boats, barges and small boats.

The inmost blind end of the pipeline is also connected with valve and pipe for controlled water pumping inside the pipeline through pump during sinking. The air pressure inside the pipe shall be adjusted depending on the depth through the air valve and compressor to prevent any “run way”.

The calculated pulling force must be applied in the outmost end (end near shore) of the pipe before the sinking starts. This force can vary during the sinking operation and shall be specially calculated beforehand.

The sinking starts by opening of the air valve in the outmost end carefully and controlling the inside pressure by a manometer if required to charge the pipe with compressed air. The Contractor shall before starting the sinking operation will prepare the curve showing the necessary air pressure as it is the function of sinking depth. The sinking speed shall be a controlled speed and shall not exceed 0.3 m/s.

All precautions should be taken to avoid buckling of pipe section. The sinking operation shall be continuous process. If for any reason, there is an interruption in the sinking operations, the

reverse sinking process should start immediately by starting the compressor and must be completed within 15 minutes.

When the sinking reaches the outmost end of the pipeline, the S- configuration will transform to J-configuration and at this position, very precise and correct pulling force and sinking speed shall be applied to prevent dynamic acceleration forces when the last volume of air leaves the pipe. 50% of the pipe length, without water should be able to sink during launching. Hence proper anchorage should be done.

5.3.2.9 As-Lowered Survey (Post-Trench Survey)

As-lowered survey shall be conducted in order to meet the following objectives:

- To provide all relevant documentation necessary to demonstrate and to prove that the pipelines have been lowered in accordance with the acceptance criteria.
- Video inspection of the physical condition of top and sides of the As-lowered pipeline for detection of possible damage, pipeline suspensions, etc.
- Determination of As-lowered pipeline position.

5.3.2.10 Anti-Trawl Barriers for Intake and Outfall

Within the Scope of Work of this project is the installation of about 50 nos. 2.50 x 2.50 x 1.50 m anti-trawling fishing concrete blocks in two concentric lanes having origin in the centre of the two Intake structures. Also, similar anti-trawl fishing protection zone shall be provided around diffusers. The external protection barrier of blocks is connected by a nylon net 0.02 dia. 10 mm sq opening of an approximate growth of 250 m. The installation of these concrete blocks shall be carried out at the real end of the construction, when the Intake/outfall structure is installed by using the crane of the installation barge with the assistance of the underwater equipment.

Any different solution in the installation proposed by Contractor shall be approved by Employer's representative.

5.3.3 Inspection

Contractor shall perform stage wise inspection and testing of all equipment/material used to carry out the survey work and the same shall be witnessed by Engineer/Employer's representative. Certified test reports of the instrument used shall be provided. Contractor shall carry out onshore pressure testing (hydro testing) of the intake and outfall pipeline at 1.5 times the rated pressure prior to marine installation of the pipelines. Hydrostatic testing of the system should be carried out as per IS-7634 – 1975/ equivalent European standard. Contractor shall provide a means of remotely monitoring the trenching operations. A full video record of trenching operations shall be obtained and submitted to the Employer. The operations observed will depend on the trenching equipment being used. Trenching shall proceed only when video monitoring is available. Contractor shall continuously monitor the status of trenching operations, the lowered depth of pipe and the position of the pipelines in the trench to ensure satisfactory performance of the equipment being used.

5.3.4 Diving or ROV Reporting

As part of the trenching spread, Contractor shall provide an experienced Diving team and/or the Remote Operating Vehicle (ROV) with all required facilities to perform the Scope of Work. Facilities for continuous video monitoring of trenching machine operations shall be provided. VHS (Video Home System) or VRS (Direct memory card based Video recording System) or approved recording facilities including sufficient tape supplies shall be provided to record all video pictures. During the trenching operations, Contractor divers or ROV shall periodically report to Employer at least once every 24 hours on the operation of the trenching machine. This check shall be increased to every 8 hours after the initial start-up for the first 24 hours. The performance report for information about the condition of the pipe and joints, depth and profile of trench and video inspection back-up shall be provided every day through email.

5.3.5 Pipe Laying

Laying of the Intake and Outfall pipelines is expected to be with the “Bottom Pull” system carried out by an appropriate pulling barge equipped with a suitable pulling winch. The two accessories approx. 100 mm dia. hypochlorite and 100 mm dia. compressed air respectively submarine pipelines can be laid simultaneously with the main 2500 mm OD HDPE pipeline. In this case the intake line shall be firmly anchored to the sea bottom and natural backfilling so that the current and/or storm shall always be under control and not disturb the pipeline. With the utilization of the above system the Contractor shall be responsible to prepare a suitable area onshore for the transportation, storage and assembly of the pipeline strings. Contractor shall submit to the Employer, for approval, a detailed layout of the Site including the description of the sources of power, water, aggregates etc. he intends to utilize for the Project.

If Contractor intends to utilize a different system of laying, he may be allowed to do so but shall propose the alternative procedure to the employer for their approval. The proposed procedure for installation shall describe in details about the methodology and equipment required for Employer's review and approval. In any case, the Contractor shall deliver to the Employer the full description of the marine equipment proposed to be deputed for the execution of the marine operations clearly indicating whether the equipment is owned, hired or at a temporary disposal.

5.3.6 Backfilling

5.3.6.1 Intake Pipeline

Once the entire offshore length of intake pipeline has been laid and the final position controlled by positioning system is assured, the sand backfilling can start ensuring that the extremities of the line at the intake chamber and spool piece end respectively remains free for the future connection to the onshore equipment and to the offshore intake screen installation. Backfilling shall be carried out using the natural original as backfilling material sand, restoring to the original situation. Contractor shall take due care during backfilling that together with the fine sand, coarse material that can damage the Intake pipe is not used. Measurements of the backfilling shall be continuously under control of the Contractor and report and diagrams of the profile submitted daily to the Employer. The backfilling shall be carried out in subsequent stages in order to allow the sand to be deposited duly compacted and to give, as final result, the

original sea bottom configuration and water depth.

5.3.6.2 Intake Structure Area

After the installation of the Intake structure and its connection to the HDPE submarine pipeline with special spool piece, the area surrounding the Intake structure shall be covered by a layer of approximate weight of stones of 5-100 Kg size up to minimum 2 m below the natural sea bed level. On top of this small size stones layer, another layer 1.0 m thick of 250-500 Kg stones shall be installed. The area covered by these two layers shall have a diameter of 50 m having origin in the centre of the Intake screen structure (Intake Head). Nylon net shall be installed all around with floating buoys.

The structure must be modelled in order to establish the structural dimensions, so that it is able to support the forces generated by the calculated force actions. The concrete structures, the piece shall be reinforced, and it is recommended to construct a finite elements model, this is because, very often, it is intended that the structure has a significant weight, and accordingly the concrete walls and base plates have significant thicknesses. The structure/tower/head should be anchored to the hard strata below the sea bed level and the area around that shall be filled with gravels. The vertical height in 1:3 from bottom of sea bed to the 300 mm level below the screen should be graded with gravels to prevent intake of sea bed turbulence sediments in the plant.

5.3.6.3 Outfall Pipeline and Diffusers Area

Similarly, the backfilling operations for the entire length of Outfall pipeline, shall be carried out by Contractor in order to return to the original configuration of the seabed. The area where the diffuser's manifold has to be installed, having approximate dimensions of 70 x 15.0 m and a thickness of 2.0 m average, shall be covered by a layer of 200-500 Kg stones. This may be changed after proper calculation to be carried out by the Contractor.

5.3.6.4 Outfall Diffusers Installation

The Outfall diffuser is constituted by a HDPE manifold 2500 mm OD of an approximate length of 150 m and having about 30 nos. internal dia 350 mm HDPE pipe diffusers inserted with an angle of 50° in respect of the upper tangent of the pipe. This is an indicative design information. Additional simulations for brine dispersion will be done by the Contractor to fine-tune the diffuser location and arrangement. All diffusers are blind flanged and flanges shall be removed by divers after the installation of the Outfall and Intake is completed.

5.3.7 Contractor Equipment, Personnel & HSE Requirement

5.3.7.1 Equipment

Contractor shall furnish complete details of the machineries to be deployed for the trenching spread capable of working in the involved water depths, seabed conditions and environmental conditions. Contractor trenching equipment and its operation shall be such that the pipelines and their joints do not sustain damage. Contractor shall present all design and operation calculations demonstrating that the machine is appropriate, safe and efficient for the trenching works. Documentation shall include results of all field trials, including description of location,

soil types and trenching performance.

5.3.7.2 Support Machinery

All vessels/ support machineries required for carrying out of the Scope of Work shall be in full working order and in good conditions. Contractor shall provide to Client descriptions and technical information on all proposed trenching vessels. The vessel used for the works shall have the following characteristics:

- i) Ensure a good operating stability.
- ii) Have installed a suitable capacity for the job requirements crane.
- iii) Satisfy international safety rules applicable in the work area.
- iv) Have all the permits required to operate in the work area.
- v) Hold certificates issued by Lloyds or Bureau Veritas or others.
- vi) Ensure suitable board and lodgings for 2 Employer's technicians.
- vii) Radio equipment with frequencies for establishing reliable links with local radio stations.
- viii) Allow suitable space with the necessary equipment and facilities for divers' activities.
- ix) Provide a workshop for instrument maintenance.
- x) Allow suitable space for the installation of the Data Acquisition System and Data Processing equipment.
- xi) Provide air-conditioned working areas.

The contractor shall be fully responsible to complete the contract as per requirements with at most safety and meeting the environmental regulations.

5.4 Inlet Structure

The Inlet system including feed channel, chemical dosing, pre-chlorination, and rapid mixing shall be of reinforced concrete construction in CC mix M35. The chamber shall have the concrete stairs and a 1m wide walkway along the length and across the width to allow operation and maintenance of the system with hand railing of SS316 on all the peripheral length, and reinforced concrete staircase. The Structure shall be constructed as per approved detailed drawings to withstand the seawater contact for the design life time.

5.5 Chemical Buildings

Three Chemical building shall be provided for the pre-treatment, the RO system including CIP chemicals and for the post treatment.

The pre-treatment chemical building shall have 3 portions or fully separate structures. One portion of the building shall be assigned for Ferric Chloride and Polyelectrolyte preparation and storage. Other two portions shall be assigned for Chlorination and Acid storage and dosing system. Warranted

The RO Chemical building shall be built near RO building, which will inhouse all chemical

tanks and dosing system for RO trains and CIP system. The post-treatment chemical building shall inhouse caustic and hypochlorite storage and dosing system.

Adequate space shall be provided for storage, preparation and dosing of the chemical solution. The building should also have 1-3 ton EOT (electrically operated overhead travelling crane) as needed to move the pumps, motors and agitators for installation and maintenance. The details of the tanks and dosing system are provided in the Part-2 Section VI, A3 Particular Process Requirements.

Separate and adequate vehicle approaches shall be provided for each portion of the building. The chemical building shall have sufficient ventilation as per the requirements given elsewhere. Sufficient stairs and walkway with hand railing of SS316 shall be provided to inspect the agitators and inside the chemical tanks. A covered reinforced concrete service water storage tank (minimum 2 hours capacity at maximum consumption) shall be constructed on the roof of each chemical building for chemical preparation and chemical inline dilution and line flushing as needed. Adequate toilet and wash room attached to the chemical building shall be constructed as per the specifications in the tender document.

5.6 Flocculator & Clarifier with Tube Settlers

The Clariflocculator with Tube settler shall be of reinforced concrete with access from two ends and walkway facilities for maintenance and inspection. The structure shall be constructed in RCC mix M35 as per the requirements for structures in contact with seawater. Drainage of flocculation tanks and tube settlers shall be from each hopper including back flushing system for cleaning purposes with manual valves. There will be a magnetic flowmeter and an auto operated knife valve with remote sensors in the common header of sludge from flocculators and also in the common header of sludge from tube settlers. The clarified water from tube settler will be fed to the DAF. There is a bypass line which circumvent the DAF unit and directly feeds to the Filter inlet channel.

5.7 DAF and Filter Building

DAF (Dissolved Air Flotation) and Dual Media Filters shall be housed in reinforced concrete building with access from two ends and sufficient walkway facilities and space for maintenance and inspection. The structure shall be constructed in RCC mix M35 as per the requirements for structures in contact with seawater. There shall be sufficient ventilation and glass windows with steel mesh to prevent birds entrance into the building. Details of the DAF and Filters have been provided in the Part-2 Section VI, A3 Particular Process Requirements.

5.8 RO Building, Warehouse and Workshop

The RO building, warehouse and workshop shall be PEB (Pre engineered Buildings) steel structures. Design of structure shall be based on the dead and live load requirements of the structure as it will be built. Snow, wind, and seismic loads shall be considered where they are applicable. Racking must be built stronger and be better braced. The structural design process will involve the steps of i) calculating the permanent actions and determining the variable actions, ii) identifying the load paths that carry the applied actions (vertical and horizontal) to the foundations

and, iii) selecting preliminary sizes for the members.

All nuts and bolts and fasteners shall be of stainless steel and all other steel items shall be hot galvanised. All steel beams and columns shall be polished and epoxy painted. For the roof and wall panel shall be steel sheets (PU sandwich panel). The door and window of the steel frame structure can be made of aluminium alloy. There will be sufficient fixed glass windows at roof and wall to lighten inside the building. There shall be sufficient crane runway beam designed according to your overhead crane parameter and EOTs of the required load bearing to meet the requirement.

RO building (Industrial Steel structure) of each stream shall inhouse the RO skids, CIP system, RO flushing pumps and all system associated with RO system and also a local control Room at the Mezzanine floor area as per proposed drawing and shall be implemented after Approval of the Engineer.

The warehouse and workshop shall be adjacent buildings of minimum area 80m x 40m and 50m x 40m respectively. Both the building shall have all features and facilities required for the purpose. Contractor shall design based on the Site requirements with IS code standards.

5.9 Limestone Filter

The Contractor shall provide reinforced concrete building as per Proposed and approved drawings for Limestone filter with access at the top of the filter. The structure shall be constructed in RCC mix M35. Details of the Limestone filter has been provided in the Part-2 Section VI, A3 Particular Process Requirements.

5.10 Water Retaining Tanks

All water retaining tanks such as Intake well, RO feed tank, Clear water tank, Sludge balance tank, Sludge holding tank, Outfall tank and other tanks shall be of reinforced concrete minimum M-35 or as per as per approved design mix based on the IS code of reference for sea water as special case consideration, along with access and walkway facilities as described elsewhere. All tanks where needed, shall overflow to the Outfall tank for discharge to the sea.

5.11 Sludge Thickener & Pump House

The sludge shall be pumped from the sludge balancing tank to gravity sludge thickeners and dosed with polymer to assist the thickening process. Two gravity thickeners shall be provided. The thickener tanks shall be of reinforced concrete (M-35) or as per IS codes for reference for special sea water design construction. The tanks shall have a sloping bottom with central hopper. The circular tank shall have a peripheral weir and collecting channel. Other facilities such as an access bridge to centre rotating scraper, walkways and stairs to ground with SS316 hand railing shall be provided as described elsewhere. The supernatant from the sludge thickeners shall flow by gravity to the Outfall tank.

5.12 Sludge Dewatering Building

The sludge dewatering building shall be a two storied structure. The polymer feed systems, belt

filter press feed pumps, belt wash water pumps and chemical dosing system should be located on the ground floor of this building. The belt filter presses and electrical room should be located on the first floor of this building. The building should have necessary staircases. There shall be an intermediate platform along a conveyor belt below the first floor. Chutes shall be provided for discharging dewatered sludge cake into the trailer. Necessary foundations shall be provided for the BFPs. The floor slabs on which the BFPs are positioned shall be designed to account for the loadings from the BFPs in the event of the BFP vibration dampening equipment failing. A covered reinforced concrete service water storage tank shall be mounted on the roof of the sludge dewatering building. A toilet and washroom shall also be provided in the sludge dewatering building.

5.13 Substation Building

The construction of new substation buildings as essential including switchyard and transformer area shall be constructed with RCC framework looking to the space requirement. Suitable fencing shall be done of transformer area.

5.14 Administrative, Central Plant Control and Laboratory Buildings

Two buildings shall be constructed – one for the administrative works and another for the plant control plus the laboratory. The administrative building shall be G+2 story building. While a G+1 story building shall be constructed to locate the plant control room at the ground floor and laboratory at the first floor or vice versa with a record room for drawings and all plant information. An indicative plan of the building floors has been provided in the Part-2 Section VI, C Drawings.

The buildings shall be complete with minimum facilities to make a complete working place for the engineers and technicians to sit and work. Items will include but not limited to the Work Stations desks, Executive chairs, officers chairs, conference room chairs and tables, other desk, chairs with writing pad attached in the Training room writing boards, Over Head Projector in the meeting/conference room for minimum 25 officers and Computer desktop/laptop for Engineers as needed, Chairs tables, Fans , Split (A/c) Air-condition room for all rooms, and as where required as per the Engineers, Water for Drinking and toilet /washroom facilities, Adequate Lighting facilities, contractor shall also propose for the Engineer's approval and few other Facilities proposed at Ground floor shall be Entrance corridor with Lift and Staircase, Security room, Reception, First Aid center, Safety Manager room, Client Manger's office, Conference room with screen view from Video Monitoring system and can view the complete plant with different area by control system, Contractor Manager's room, Night shift manager room, Engineer's office rooms, Canteen, adequate Toilets and Wash rooms and contractor shall note that all Technician room shall be in the respective buildings of RO and Workshop and for other MEP areas for easy maintenance and for fault attending purpose and In the First Floor Civil Engineer's room, MEP Engineer's Room, HR and Admin officer's room, Canteen, Toilets and wash room facilities and Lift and dining area with all Architectural, False ceiling , HVAC , MEP and other Facilities .

Second floor is for Guest room accommodation with bed room with full furnished facilities for

the guest to come and stay with family. It will include all items in the guest house which is deemed essential to stay for a family. Each room with toilet and wash room attached with shower water shall be provided with fully furnished bed, tables TV room , chairs , tables drinking water and a small dining area etc. to the Engineer's satisfaction. Canteen Facilities and on the roof terrace will be Sea View room with telescopic arrangement and Lift and staircase facilities and video camera monitoring system and Emergency alarm system.

Another adjacent Control and Laboratory Building (G+1) will have the Computer, Laboratory, Microbiology and Record rooms plus the Multipurpose Training Room with all facility. The details of the buildings have been provided in the Part-2 Section VI, A3 Particular Process Requirements. All the works and all details and facilities shall be carried out by the Contractor as per the Drawing proposed and approved by the Engineer, and also special consideration will be taken for the Construction works for the Sea shore area especially for the type structural works and foundation. The building will have good finishes with Granite floor, and Vitrified floor finishes and tiles for the Toilet and Bathroom walls and false ceiling where required and Corners of the wall with gypsum finishes and the wide glass walls with Glass doors and adequate shelves and Cupboards for the Files. Doors and windows will be of teak wood unless if any other recommended by the Employer. Some windows can be aluminum as per drawing and all finishing works like painting, special lighting, solar fixing etc. and other decorations and aesthetics will be as per drawings proposed and Engineer's Choice. However, the contractor shall provide the facility to the utmost satisfaction of the Employer.

Contractor shall note that from the Central Control room a provision shall be made for Engineers to view the Plant and different buildings through glass set up and by Computer with Video Camera Monitoring System and other IT system as per the requirement of the Engineer. Also adequate internet facility shall be provided in the Administrative and Control buildings. Ten Laptops with latest required software shall be provided. All other facilities shall be proposed and implemented fulfilling the Engineer's satisfaction.

The facilities will include but not limited to the following.

S. No.	Floor Levels	Name of the room	Facilities details and Finishing details .
1	Ground floor	Front corridor and Steps	<ul style="list-style-type: none"> • Floor finish – Granite stone with good polish .
		Security Room	<ul style="list-style-type: none"> • Floor finish – Granite • Ceiling fan- 1Nos, Wooden Table-01 Nos • Wooden Chair -01 Nos • Guest chair -02 Nos • Fan -1 No . • Telephone, internet , Intercom, Video monitoring and tracking and checking screen .
		Reception room	<ul style="list-style-type: none"> • Executive Sofa for 6 seaters -1 no and Chairs -3 nos. • Front Table -news paper -1 no
		First aid room	<ul style="list-style-type: none"> • Granite floor finish Steel Table-1 no. • Guest Chair-2 nos.

S. No.	Floor Levels	Name of the room	Facilities details and Finishing details .
			<ul style="list-style-type: none"> Office desk -1 no
		Lift	2 nos.as specified by Engineer.
		Stair case	2 nos. As per drawing .
		Canteen area	<ul style="list-style-type: none"> Complete 30 nos. steel chair , steel table with glass top or mica sheet wood finish for dining Fan 10 nos. Hand Wash area 1.2 m length – 2nos with 4 taps each A complete Solar and electrically operated Heaters will be used for heating prepared food and for some snacks , coffee and tea and milk and small food and ready made food only . and a small cool drinks and Big refrigerator
		Front side wall at corridor	<ul style="list-style-type: none"> Plant Model display -1 no. Tube lights in the ceiling 2 nos. 40 watts each .
		Client Manager's room, Contractor' room	<ul style="list-style-type: none"> One big table 6 ft length X 5 Feet width , chair -4 nos. Executive Chair-1 no Normal chairs -3 no A 100 liters fridge for each manager . Attached Toilet and Wash areas . Doors and windows – Teak wood Door and aluminium / Teak wood window . Fan-1 no 1.5 ton Samsung or any other specified wall mounted near ceiling Split A/c -1 no. Telephone, intercom, Internet wifi, Lap top for every manager and TV with plant monitoring video screens .
		Conference room	<ul style="list-style-type: none"> A big Conference 20 seater table 10 nos. on both side and Chairs20 nos. Ceiling fan- 8 nos. at 1 .2 m distance minimum Tube Lights 12nos. Over Head projector with complete set up for meeting 1 no. Presentation Screen -1 no and Boards and Marker and wifi internet access to monitor running Plant status as at site .

S. No.	Floor Levels	Name of the room	Facilities details and Finishing details .
		General Male and Female toilets	<ul style="list-style-type: none"> • Exhaust fan -3 nos. each , • Hand wash 2 no. each , • urinals-3 nos. for Male toilet . M/F as per Drawing toilets-3 nos. each , Indian and western .
		Janitor room	<ul style="list-style-type: none"> • Ceiling Fan -1 no. • Ventilation fan-1 no.
		Client Engineer's room, Contractor's Engineer's Room , Safety engineers room , Supervisor's Room ,Junior engineer's room	<ul style="list-style-type: none"> • Office Table -1 no. each officer / Engineer • Executive chair I no each , • Guest Chair 2 nos. per room , • Visitor chair 4 nos. extra . • With ceiling fan 1 no. per officer , with split A/c 1.5 ton 4 nos. with 2 nos. per 3 Engineers . • Floor finish shall be Vitrified floor and at corridor – Granite Floor finish .Additional Chairs shall be as per drawing . • Doors and windows , natural Air ventilation and natural sun light as per drawing , as per bye laws of NBC . • Each engineer will have a small refrigerator of 50 litres. capacity .
		Drinking water and STP (Small Sewage Treatment plant and RCT (Rain Water Collection Tank)	<ul style="list-style-type: none"> • For the Total building and the Microbiology and Laboratory building
		Front walk way 1.2 m wide	<ul style="list-style-type: none"> • All round the Building and with adjacent is the Green Land scape with drip irrigation facility as per Drawing
		Laboratory room, Microbiology room	<ul style="list-style-type: none"> • Comfortable Chairs -minimum 12 nos. each room and • 12nos Table as per drawings or as per lab requirements and Drawings . • 20 tube lights each big room and Fan . • 1.5 ton Split type Air condition 4 nos. wall mounted and with Teak wood doors and windows . with entrance steps with Granite floor finish and corridor 1.2 m wide with anti skid tiles • Adjacent is plantation for the land scape with green grass and small plant .

S. No.	Floor Levels	Name of the room	Facilities details and Finishing details .
			<ul style="list-style-type: none"> • Microbiology room and Laboratory floor will have acid proof tiles . • Sufficient, adequate air vent and Sun Light will be provided for Both the rooms . • A big toilet and Bathroom for male and Female will be provided as per drawing , • Minimum 3 no of urinals and two toilets will be provided for male toilet area a small hand wash area . • or female toilet one Hand wash area and two toilets will be provided with tile finish at the walls .
	Ground floor	Corridor area	<ul style="list-style-type: none"> • Adequate Lighting will be provided . • solar panels will be supported for back up lights and power support • Floor finish shall be granite floor of client approved colour .
2	First floor	Front portico	<ul style="list-style-type: none"> • 1.2 m wide all round the building with Tile for the floor • parapet wall 10 cm thick 1.2 m Ht • Stainless steel finish hand rail 0.5 m Ht .
		All staircase	<ul style="list-style-type: none"> • Anti skid Tiles finish . • with stainless steel hand rail .
		Electrician room	<ul style="list-style-type: none"> • Vitrified tile finish , • 1 ceiling fan , • a small office table • Two chairs , Two tube lights .
		Pantry	<ul style="list-style-type: none"> • A Micro oven , wash basin, and a ceiling Fan , 2 tube lights .
		Night shift manager's room both client and contractor	<ul style="list-style-type: none"> • 2 tube lights , • 1.5 ton Split a/c wall mounted , • A big Office table , • Executive chair- 1 no. • Lap top and fridge , • Two visitor chair and a small sofa 3 seater for each room . • Intercom, • telephone, • Mobile , • (walky talky for inside plant coordination), • Video monitoring provision for the Plant progress .
		Library room	<ul style="list-style-type: none"> • Adequate 5 seater table 2 nos. and • 10 single seater chairs . • with toilet facility for male only and • Female will use general toilet facility out side the library .

S. No.	Floor Levels	Name of the room	Facilities details and Finishing details .
		Meeting room	<ul style="list-style-type: none"> • Will have 12 nos. seater table . • 5 nos. chairs on both side . • 2 nos. at center, opposite side . and additional chair and table if any required . • Sufficient lighting with 8 no tube lights and Doors and windows as per drawing and NBC minimum reference code .
		Supervisors room, HR room, plant Office Administrator room, Instrumentation Engineer room , Plumbing Engineer , Electrical Engineer room , Civil Engineer room ,	<ul style="list-style-type: none"> • Each room will have minimum 2 tube lights of 40 watts , Each room 1 fan and a lap top for all staffs and for Engineers and other officer vital person each with Internet • Each Intercom , telephone and Mobile and Walky talkie , and lap top monitoring for the Plant video progress provision and site coordination facilities • Each section ref Drawing one male toilet with Hand wash and Female Toilet, with Hand wash and • adequate Opening for natural air ventilation and also Sun light with Doors and Windows . • Floor finish shall be vitrified Tiles. • Each Section will have 2 split a/c 1.5 tons Samsung Model Unless specified or as per approved Drawing .
		Corridor 1.2 m wide	<ul style="list-style-type: none"> • Will be of Granite Finish and with sufficient sun light ventilation .
		Electrician room	<ul style="list-style-type: none"> • One tube light and a small 60 watts bulb and a ceiling fan and a Table and two Chair for workers.
		Pantry room	<ul style="list-style-type: none"> • Two tube light 40 watts .. A sitting chair . • A Micro oven provision , • Electric heaters • A ceiling fan and • 100litres refrigerator -1 no.
	First floor	Multipurpose meeting room	<ul style="list-style-type: none"> • Will have adequate 30 nos. Chairs and writing table and big table for the Trainer with executive chair • Adequate lighting Facility and • 8 nos. split a/c and • 8 nos. Ceiling fan and with Over head projector facility and video monitoring the plant facility with TV and PowerPoint Screen .and a Computer and Lap top will be provided as per requirement sufficiently . • Doors and windows adequate for natural air and Sun Lighting facility is provided as per NBC

S. No.	Floor Levels	Name of the room	Facilities details and Finishing details .
	First floor	Research &Development Room and Record storage room	<ul style="list-style-type: none"> • A 20seater Workstation with laptop for each • chairs for all research staffs • A master table • A Executive chair for the Research Head. • Sufficient lighting with 20 nos. • Tube lights LED and • Internet facility, • Intercom, • Video came Tv screen to view the Plant 4 nos. at all side of wall and for each lap top . • Adequate natural air ventilation and Sun light facility provided . • A well-defined record storage room will be provided to Store all record and will be used as and when required .
		First floor toilet and wash area facility .	With adequate exhaust fans and wash area and urinals and closet for both male and female will be provided .
	Second Floor Area	VIP Suite room	<ul style="list-style-type: none"> • TV- 1 NO • Sofa three seater -1 no • Bucket seat sofa individual-2 nos. • Visitor seating sofa -4 nos. • A Table and executive Chairs -4 nos., • Visitor chairs -4 nos. • Executive Master Bed room with complete Master bed and cot and Blanket . • A Dressing table • 1 split 1.5 ton Air conditioner, • 4 tube lights, • Ceiling Fan 3 nos. each room and • Adequate 2 nos. doors and windows with teak wood or as per drawing , • A Small fridge and a Mirror wall mounted and clock and reading and writing chair and table with Internet, Intercom, Computer / Lap top, • TV screen to check the plant during emergency • Alarm and fire extinguisher
		Conference room	<ul style="list-style-type: none"> • For the private and confidential discussion to the Plant Manager and for Engineer . this room shall be with 12 nos. tube lights , • 8 nos. Ceiling Fan and • 16 seater table and 16 Chairs and

S. No.	Floor Levels	Name of the room	Facilities details and Finishing details .
			<ul style="list-style-type: none"> • A over Head projector and • Screen and video monitoring Tv for the Plant progress visualization .Adequate Doors and windows and Screen pointers and other accessories .
		Lift and staircase	Shall be up to second floor roof to see the plant and for sea view room with lift head room at the Second floor
		Toilet for male and female at the second floor .	<ul style="list-style-type: none"> • Adequate toilet facilities are provided 3 toilets for male and 3 toilets for female and • 3 urinals for male and • wash area facilities . • Sufficient lights are provided with 4 tube lights of 40 Watts each male and female areas and • 3 nos.Exhaust fan and a wall mounted mirror at the hand wash basin area .
		Engineers suite room or bed room 2 nos. of eight bed rooms	<ul style="list-style-type: none"> • Total Bed room are provided with sufficient Tube lights of 2nos each room of 40 watts • A small fridge commonly provided 100 litres for four Engineer total 2 nos. • Single bed cot and bed each engineer • 2 nos. blanket and pillow • Mirror and Common toilet facility one for two Engineers. • common Lobby for watching TV and Plant progress and with Internet facility • wifi and Intercom. • Reading table and chair • A two seater Sofa provided . • Each room a single ceiling fan and • Common two no 1.5 ton Split a/c commonly controlled by two engineer per A/c. • Adequate Window and Door facilities are provided for each room one window .
		A big private room	<ul style="list-style-type: none"> • Provided with 4 nos Tube lights40 watts , • 2 no. ceiling fan, a door and Two windows and a small fridge • Meeting chairs 6 nos and • 3 nos sofa . • Intercom • Internet facilties • Telephone and mobile and • TV room • Sufficient Chair and work table with a single lap top and Tv to view the Plant progress.
		A portico at the second floor .	<ul style="list-style-type: none"> • Finishes of floor will be either Tiles or Granite as per Engineer's Choice 1.2 m wide and 1.2 m height and 120 mm thick with handrail .5 m ht

S. No.	Floor Levels	Name of the room	Facilities details and Finishing details .
			to view the plant from the Balcony all round the building .
			<ul style="list-style-type: none"> • Comfortable emergency exit doors and sufficient air ventilation and Sunlight are provided for the entire building .
			<ul style="list-style-type: none"> • Roof terrace will be specified roof tiles with water proofing material and water tanks and sea view room
		Sea view room	<ul style="list-style-type: none"> • Floor with marble finish . • Drinking water facilities at roof level . • Wash room and Toilet facilities for emergency use. • Adequate sunlight and Air ventilation • 6 nos tube lights and 6 nos.chairs • Sofa 6 seater and work table , • Telescope to see the plant and sea view and floor is either Vitrified or Granite finish .

General facilities for the Plant area

S. No.	Plant area	Finishing Requirements	Additional Requirements
a)	Security room -2 Nos (at Entrance and Exit)	Desk 2 nos , table 6 feet length 1 no. , Chair – 3 nos , Intercom, telephone -1no., Television- 1no with video cam monitoring the vehicles and other people movements only , Adequate tube light 2 nos and ceiling Fan -1 no, table fan-1 , Computer Table and chair 1 no., Internet , Wifi , Mobile facilities .)	Additional security room at the Sea Side Back side of the Plant .(with Chair , table, Intercom, Telephone, Mobile, Wifi

5.15 Design Submissions

Complete detailed design calculations of foundations and superstructure together with general arrangement drawings, architectural drawings, reinforcement drawings and other drawings shall be submitted to the Engineer /Employer's representative. Separate design calculations for foundations and superstructures submitted independent of each other shall deemed to be incomplete and will not be accepted. The design considerations described hereunder establish the minimum basic requirements of plain and reinforced concrete structures, masonry structures and structural steel works. However, any particular structure shall be designed for the

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

5.16 Design Standards

All designs shall be based on the latest 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 Engineer.

In case of any variation or contradiction between the provisions of the IS Standards or Codes and the specifications given along with the submitted tender document, the provision given in this Specification shall be followed. All the reinforced concrete structural designs shall generally conform to the following publications of the Indian Standards Institution:

- IS:456 Code of Practice for plain and reinforced concrete
- IS:875 Code of Practice for design loads for buildings and structures (Part I to V)
- IS:3370 Code of Practice for concrete structures for the storage of liquids (Part I to IV)
- IS:1893 Criteria for earthquake resistant design of structures (Part-1)
- IS:2974 Code of Practice for design and construction of machine foundations (Part 1 to 4)
- IS:13920 Ductile Detailing of Reinforced Concrete Structures subjected to Seismic forces- Code of Practice

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

- IS:800 Code of Practice for general construction in steel
- IS:806 Code of Practice for use of steel tubes in general building construction

5.17 Design Life

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

5.18 Joints

Movement joints such as expansion joints, complete contraction joints, partial contraction joints and sliding joints shall be designed to suit the structure. However, contraction joints shall be provided at specified locations spaced not more than 7.5 m in both right angle directions for walls and rafts. Expansion joints of suitable gap at suitable intervals not more than 30 m shall be provided in walls, floors and roof slabs of 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 waterstops of 150 mm width shall be used for walls and 230 mm width for base slabs.

5.19 Design Loadings

All buildings and structures shall be designed to resist the worst combination of the following loads/stresses under test and working conditions; these include dead load, live load, wind load, seismic load, and stresses due to temperature changes, shrinkage and creep in materials, dynamic loads:

5.19.1 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:

(i)	Weight of water	9.81 kN/m ³
(ii)	Weight of soil (irrespective of strata available at site and type of soil used for filling etc). However, for checking stability against uplift, actual weight of soil as determined by field test shall be considered	20.00 kN/m ³
(iii)	Weight of plain concrete	24.00 kN/m ³
(iv)	Weight of reinforced concrete	25.00 kN/m ³
(v)	Weight of brickwork (exclusive of plaster)	22.00 N/m ² per mm thickness of brickwork
(vi)	Weight of plaster to masonry surface	18.00 N/m ² per mm thickness
(vii)	Weight of granolithic terrazo finish or rendering screed, etc.	24.00 N/m ² per mm thickness
(viii)	Weight of sand (filter media)	26 kN/m ³
(ix)	Weight of MS chequered plates	78.5 N/m ² per mm thickness of plates

5.19.2 Live Load

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

(i)	Live load on roofs	1.50 kN/m ²
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(ii)	Live load on floors supporting equipment such as pumps, blowers, compressors, valves etc.	10.00 kN/m ²
(iii)	Live load on all other floors walkways, stairways and platforms	5.00 kN/m ²

In the absence of any suitable provisions for live loads in IS Codes or as given above for any particular type of floor or structure, assumptions made must receive the approval of the Engineer prior to starting the design work. Apart from the specified live loads or any other load due to material stored, any other equipment load or possible overloading during maintenance or erection/construction shall be considered and shall be partial or full whichever causes the most critical condition.

5.19.3 Wind Load

Wind loads shall be as per IS:875 Part (III).

5.19.4 Earthquake Load

This shall be computed as per IS:1893. An importance factor appropriate to the type of structure shall be considered for design of all the structures. Chennai comes under Earthquake zone III.

5.19.5 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. Also, Natural disaster due to tsunami which occurred on Dec26 2004 at Chennai coastal area will also be considered now so that structures will be better safe with higher Stability and Durability.

5.20 Design Conditions for Liquid Retaining Structures

Water level is assumed at the ground level for design of all the structures. All underground or partly underground liquid containing structures shall be designed for the following conditions:

- (i) Liquid depth up to full height of wall including free board: no relief due to soil pressure from outside to be considered
- (ii) structure empty (i.e., empty of liquid, any material, etc.): full earth pressure and surcharge pressure wherever applicable, to be considered
- (iii) partition wall between dry sump and wet sump: to be designed for full liquid depth up to full height of wall
- (iv) partition wall between two compartments: to be designed as one compartment empty and other full
- (v) structures shall be designed for uplift in empty conditions with the water table as indicated in geotechnical report
- (vi) walls shall be designed under operating conditions to resist earthquake forces from earth pressure mobilisation and dynamic water loads

- (vii) Underground or partially underground structures shall also be checked against stresses developed due to any combination of full and empty compartments with appropriate ground/uplift pressures from below to base slab. A minimum factor of 1.2 shall be ensured against uplift or floatation.
- (viii) All the liquid retaining structures shall be designed for maximum design crack width of 0.1 mm for direct tension and flexure.

5.21 Foundations

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

5.22 Design Requirements

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

- (i) All blinding and leveling concrete shall be a minimum 150 mm thick in concrete grade M15.
- (ii) For all water retaining reinforced concrete structures, concrete shall be of a minimum M35 grade (and as per IS 3370) and for all other reinforced concrete structures, reinforced concrete shall be of a minimum M35 grade (and as per IS 456). Maximum aggregate size shall be 20 mm for all the reinforced concrete works.
- (iii) The concrete for reinforced concrete structures shall have a minimum cement content of 360 kg/m³ with a maximum 20 mm size aggregate. Reinforced concrete shall have minimum slump of 100mm with maximum water cement ratio of 0.45.
- (iv) The minimum clear cover to all reinforcement including stirrups and links shall be 50 mm for all water retaining structures. As a design consideration to control the crack, though general requirement shall be as per IS:3370 but all the water retaining structures including roof slab shall be designed on permissible crack width of 0.1 mm (as per BS 8007).
- (v) The amount of reinforcement in each of the two directions at right angles within each surface zone should not be less than 0.35% of the surface zone cross section (as per Clause 2.6.2.3 of BS 8007-1987). For slabs, minimum of 10 mm dia bars shall be used to avoid any deformation of lesser diameter bars under loads prior to construction.

- (vi) The minimum cover to the main reinforcing bars for different members for non-water retaining structures shall be as follows unless stated otherwise:
- | | | |
|---|---|-------|
| Slab (Floor, Roof, Canopy, and Staircase) | : | 30 mm |
| Beams (Sides, Bottom & Top) | : | 40 mm |
| Columns | : | 50 mm |
| Pedestals (in contact with earth) | : | 50 mm |
| Basement wall, retaining walls | | |
| a) Face in contact with earth | : | 40 mm |
| b) Interior face | : | 30 mm |
| Foundations | : | 50 mm |
- (vii) For reinforced concrete structures, reinforcement shall be HYSD Steel of grade Fe 500 (coated) as per acceptance of the Engineer.
- (viii) All buildings shall have a minimum 1.2 meter wide, 100 mm thick plinth protection paving in M20 grade concrete or stone slabs/tiles. All plinth protection shall be supported on well compacted strata.
- (ix) All pipes and ducts laid below the structural plinth and road works shall be surrounded with concrete of minimum grade M15 over sand bedding or as per approved drawings.
- (x) Detailing of the reinforcement and sizing of structural members shall be done as per latest IS:-13920.
- (xi) Any structure or pipeline crossing below roads shall be designed for Class 'A' of IRC loading. All foundation shall have water proofing coating and wrapping as per Drawing due to sea shore / or as per IS code.
- (xii) Sliding layer or slip layer shall be provided between sub base and structural slab (Raft). Polythene sheets of 1000 gauge shall be provided as sliding layer as per IS specification.
- (xiii) Water tightness testing of water retaining structures shall be performed in accordance with IS:3370 (Part I). It is described in Clause 5.34 under this Part-5. The depth of water for testing shall be up to the soffit of the covering slab.

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

(i)	Walls for liquid retaining structures	300 mm
(ii)	Roof slabs for liquid retaining structures (other than flat slabs)	240 mm
(iii)	Bottom slabs/Raft for liquid retaining structures	300 mm
(iv)	Floor slabs including roof slabs, walkways, canopy slabs	150 mm
(v)	Walls of cables/pipe trenches, underground pits, etc.	150 mm
(vi)	Column footings	450 mm
(vii)	Parapets, chajja	125/150 mm
(viii)	Precast trench cover	75 mm

- (xiv) Design of all reinforced concrete structures shall be as per IS:456, of pre-stressed concrete structures as per IS:1343. Water retaining structures as per IS 3370, The structural safety of all foundations on soil shall, in general be based on IS:1904.
- (xv) For calculation purpose “Limit state Design” methods according to IS:456-2001 shall generally be adopted, except for water retaining structures where IS:3370 (Part I-IV) shall be referred and other special cases requiring design by working stress method.
- (xvi) All grouting below machine/equipment bases, and pockets shall be non-shrinking grout of adequate thickness and minimum grade of M35 with 6mm and down aggregates. Grouting below structural column bases shall be minimum grade of M35 with 6mm and down aggregates.
- (xvii) PCC grade M15 – Apron, plinth protection, screed concrete, foundation below masonry walls, encasing of underground pipes & conduits, ground floor at plinth level, toilet, rest room, etc.
- (xviii) All foundations and concrete structures shall be designed to resist full operating dead and live loads, with appropriate combination of wind and seismic forces and with due allowance for impact, inertia loading, vibration, unbalanced dynamic loads, etc. as secondary effect of live loads, erection loads, temperature variation etc. While designing structures and foundations either the effect of seismic forces or wind loads, whichever produces the worst effect, shall be considered along with usual load conditions. Apart from the installation and operating loads indicated by the equipment manufacturers, the design of buildings and structures shall be based on dead and imposed loads calculated according to IS:875. All structures shall be designed for seismic load as per IS1893 2002/latest in the category one above as stated in the specified code.
- (xix) Concentrated and uniformly distributed live load on floors and platforms shall be considered depending upon the usage and in accordance with maximum expected process requirements, to be indicated by the equipment manufacturers. When the loads are movable, they shall be so placed as to get worst effect in moment & shear, axial load etc. for which the elements shall be designed. The effect of concentrated load shall not be reduced. Due allowance shall be made, wherever necessary, for installation and operation of any equipment as per equipment manufacturer's data and recommendations. The design shall be based on the maximum loading due to uniform live load and/or equipment loading including impact, vibration, unbalanced operating forces, etc.
- (xx) Foundations for structures and equipment shall be proportioned to resist the worst combination of loading and shall generally be designed as per the provision of IS:1904 for open foundations on soil and IS: 2911 for foundations on piles.

5.23 Concrete and Allied Works

5.23.1 Materials in General

The term "materials" shall mean all materials, goods and articles of every kind whether raw,

processed or manufactured and equipment and plant of every kind to be supplied by the Contractor for incorporation in the Works. Except as may be otherwise specified for particular parts of the Works, the provision of clauses in "Materials and Workmanship" shall apply to materials and workmanship for any part of the Works. All materials shall be new and of the kinds and qualities described in the Contract and shall be at least equal to approved samples.

As soon as practicable after receiving the order to commence the Works, the Contractor shall inform to the Engineer of the names of the suppliers from whom he proposes to obtain any materials but he shall not place any order without the approval of the Engineer which may be withheld until samples have been submitted and satisfactorily tested. The Contractor shall thereafter keep the Engineer informed of orders for and delivery dates of all materials.

Materials shall be transported, handled and stored in such a manner as to prevent deterioration, damage or contamination failing which such damaged materials will be rejected and shall not be used on any part of the Works under this contract.

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. The Employer's representative 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 Employer's representative approval obtained, prior to starting of concrete work.

5.23.2 Materials for Standard Concrete

The ingredients to be used in the manufacture of concrete shall consist solely of Portland cement, clean sand, natural coarse aggregate, clean water and admixtures, if specifically called for on drawings or specifications, or to the approval of the Employer's Representative if conditions at site warrant its use.

5.23.2.1 Cement

Unless otherwise specified in the Specification or called for by the Employer's Representative, cement shall be ordinary Portland cement (OPC-43 grade) Bags /SRS/ conforming to IS:269 unless specifically defined. The use of bulk cement will be permitted only with the approval of the Employer's Representative. Changing of brands or type of cement within the same structure should be avoided as far as possible.

However, cement for all works submerged under sea water shall be Portland Slag cement43 grade in 50 kg. Bags conforming to IS:269 unless specifically defined. The use of bulk cement will be permitted only with the approval of the Employer's Representative. Changing of brands or type of cement within the same structure should be avoided as far as possible. Sample shall be tested at approved Laboratory at Contractor's cost from each lot of cement delivered at site.

The Contractor will have to make his own arrangements for the supply and storage of an adequate quantity of cement. Employer will not supply cement. It will be the responsibility of the Contractor to ensure adequate and proper storage and 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 arrangement shall be such there is no dead storage. Not more than 12 bags shall be stacked in any tier. The Employer's Representative shall approve the storage arrangement. Consignments cement shall be stored as received and shall be consumed in the order of their delivery.

Cement held in storage for a period of ninety (90) days or longer shall be tested. Should at any time the Employer's Representative 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 the approved laboratory and until the results of such tests are found satisfactory, it shall not be used in any work. The Contractor shall not be entitled to any claim of any nature on this account.

5.23.2.2 Aggregates

i) General

'Aggregate' in general designates both fine and coarse inert materials used in the manufacture of concrete.

"Fine Aggregate" is aggregate most of which passes through 4.75 mm IS sieve.

"Coarse Aggregate" is aggregate most of which is retained on 4.75 mm IS sieve.

All fine and coarse aggregates proposed for use in the Works shall be subject to the Employer's Representative'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 Employer's Representative.

Aggregates shall, except as noted above, consist of natural sands, manufactured Quarry Sand-M-Sand, crushed stone and gravel from a source known to produce satisfactory aggregate for concrete and shall be chemically inert, 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 shall 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 mix design and determination of suitability shall be taken under the supervision of Employer's Representative 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 Employer's Representative in advance of the work for use in determining aggregate suitability. The costs of all such tests, sampling, etc., shall be borne by 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 aggregate 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 used for lifting the coarse aggregates from bins or stockpiles. Coarse aggregate shall be piled in layers not exceeding 1.20 meters in height to prevent coning or segregation. Each layers shall cover the entire area of the stock pile before succeeding layers are started. Aggregates that have become segregated shall be rejected. Rejected material after remixing may be accepted, if subsequent tests demonstrate conformance with required gradation.

iv) Specific Gravity

Aggregates having a specific gravity below 2.6 (saturated surface dry basis) shall not be used without special permission of the Employer's Representative.

5.23.3 Fine Aggregate

Fine aggregate shall consist of natural or crushed sand conforming to I.S. 383 (latest version). 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.

a) Machine-made Sand – M-Sand

Machine-made sand will be acceptable, provided the constituent rock gravel composition shall be sound, hard, dense, non-organic, uncoated and durable against weathering.

b) 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 fractions.

c) Foreign Material Limitations

The percentage of deleterious substance in sand delivered to, the mixer shall not exceed the following:

		Percent by weight	
		Uncrushed	Crushed
i)	Material finer than 75 micron I.S sieve	3.00	15.00
ii)	Shale	1.00	—
iii)	Coal and lignite	1.00	1.00
iv)	Clay lumps	1.00	1.00

		Percent by weight	
		Uncrushed	Crushed
v)	Total of all above substances including items (i) to (iv) for uncrushed sand and items (iii) and (iv) for Crushed sand	5.00	2.00

d) Gradation

Unless otherwise directed or approved by the Employer's Representative, the grading of sand shall be within the limits indicated hereunder.

I.S. Sieve Designation	Percentage Passing for			
	Grading Zone I	Grading Zone II	Grading Zone III	Grading Zone IV
10 mm	100	100	100	100
4.75 mm	90-100	90-100	90-100	95-100
2.36 mm	60-95	75-100	85-100	95-100
1.18mm	30-70	55-90	75-100	90-100
600 micron	15-34	35-59	60-79	80-100
300 micron	5-20	8-30	12-40	15-50
150 micron	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 micron I.S. sieve, by total amount not exceeding 5 percent, 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 size 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 unless mix designs and preliminary tests shall show its suitability for producing concrete of specified strength and workability.

e) Fineness Modulus

The sand shall have a fineness modulus of not less than 2.2 or more than 3.2. The fineness modulus is determined by adding the cumulative percentages retained on the following I.S. sieve sizes (4.75mm, 2.36mm, 1.18mm, 600micron, 300micron and 150micron) and dividing the sum by 100.

5.23.4 Coarse Aggregate

Coarse aggregate for concrete, except as noted above, shall conform to IS: 383. This shall consist of natural or crushed stone and gravel, 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.

a) Screening and Washing

Natural gravel and crushed rock shall be screened and/or washed for the removal of dirt or

dust coating, if so directed by the Employer's Representative.

b) Grading

Coarse aggregate shall be either in single size or graded, in both cases the grading shall be within the following limits:

I.S. Sieve Designation	Percentage passing for single sized aggregate of nominal size					Percentage passing for Graded aggregate of nominal size			
	40 mm	20mm	16mm	12.5mm	10mm	40mm	20mm	16mm	12.5mm
63 mm	100	-	-	-	-	100	-	-	-
40 mm	85-100	100	-	-	-	95-100	100	-	-
20 mm	0-20	85-100	100	-	-	30-70	95-100	100	-
16 mm	-	-	85-100	100	-	-	-	90-100	-
12.5 mm	-	-	-	85-100	100	-	-	-	90-100
10 mm	0-5	0-20	0-30	0-45	85-100	10-35	25-55	30-70	40-85
4.75 mm	-	0-5	0-5	0-10	0-20	0-5	0-10	0-10	0-10
2.36 mm	-	-	-	-	0-5	-	-	-	-

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 in such quantities that will not, in the opinion of the Employer's Representative, affect adversely the strength and/or durability of concrete. The maximum size of coarse shall be the maximum size specified above, but in no case greater than 1/4 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. Plums above 160 mm and upto any reasonable size can be used in plain mass concrete work of large dimensions upto a maximum limit of 20% by volume of concrete when specifically approved by Employer's Representative. 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 the reinforcement whichever is smaller. The amount of fine particles occurring in the free state or as loose adherent shall not exceed 1% when determined by laboratory sedimentation tests as per I.S. 2386. After 24 hours immersion in water, a previously dried sample shall not have gained more than 10% of its oven dry weight in air, as determined by I.S. 2386.

c) Foreign Material Limitations

The percentage of deleterious substances in the aggregate delivered to the mixer shall not exceed the following or refer Is code 383 -1970:

S.N.	Foreign Material	Percent by weight	
		Uncrushed	Crushed
i)	Material finer than 75 micron I.S Sieve	3.00	3.00
ii)	Coal and lignite	1.00	1.00

S.N.	Foreign Material	Percent by weight	
		Uncrushed	Crushed
iii)	Clay lumps	1.00	1.00
iv)	Soft fragments	3.00	—
v)	Total of all the above substances	5.00	5.00

5.23.5 Water

Water used for both mixing and curing, shall be free from injurious amounts of deleterious materials. Product water is generally satisfactory for mixing and curing concrete.

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 I.S. 456. The sample of water 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.

Average 28-day compressive strength of at least three 15 cm concrete cubes prepared with water proposed to be used shall not 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 I.S. 516.

The initial setting time of test block made with the appropriate test cement and the water proposed to be used 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 blocks shall be prepared and tested in accordance with the requirements of I.S. 4031.

Where water can be shown to contain an excess of acid, alkali, sugar or salt, Employer's Representative may refuse to permit its use. As a guide, the following concentrations represent the maximum permissible values:

- (a) 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 I.S: 3025.
- (b) To neutralize 200-ml. sample of water, using methyl orange, as an indicator should not require more than 10 ml. of 0.1 Normal HCL. The details of test shall be as given in I.S: 3025.
- (c) Percentage of solids, when tested in accordance with the method indicated below, shall not exceed the following:

Solids	Percent	Method of Test
		(Ref. to Cause No. In IS :3025)

Solids	Percent	Method of Test
Organic	0.02	10 and 11 (organic solids = total solids minus ignited residue)
Inorganic	0.30	11 (ignited residue)
Sulphates (as SO ₄)	0.05	20
Alkali Chloride (As) ~	0.20	24
Suspended matter	0.20	12

5.24 Steel Members Encased in Concrete

Structural steel columns, beams, girders and bracings to be encased in concrete shall be unpainted. The encasing shall be done in concrete with 10 mm maximum size aggregate and works cube strength not less than 15 N/mm² at 28 days unless otherwise specified. The steel member shall be wrapped with galvanised wire mesh of adequate size.

All stell members in the floor level in tanks contact with sea water shall be embeed in concrete for min. 450 mm above the fished floor level.

The galvanised wire mesh shall be at 20 mm from the edge or surface of the steel member and shall be held in position securely. The steel, member will have a minimum cover of 50 mm unless otherwise indicated on the drawings. Where the clear cover to steel is more than 75mm, mild steel bar and concrete with 20 mm coarse aggregate can be used.

5.24.1 Controlled Concrete

All concrete in the works shall be "controlled concrete" as defined in IS 456, except for M7.5 and M10 for which nominal mix concrete shall be used. Whether reinforced or otherwise, all concrete works to be carried out under this specification shall be divide into the following classification:

Minimum compressive strength of 15 cm. Cubes at 7 and 28 days after mixing conducted in accordance with I.S. 516						
Class	Preliminary test N/mm ²		Works test N/mm ²		Max. size of aggregate	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	
M35	30.0	44.0	23.5	35.0	20	
M30	25.0	38.0	20.0	30.0	40 or 20	
M25	22.0	32.0	17.0	25.0	40 or 20	
M20	17.5	26.0	13.5	20.0	40 or 20	
M15	13.5	20.0	10.0	15.0	40 or 20	

As indicated in the specifications or as required.

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

Minimum cement content in the concrete used for liquid/ water retaining structure shall be 360 kg/m³ for 20 mm downgraded aggregate and 325 kg/m³ for 40 mm downgraded aggregate.

5.24.2 Mix Design

5.24.2.1 General

This is to investigate the grading of aggregates, water cement ratio, workability and the quantity of cement required to give preliminary and works cubes of the minimum strengths 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 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 mix proportions, over-wet mixes shall always be avoided. While fixing the value for water/cement ratio for preliminary mixes, assistance maybe derived from IS: 456.

The Contractor shall give the Engineer seven days' notice in writing, of the date on which, any of the materials will be ready for testing or inspection at the supplier's premises or at a laboratory approved by the Engineer. The Employer's representative shall attend the test at the appointed place within seven days of the said date on which the materials are expected to be ready for testing or inspection according to the Contractor, failing which the test may proceed in his absence unless instructed by the Engineer to carry out such a test on a mutually agreed date in his or his representative's presence. The Contractor shall in any case submit to the Engineer, within seven days of every test, such number of certified copies (not exceeding six) of the test results as the Engineer may require. Approval by the Engineer, as to the placing of orders for materials or as to samples or tests, shall not prejudice any of the Engineer's powers under the Contract. The provisions of this clause shall also apply to materials supplied under any nominated sub-contract.

5.24.2.2 Preliminary Tests

Test specimens shall be prepared with at least two different water/cement ratios for each class of concrete, consistent with workability 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 proportions 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 Employer's Representative 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 aggregates for each batch shall be determined by weight to an accuracy of 1 part in 1000 parts.

(i) Mixing Concrete

It shall be done by hand or in a small batch mixer as per I.S. 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 colour. 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 minute until the resulting concrete is uniform in appearance. Each batch of, concrete shall be of such a size as to leave about 10% excess concrete, after moulding the desired number of test specimens.

(ii) Consistency

The consistency of each batch of concrete shall be measured immediately after mixing, by the slump test in accordance with I.S. 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 remixed 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.

(iii) Size of Test Cubes

Compression tests of concrete cubes shall be made as per I.S.516 on 15 cm. cubes. Each mould shall be provided with a metal base plate having a plain surface so as to support the mould during filling without leakage.

The base plate shall be preferably attached to 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 $90 +_- 0.5^\circ$. The interior faces of the mould shall be plain surface with a permissible variation of 0.03 mm.

(iv) Compacting

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

(v) Curing

Curing shall be as specified in I.S.516. The cubes shall be kept in moist air of at least 90% relative humidity at a temperature of $27^\circ \pm 2^\circ$ C for 24 hours $\pm 1/2$ hour 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 $27^\circ \pm 2^\circ$ C temperature "until required for test. Curing water shall be always clean without any chemicals and will be renewed every seven days. A record of maximum temperatures at the place of storage of the cubes shall be maintained during the period they remain in storage.

(vi) Testing of Specimens

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 Employer's Representative. The test results shall be accepted by the Employer's Representative if the average compressive strength 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 Employer's Representative 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 requirement specified. All these preliminary tests shall be conducted by the Contractor at his own cost in the approved laboratory.

5.24.3 Proportioning, Consistency, Batching and Mixing of Concrete

5.24.3.1 Proportioning

(i) Aggregate

The proportions which shall be decided by conducting preliminary tests shall be by weight. These proportions of cement, fine and coarse aggregates shall be maintained during subsequent concrete batching by means of weigh batchers conforming to I.S. 2722 capable of controlling the weights within one percent of the desired value. Except where it can be shown to the satisfaction of the Employer's Representative that supply of properly graded aggregate of uniform quality can be maintained over the period of work, the grading of aggregate shall be controlled by obtaining the coarse aggregate in different sizes and blending them in the right proportions.

The different sizes shall be stocked in separate stock piles. The grading of coarse and fine aggregate shall be checked as frequently as possible, as determined by the Employer's Representative, to ensure maintaining of grading in accordance with the samples used in preliminary mix design. The material shall be stock piles well in advance of use.

(ii) Cement

Cement shall be measured by weight.

(iii) Water

Only such quantity of water shall be added to the cement and aggregates in the concrete mix as to ensure dense concrete, specified surface finish satisfactory workability, consistent with the strength stipulated for each class of concrete. The water added to the

mix shall be such as not to cause aggregation of materials or the collection of excessive free water on the surface of the concrete.

(iv) Definition of Water/ Cement Ratio

The water cement (W/C) ratio is defined as the weight of water in the mix (including the surface moisture of the aggregates) divided by the weight of cement in the mix.

(v) Water/ Cement Ratio

The actual water cement ratio to be adopted shall be determined in each instance by the Contractor and approved by the Employer's Representative.

(vi) Proportioning by Water/ Cement Ratio

The W/C ratio specified for use by the Employer's Representative shall be maintained. The Contractor shall determine the water content of the aggregates as frequently as directed by the Employer's Representative as the work progresses and as specified in I.S. 2386 (Part ID) and the amount of mixing water added at the mixer shall be adjusted as directed by the Employer's Representative so as to maintain the specified W/C ratio. To allow for the variation in weight of aggregates due to variation in their moisture content, suitable adjustments in the weights of aggregates shall also be made.

5.24.3.2 Consistency and Slump

Concrete shall be of consistency and workability suitable for the conditions of the job. After the amount of water required is determined, the consistency of the mix shall be maintained throughout the progress of the corresponding parts of the work and approved tests e.g. slump tests, compacting factor tests, in accordance with I.S.1199, shall be conducted from time to time to ensure the maintenance of such consistency.

The following tabulation gives a range of slumps which shall generally be used for various types of construction unless otherwise instructed by the Employer's Representative:

Table 5-1: Slumps for Various Types of Construction

Works Details	Slump in millimeters	
	Maximum	Minimum
Reinforced foundation walls and footings	75	25
Plain footings and substructure walls	75	25
Slabs, Beams and reinforced walls	100	25
Pumps & Miscellaneous Equipment foundations	75	25
Building Columns	100	25
Pavements	50	25
Heavy Mass Construction	50	25

5.24.3.3 Batching and Mixing of Concrete

The materials and proportions of concrete materials as established by the preliminary tests for the mix designs shall be rigidly followed for all concrete on the Works and shall not be changed except when specifically permitted by the Employer's Representative.

Concrete shall be produced only by weigh batching the ingredients. The mixer and weigh batchers shall be maintained in clean, serviceable condition. The accuracy of weigh batchers shall be periodically checked. They shall be set up level on a firm base and the hopper is empty. Fine and coarse aggregates shall be weighed separately. Volume batching will not be permitted. However, the Employer's Representative may permit volume batching by subsequent conversion of the weights of the aggregate into their equivalent volumes knowing their bulk densities, only in the case of small and less important pours involving weigh batching are not likely to be taken up. Concrete shall be of strength stipulated in the respective items. All concrete shall be mixed in mechanically operated batch mixers complying with I.S. 1791 and of the approved make with suitable provision for correctly controlling the water delivered to the drum. The quantity of water actually entering the drum shall be checked with the reading of the gauge or valve setting, when starting a job. The test should be made while the mixer is running. The volume of the mixed material shall not exceed the manufacturer's rated mixer capacity. The batch shall be charged into the mixer so that some water will enter the drum in advance of cement and aggregates. All water shall be in the drum by the end of the first 15 seconds of the specified mixing time.

Each batch shall be mixed until the concrete is uniform in colour, for a minimum period of two minutes after all the materials and water are in the drum. The entire contents of the drum shall be discharged in one operation before the raw materials for the succeeding batches are fed into the drum. Each time the work stops, the mixer shall be cleaned out and when next commencing the mixing, the first batch shall have 10% additional cement to allow for sticking in the drum.

5.25 Mix Design Reinforced Concrete

All water retaining structures shall be designed as per IS3370 part I to IV.

The works under this head covers all activities including raw materials, transportation to site, Reinforced Cement Concrete grades M15, M20, M30, M35, M40 shall be mix design as specified in General Specifications. In case WPC is required to be added (if specified), same shall conform with general specifications in all respects. Admixtures, as specified in General Specifications, shall be added, if directed by Employer's Representative depending on grade of concrete and construction requirements without any extra cost implication. Minimum M 30 grade for buildings and M-35 for Water Retaining Structures shall be used, no grade below the said is permissible. Care shall be taken to ensure proper cleaning and washing of the Drum.

Contractor shall comply with all testing requirements as specified in General Specifications for raw materials and concrete (for all grades of concrete).

5.25.1 Admixtures

5.25.1.1 General

Admixtures may be used in concrete where required, only with the approval of the Employer's Representative based upon evidence that, with the passage of time, neither the compressive strength nor its durability reduced.

Calcium chloride shall not be used for accelerating set of the cement for 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 to exceed 1 1/2 % 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 instructions and in the manner and with the control specified by the Employer's Representative.

5.25.1.2 Air Entraining Agents

Neutralized vinsol resin or any other approved air entraining agent may be used to produce the specified amount of air in the concrete mix and these agents shall conform to the requirements of ASTM standard 6-20. Air entraining admixtures for concrete. The recommended total air content of the concrete is 4% ± 1%. The method of measuring air content shall be as per IS: 1199.

5.25.1.3 Water Reducing Admixtures

Water reducing lignosulfonate admixture may be added in quantities approved by the Employer's Representative. The admixtures shall be added in the form of a solution.

5.25.1.4 Retarding Admixtures

Retarding agents may be added to the concrete mix in quantities approved by the Employer's Representative.

5.25.1.5 Water-Proofing Compound

- i) As directed by the Employer's Representative, the Contractor shall use approved waterproofing compound made by manufacturers as per list of makes herein, Volume-2, Employer's Requirement. In the reinforced concrete works. The quantity to be used shall be two percent by weight of cement or shall be in accordance with the manufacturer's instructions subject however to the approval of the Employer's Representative. The compound shall not contain calcium chloride and shall conform to IS: 2645.
- ii) Mixing water proofing compound with cement. The compound should be mixed thoroughly with the cement by hand before the cement is mixed with aggregate. Thorough mixing is essential. The two materials should be heaped on a mixing board thoroughly turned over several times with a shovel and finally passed through a fine sieve. If labour is unsatisfactory the sieving should be done twice to ensure maximum dispersal of the compound throughout the cement.
- iii) Mixing the concrete - The mixture of water proofing compound and cement should then be added to the aggregate, the dry materials turned over twice and the correct amount

of water then added through a rose spray, A further thorough mixing by spade should immediately follow. Only the minimum quantity of water necessary to give workability should be used such that it will make the concrete just sufficiently plastic for purposes of placing and thorough consolidation without affecting its strength.

5.25.1.6 Corrosion Inhibitors

Corrosion Inhibitors shall be added to concreting for water retaining structures in contact with sea water as well for use of concrete to embed the structural steel.

5.25.2 Concrete in Alkali Soils and Alkaline Water

Where concrete is vulnerable to attack from alkali salts or alkaline water, special cements containing low amount of tricalcium aluminate shall be used, if so specified or directed. Such concrete shall have a minimum 28 days compressive strength of 25 N/mm² and shall contain not less than 3.7 KN of cement per cubic metre of concrete in place. If specified, additional protection shall be obtained by the use of chemically resistant stone facing or a layer of Plaster of Paris covered with suitable fabric, such as jute thoroughly impregnated with tar.

5.25.3 Preparation Prior to Concrete Placement

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 of bottoms of columns and wall forms, to permit removal of saw dust wood shavings, binding wire, rubbish, dirt, etc. Openings shall be placed or holes drilled so that these materials and water can be removed. Such openings/holes shall be later suitably plugged. The various trades 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 embedded to be cast in the concrete as specified or required or as is necessary for the proper execution of the work.

All embedded parts, inserts, etc., supplied by the Corporation or the Contractor shall be correctly positioned and securely held in the forms, to prevent displacement during depositing and vibrating of concrete.

All anchor bolts shall be positioned and kept in place with the help of properly manufactured templates unless specifically waived in writing by the Employer's Representative.

Slots, openings, holes, pockets, etc., shall be provided in concrete work in the positions specified or required or as directed by the Employer's Representative.

Reinforcement and other items to be cast in concrete shall have clean surfaces that will not impair bond.

Prior to concrete placement all work shall be inspected and approved by the Employer's Representative and if found unsatisfactory, concrete shall not be poured until all defects have been corrected.

Approval by the Employer's Representative of any and all materials and work as stated herein

shall not relieve the Contractor from his obligation to produce finished concrete in accordance with the requirements of the specification.

5.25.3.1 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 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 used by rains, the works shall be covered with tarpaulins immediately after the concrete has been placed and compacted before leaving the work ended. 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 is removed. To avoid flow of water over/around freshly placed concrete, suitable drains and sumps shall be provided.

5.25.3.2 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.

5.26 Standards

Materials and workmanship shall comply with the relevant Indian Standards (with amendments) current on the date of submission of the tender. Where the relevant standard provides for the furnishing of a certificate to the Engineer, at his request, stating that the materials supplied comply in all respects with the standard, the Contractor shall obtain the certificate and forward it to the Engineer. The specifications, standards and codes listed below are considered to be part of these specifications. All standards, specifications, codes of practices referred to herein shall be the latest editions including all applicable official amendments and revisions. In case of discrepancy between the Specifications and the Standards referred to herein, the Specifications shall govern.

5.26.1 Materials

- IS:269 Specification for 33 grade ordinary Portland cement
- IS:278 Specification for Galvanized Steel Barbed Wire for Fencing
- IS:383 Specification for coarse and fine aggregates from natural sources for concrete
- IS:428 Specification for distemper, oil emulsion, colour as required
- IS:432 Specification for mild steel and medium tensile steel bars and hard drawn steel wire for concrete reinforcement (Parts 1 & 2)
- IS:455 Specification for Portland slag cement
- IS:458 Specification for precast concrete pipes (with and without reinforcement)

- IS:650 Specification for standard sand for testing of cement
- IS:651 Specification for salt glazed stoneware pipes and fittings
- IS:808 Specification for dimensions for hot rolled steel beam, column channel and angle sections
- IS:814 Specification for covered electrodes for manual metal arc welding of Carbon and Carbon Manganese steel
- IS:1003 Specification for timber paneled and glazed shutters (Parts 1 & 2)
- IS:1038 Specification for steel doors, windows and ventilators
- IS:1077 Specification for common burnt clay building bricks
- IS:1398 Specification for packing paper, water proof, bitumen laminated
- IS:1489 Specification for Portland pozzolana cement (Parts 1 & 2)
- IS:1566 Specification for hard drawn steel wire fabric for concrete reinforcement
- IS:1580 Specification for bituminous compounds for water proofing and caulking purposes
- IS:1786 Specification for high strength deformed steel bars and wires for concrete reinforcement
- IS:1852 Specification for rolling and cutting tolerances for hot rolled steel products
- IS:1948 Specification for aluminum doors, windows and ventilators
- IS:1977 Specification for structural steel (ordinary quality)
- IS:2062 Specification for steel for general structural purposes
- IS:2140 Specification for Stranded Galvanized Steel Wire for Fencing
- IS:2185 Specification for concrete masonry units (Parts 1 & 2)
- IS:2202 Specification for wooden flush door shutters (Parts 1 & 2)
- IS:2645 Specification for integral cement water proofing compounds
- IS:2750 Specification for steel scaffoldings
- IS:2835 Specification for flat transparent sheet glass
- IS:3384 Specification for bitumen primer for use in waterproofing and damp proofing
- IS:3502 Specification for steel chequered plates

- IS:4021 Specification for timber door, window and ventilator frames
- IS:4350 Specification for concrete porous pipes for under drainage
- IS:4351 Specification for steel door frames
- IS:4990 Specification for plywood for concrete shuttering work
- IS:8112 Specification for 43 grade ordinary Portland cement
- IS:9862 Ready mixed paint, brushing, bituminous, black, lead free, acid, alkali, water and chlorine resisting
- IS:10262 Recommended guidelines for concrete mix design
- IS:12269 Specification for 53 grade ordinary Portland cement
- IS:12330 Specification for sulphate resisting Portland cement

5.26.2 Tests

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

5.26.3 Codes of Practice

- IS:456 Code of practice for plain and reinforced concrete

- IS:783 Code of practice for laying of concrete pipes
- IS:800 Code of practice for general construction in steel
- IS:806 Code of practice for use of steel tubes in general building construction
- IS:816 Code of practice for use of metal arc welding for general construction in mild steel
- IS:817 Code of practice for training and testing of metal arc welders
- IS:875 Code of practice for design loads (other than earthquake) for building structures (Parts 1 to 5)
- IS:1081 Code of practice for fixing and glazing of metal (steel and aluminum) doors, windows and ventilators
- IS:1172 Code of practice for basic requirements for water supply, drainage and sanitation
- IS:1477 Code of practice for painting of ferrous metals in buildings (Parts 1 & 2)
- IS:1597 Code of practice for construction of stone masonry (Parts 1 & 2)
- IS:1742 Code of practice for building drainage
- IS:1893 Criteria for earthquake resistant design of structures (Part 1)
- IS:1904 Code of Practice for Design and Construction of Foundation in Soils: General Requirements.
- IS:1948 Specification of aluminum doors, windows and ventilators
- IS:2065 Code of practice for water supply in buildings
- IS:2204 Code of practice for construction of reinforced concrete shell roof
- IS:2210 Code for design of reinforced concrete shell structures and folded plates
- IS:2212 Code of practice for brickwork
- IS:2338 Code of practice for finishing of wood and wood based materials (Parts 1 & 2)
- IS:2394 Code of practice for application of lime plaster finish
- IS:2395 Code of practice for painting, concrete, masonry and plaster surfaces (Parts 1 & 2)
- IS:2470 Code of practice for installation of septic tanks (Parts 1 & 2)
- IS:2502 Code of practice for bending and fixing of bars for concrete

reinforcement

IS:2571 Code of practice for laying in-situ cement concrete flooring

IS:2595 Code of practice for radiographic testing

IS:2751 Recommended practice for welding of mild steel plain and deformed bars for reinforced construction

IS:2974 Code of practice for design and construction of machine foundations (Parts 1 to 4)

IS:3114 Code of practice for laying of Cast Iron pipes

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

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

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

IS:3658 Code of practice for liquid penetrant flaw detection

IS:3935 Code of practice for composite construction

IS:4000 Code of practice for High strength bolts in steel structures

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

IS:4111 Code of practice for ancillary structures in sewerage system
(Parts 1 to 4)

IS:4127 Code of practice for laying of glazed stoneware pipes

IS:4326 Code of practice for Earthquake Resistant Design and Construction of Buildings

IS:4353 Recommendations for submerged arc welding of mild steel and low alloy steels

IS:5329 Code of practice for sanitary pipe-work above ground for buildings

IS:5334 Code of practice for magnetic particle flaw detection of welds

IS:5822 Code of practice for laying of welded steel pipes for water supply

IS:7215 Tolerances for fabrication of steel structures

IS:9595 Recommendations for metal arc welding of carbon and carbon manganese steels

IS:10005 SI units and recommendations for the use of their multiples and

of certain other units

5.26.4 Construction Safety

IS:3696 Safety code for scaffolds and ladder (Parts 1 & 2)

IS:3764 Safety code for Excavation work

IS:7205 Safety code for erection of structural steel work

IS:3696 Safety code for scaffolds and ladder (Parts 1 & 2)

IS:3764 Safety code for Excavation work

IS:7205 Safety code for erection of structural steel work

5.27 General Arrangement of Plant

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

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

5.27.1 Buildings and Structures

All the building and structure works shall generally comply with the following requirements, unless otherwise specified elsewhere.

1. All building works shall be of reinforced concrete framework.
2. All external walls shall be in solid cement concrete blocks or brick masonry. Concrete Blocks shall be provided as per IS:2185 (Latest Revision) and shall be 200 mm thick or Brick masonry with one Brick wall thick (230 mm). Solid Concrete blocks shall have minimum compressive strength of 5 N/mm².
3. All internal partition walls shall be in solid concrete blocks or brick masonry. Concrete block shall be provided as per IS:2185 (Latest Revision) or Brick masonry with Half Brick thick (115 mm). Solid Concrete blocks shall have minimum compressive strength of 5 N/mm². All internal walls shall be 200/230mm thick except for toilets. Toilet partition walls shall be in 100/115 mm thick solid concrete block/brick.

4. (a) Finishes to concrete liquid retaining structures shall be:
F2 External surfaces, buried
F3 External surfaces exposed and up to 300 mm below ground level
F2 Internal surfaces
(b) Finishes to other concrete structures shall be:
F2 Buried
F2 Exposed, where plastering is specified
F3 Exposed
5. All internal masonry surfaces finish shall have 12 mm thick plain faced cement plaster in cement mortar (1:4) with neat cement finish on top. Over this, one coat of primer and two coats of plastic emulsion paint of approved quality and shade shall be provided.
6. All external masonry surfaces and concrete surfaces with rough board finish shall have 20 mm thick sand faced cement plaster in two coats, base coat 12 mm thick in cement mortar 1:4 and finishing coat 8 mm thick in cement mortar 1:4. Waterproofing compound of approved make and quality shall be added to the cement mortar in proportions as specified by the manufacturer.
7. All external surfaces above ground level shall have one coat of primer and two coats of waterproof cement based paint of approved quality and shade. A coat of silicone water repellent paint shall also be applied thereon or as advised based on site condition by the Engineer.
8. Toilet areas, internal walls tiled up to 1.5m and rest and ceilings, shall have one coat of primer and two coats of plastic emulsion paint.
9. Toilet floor slab shall be filled with brick bat coba (broken bricks in lime) and provided with waterproofing as per the specifications of an approved specialist waterproofing company.
10. The finished floor level in toilet areas shall be 25 mm below general finished floor level elsewhere in the building.
11. The flooring in all other areas except control building, chemical building, store building, pump station buildings and toilets and staircases shall be in 450 mm x 450 mm x 25 mm thick polished Kota-stone of approved shade and pattern and placed in cement mortar to give overall thickness of 50 mm. Half tile skirting shall also be provided in these areas.
12. The flooring along with skirting in administration and control building shall be 20 mm thick mirror polished, machine cut granite slab of approved shade and pattern placed in cement mortar (1:4). Skirting for 150mm height shall be provided in these areas. Granite stone shall be provided for laboratory platforms fixed over double sandwiched cuddappah support as directed and the edges of granite is to be embedded into the wall.
13. The flooring in chemical building shall be of ceramic unglazed vitreous acid resisting tiles.
14. Pumping station buildings shall have cement concrete flooring with surface hardener.

15. All Chemical buildings shall have heavy-duty abrasion resistant tile flooring.
16. Toilet areas shall have glazed ceramic vitrified tiles placed in cement mortar 2000 mm high dado, in 150 mm x 150 mm x 6 mm thick glazed tiles placed in cement mortar shall also be provided in these areas.
17. The toilet facilities in control building shall include at least:
 - (i) 2 Nos. water closets with white porcelain European pan minimum 580 mm long with flushing cistern of 10 liters capacity.
 - (ii) 2 Nos. urinals of sizes 600 mm x 400 mm x 300 mm flat back type in white porcelain separated by a marble partition of size 680 mm x 300 mm with flushing water piping with water taps.
 - (iii) 2 Nos. wash basins of size 510 mm x 400 mm in white porcelain with inlet, outlet and overflow arrangements.
 - (iv) 2 Nos. mirror of size 400 mm x 600 mm wall mounted type fitted over wash basins.
 - (v) 2 Nos. plastic liquid soap bottles
 - (vi) 2 Nos. chromium plated brass towel rails minimum 750 mm long.
 - (vii) All stopcocks, valves and pillar cocks shall be heavy duty chromium plated brass.
 - (viii) All fittings such as 'P' or 'S' traps, floor traps, pipes, downtake pipes etc.
 - (ix) The sewage from toilet blocks shall be led to STP.
18. In control building a canteen facility shall be provided with a washbasin, a sink, required electrical points, exhaust fan, an electric water heating pot, a micro-oven and a fridge as a minimum.
19. All staircases except in the buildings, shall have 25 mm thick polished Kotastone tiles for treads and 25 mm thick of approved shade for treads & risers set in cement mortar or lime mortar to give an overall thickness of 50 mm. Stairways with 1.5 m width shall be provided to permit access between different levels within buildings. All roof tops and overhead tanks shall be made accessible with ladder provision with SS316 hand rails. Vertical ladders fitted with landing point extensions will be permitted where approved by the Engineer to access areas not frequently visited. Plaster encapsulated Cast Iron/ GRP rungs or steps shall be provided on the inner side walls of all the water retaining structures at 300mm spacing.
20. All floor cut-outs and cable ducts, etc. shall be covered with precast concrete/GRP covers in outdoor areas and epoxy costed mild steel chequered plates of adequate thickness in indoor areas. All uncovered openings shall be protected with GI pipe hand railing 32 mm GI inside dia medium class with approved paint.
21. All staircases shall be provided with Stainless Steel 316 hand railing for protection. In existing structures damaged hand railing shall be replaced.
22. The reinforced concrete roofs shall be made waterproof by water proofing as approved by the Engineer. The finished roof surface shall have adequate slope to drain quickly the rain water to R.W down take inlet points.

23. For roofing drainage, cast iron rainwater downtake with C.I/uPVC. bell mouth and C.I./uPVC grating at top shall be provided. For roof areas up to 40 sq.m minimum two nos. 100 mm diameter downtake pipes shall be provided. For every additional area of 40 sqm or part thereof, at least one no. 100 mm dia. downtake pipe shall be provided.
24. Top surfaces of chajjas and canopies shall be made waterproof by providing a screed layer of adequate slope and sloped to drain the rain water.
25. Building plinth shall be minimum 450 mm above average finished ground level around building. Wherever cable trench shall be provided below the electrical panel, Bottom level of the cable trench shall be 100mm above the plinth level.
26. All doors, windows, rolling shutters shall have lintels above. Chajja protection to lintels on external walls shall be such as to prevent the rain water splashing into the building. Chajja projection of minimum 750 mm for rolling shutters, 600 mm for doors and 450 mm for windows shall be provided to prevent the rain water splashing into the building. Chajja shall be projected 250 mm on either side from size of doors/windows/rolling shutters.
27. All windows and ventilators shall have 25 mm thick Granite stone sills bedded in cement mortar (1:3) or 38 mm M15 RCC with 8mm dia or as per flooring material.
28. All doors, windows and ventilators shall be made of aluminium conforming to the latest version of IS:1948. All fixtures for doors, windows and ventilators shall also be of aluminium and shall be provided as per IS specifications. Aluminium grills shall be provided in all the windows. Doors shall be in two panel and both panels shall be glazed/un glazed. SS wire mesh shall be provided along with aluminium grills.
29. Openings of the windows & ventilators shall be minimum 25% of the wall area.
30. Ventilator shall also be provided where height of floor is more than 3m. All windows and ventilators shall have SS wire mesh. Frame of doors, windows and ventilators shall be of aluminium of standard rolled section. Doors, Windows and Ventilators shall be of size as per schedule to be submitted by the Contractor for approval of the Engineer. The minimum size shall be as per below:

Door of opening size 1.2m x 2.1m

Door of opening size 0.75m x 2.1m for toilets

Glazed windows of minimum size 1.2m x 1.2m

Ventilators of minimum size 0.6m x 0.6m

31. Rolling shutters shall be made of 80 x 1.25 mm MS laths. Rolling shutter shall be of minimum size 3m wide x 3.0m high. Rolling shutter shall be provided in MCC cum panel room, all chemical buildings, at entry and exit of the pump house for access to pumps, motors, valves, panels and as wherever required.
32. All structural steel members shall be painted with two coats of suitable epoxy paint over one shop and one field coat of red oxide zinc chrome primer.
33. All concrete channels and ducts used for conveying liquid shall have inside finish of type F2. The width of concrete channels shall not be less than 500 mm. All open

channels shall be provided with Type 304 stainless steel hand railings.

34. Kerbs to be provided below the hand railing on the catwalks/pathways should be as per relevant sections of Factory Act.
35. All rooms in the treatment plant buildings shall be provided with appropriate sign boards of approved material indicating the function of the rooms involved.
36. Wherever equipment and machinery are to be moved for inspection, servicing, replacement etc., suitable movable gantry of minimum capacity of 2 tonnes or more as required shall be provided with monorail and operating equipment.
37. The design of buildings shall reflect the climatic conditions existing on site. Process buildings shall as far as possible permit the entry of natural light, and the use of glazed panelling shall be kept to a minimum and preference given to wall openings protected by weather canopies.
38. Emergency exit doorways and safety features shall be provided from all buildings in order to comply with local and international regulations. Stairways and paved areas shall be provided at the exit points.
39. Toilet blocks in process buildings and control blocks shall be provided with a sink with two drinking water taps of 20 mm size with adequate inlet and outlet connections.
40. The side walls of buildings shall, except those used for storage and handling of chlorine, comprise at least 15% ventilated brickwork or louvers. Ventilated brickwork or louvers shall not be used where the ingress of driven rain could affect plant or stored materials. Flat roofed areas shall be provided with roof vents to further encourage a through flow of air.
41. All the walkways shall have minimum 1.0 m width and shall be covered with cement chequered tiles.
42. Hand railings shall be 38 mm pipe made up of SS316. Height of railing not less than 1100mm. The distance between 2 vertical posts shall not be more than 1.8 metres. This shall also match with existing hand railing.
43. All the buildings shall have adequate Lighting provision with Solar panel system as per drawing proposed and also the streetlights with adequate Lighting facilities supported by Solar Lighting and even for Parks and Garden and around Boundary walls and fence in The Plant lay out as per Drawings proposed.
44. All Other facilities shall be as per the drawings proposed for approval for firefighting , burglar intrusion alarm system, inside and outside plant with adequate Video Monitoring system, vehicle parking and service maintenance and workshops and lay down area .
45. Adequate rest shelters for the workers during hot days with toilets, bathrooms and dining area shall be provided as per the IS codes standards.
46. Adequate safety facilities and speed breakers for the road with signs and signals and integrated vehicle monitoring system with USB control for the vehicles shall be

provided for safe drive and at the Entrance Safety Statistics and importance of water logo board will be made for the value based information for the Desal Plant. All other additional facilities shall also be provided as per drawings approved by the Engineer.

5.27.2 Roads, Pathways & Hard standings

A comprehensive network of roadways shall be provided around the site and permit access to the plant for necessary maintenance, delivery of consumables and personnel access. All roads shall be of asphalt macadam and minimum 9 meters wide for the main roads and minimum 6 meters wide within the blocks of pre-treatment and RO/post-treatment as indicated in the attached plant layout. Vehicular access shall be provided for all Plant structures and buildings. All roads shall be provided with drainage and shall be constructed to prevent standing water. All roads shall have adequate Road Markings and traffic marking and signs with speed limit and shall strictly follow industry norms. All the roads will have adequate lighting facilities with Solar panels and electricity for stand by optional so as to save electricity consumption as per drawings proposed .All roads shall be as per Drawings proposed and approved by the CMWSSB / Client .

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

Hard standing areas shall be provided to permit the parking of vehicles involved in the delivery of consumables from blocking site roadways during unloading or loading. The road system shall be designed such that vehicles involved in the delivery of consumables can follow a continuous route through the works and out again without the need to reverse or carryout complicated maneuvers in order to exit the site. All the roads will have adequate lighting facilities with Solar panels and standby electricity optional so as to save electricity consumption.

5.27.3 Site Drainage

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

- Storm Water Drainage
- Foul Drainage
- Process Drainage

All wastewater after treatment shall be drained in the plant Outfall Tank for discharge to the sea.

5.27.3.1 Storm Water Drainage

Storm water drains adjacent to the existing and proposed roads (under this Contract) shall be sized for a rainfall intensity of minimum 50 mm/hr, allowing for 100% runoff. Drains adjacent to roads shall be either with RCC floor and walls in M-20 concrete with minimum 150 mm

thickness or in stone masonry (1:4) of appropriate thickness, topped with 75 mm thick M-15 concrete and 20mm thick plaster on internal surfaces in cement mortar (1:4). The minimum width of drain shall be 450mm wherever not existing and needed.

The storm water drainage system shall be designed to cater for the run-off from the existing water plants treatment areas and structures. Sufficient slope shall be provided to drain the rainwater in the Outfall tank considering maximum precipitation without any logging.

5.27.3.2 Foul Drainage

The foul drainage system shall accept discharge from toilets, washrooms, offices and the laboratory. The foul drainage system shall be directed to the sewage treatment plant provided by the Contractor for appropriate capacity as indicated in the Part-2, A3 document. The rainwater and treated domestic water shall be used for toilet flushing and irrigation around the plant site.

5.27.3.3 Process Drainage

Under this project, all the wastewaters at the plant including backwash wastewater from the Dual Media Filters will be directed to the Outfall Tank for discharge to sea. No discharge will directly go to the sea. All wastewaters (domestic and industrial) must be treated first to meet the surface discharge requirements as per the concerned regulatory guidelines before discharge to the sea via the outfall tank. The Contractor shall plan the pipeline alignment, draw longitudinal section of the pipeline showing the ground levels, pipe invert levels etc., and get approval from the Engineer prior to start of the work.

The Contractor shall provide all the services including interconnections of the drain pipes, site clearance with cutting of the trees, shrub etc. coming in the drain line alignment, excavation to the required level for the pipeline, bed preparation including required bed strengthening, laying and jointing of the pipeline, back filling etc. Manhole chambers shall be provided at every junction and bends and at 45 m interval on straight reaches.

5.27.4 Cable and Pipe-work Trenches

Cable and pipe-work trenches shall be constructed in reinforced concrete. However, 500 mm x 500 mm size or smaller trenches, not on fill may be constructed in Bricks/Concrete Blocks. The trenches shall be plastered internally with cement mortar (1:4) and externally in cement mortar (1:3).

Trenches within the buildings shall be covered with Fibreglass / Hot Dip Galvanized MS chequered plates, and those outside the buildings shall be covered with M30 precast R.C.C or more suitable material as per the consent of the Engineer. The trenches shall be suitably sloped to drain rain water.

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

5.27.5 Pipes and Ducts

Reinforced concrete ducts/pipes for drainage shall have a minimum 1 metre cover while laid under roads. Access shafts of suitable size shall be provided. All drains shall be covered with precast reinforced concrete slab and designed structurally for appropriate loads. All interconnecting piping and channels in the plant shall be as per the requirements and as per specifications.

5.27.6 Valve and Flow meter Chambers

All the valves and flow meters shall be placed in the chambers as much as possible so that the ground surface remains available for free movement. The chambers are to be of adequate size to facilitate maintenance and operation. The base slab of chambers shall slope to drain the water to the common drain line or towards a sump pit from where water can be pumped out to a drain line to keep the chamber dry. The top of the valve chamber shall be 300mm above the FGL. All chambers shall be constructed in M20 reinforced concrete. Chambers shall have removable cast iron / reinforced concrete covers, as appropriate, with approach ladders and supports.

5.27.7 Pipeline Material

Due to saline environment, GRP/HDPE pipes of suitable schedule shall be used for the process at the plant. The use of mild steel pipelines shall be avoided and wherever provided in the plant with the consent of the Engineer shall be submerged arc welded with steel grade of Fe 410, conforming to IS:3589. The pipes shall have internal epoxy coatings and external polyurethane and epoxy coatings as approved by the Engineer. Polyurethane coatings shall be provided in 2 coats with total thickness not less than 500 microns over suitable primer coat. The thickness of pipes shall be adequate for internal pressure and external loading including live loads. In no case the thickness shall be less than the minimum specified in IS:3589.

5.27.8 Landscaping

The site shall be landscaped once the Works are substantially complete. Landscaping area shall be marked in layout plan. Landscaping shall include planting of suitable trees and development of grassed areas. Landscaping in general shall meet ecological and environmental conditions of the Site. Road widths shall determine the size of the tree height and spread to be selected for planting. Trees suitable for local conditions shall be selected. Plantation shall be started just after approval of the plant layout so that the plants become of good size at the completion of the capital works and start of the production at plant. Medicinal and fruit trees shall be avoided. Landscaping shall be maintained in good condition until the completion of Contract.

5.27.9 Tree Planting

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

5.27.10 Hydraulic Testing of Liquid Retaining Structures

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

On completion of the structure and before its commissioning, the contractor shall carry out a water tightness test for the maximum water head condition with the water standing at full supply level (FSL). This test shall be carried out preferably in dry season in accordance with the procedure given below.

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

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

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

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

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

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

and the Contractor shall dismantle and reconstruct the structure, to the original specification, at his own cost.

During testing and during defect liability period the impression marks created due to seepage shall be rectified and made good. No separate payment shall be made for water tightness test and the cost thereof shall deem to be covered in the rates quoted for the works.

5.27.11 Non Destructive Testing of Reinforced Concrete Structures

Non-Destructive Testing (NDT) such as Rebound Hammer /Ultrasonic Pulse Velocity test or any other approved test shall be carried out as per latest IS:13311 codes as per the instructions given by the Engineer.

5.27.12 Site Clearance

The Contractor shall cut the trees, remove the shrubs and grass prior to marking the plant layout on the ground. Prior to cutting of the trees, permission of the concern authority as needed must be obtained by the Contractor for which required official help may be extended by the Engineer. Counting of the trees shall be done by the Contractor in presence of the Engineer's Representative. The cut trees shall be handed over to the CMWSSB. The Contract cost shall cover the job of site clearance as required and no separate payment shall be allowed against this job.

5.28 MATERIALS

5.28.1 CEMENT (ORDINARY AND PORTLAND)

All Portland Cement for use on the works shall comply in every respect with requirements of the Indian Standard Quality of Cement Specification for Portland Cement as issued and amended from time to time by the Indian Standards Institution. The Portland Cement used in the works shall be manufactured in India and shall be of a make and quality to be approved by the Engineer.

No other make/grade of cement, but that approved by the Engineer will be allowed on the works and the contractor shall not change his source of supply without the approval of the Engineering in writing.

Tests ⇒ Produce test certificates to show that the cement is fully up to the specification and notwithstanding this, the Engineer may at his discretion order that the cement delivered on the work and which he may consider damaged or of doubtful character for any reason whatsoever, must be retested by approved testers and fresh certificates of its soundness produced by the contractor at his sole cost. Cement ordered for re-testing shall be withdrawn from the work pending the results of re-testing. The decision of the Engineer in this respect shall be final binding on the Contractors.

Stores ⇒ Large stock of cement shall not be kept at the works but sufficient quantities to ensure continuity of the work. The contractors shall provide and maintain proper

and sufficient storage sheds for the cement on the works. The floor of the stores shall be raised at least 9" from the ground in order to protect the bags from moisture. No cement damaged exposure or otherwise will be allowed to be used in work, but shall be removed at once from the site.

Packages ⇒ the cement shall be supplied in sound and properly secure sealed bags, weighing (1 bag) 50 kg. Net. The rates entered in the Bill of Quantities and Rates shall be held to include the cost of haulage to the work housing and protecting from the weather, risks of every kind and all expenses connected with preparing the cement for use and with using it in the work.

5.28.2 Sand

All the sand aggregate shall consist of clean, hard, strong, durable quality of river sand / M-Sand uncoated, well-graded particles when incorporated in the concrete mixture, the fine aggregate shall be free from frost, frozen lumps injurious amounts of dust, mica loam or other deleterious substances.

The sand shall be of river and taken from a source approved by the Engineer. If the Engineer considers it necessary, it shall be washed. The cost of washing must be included in this price for the concrete work. In case of non-availability of the river sand, Manufactured Sand (M-sand) from Quarry may be used after the Engineer's approval.

All sand shall pass through a sieve having meshes not more than (1/4" inch) 6 mm. Wide and if the Engineer shall require it, it shall be screened before use at the expense of the contractor. In no case shall fine aggregate be accepted containing more than two percent, dry weight, not more than three and half percent by dry volume of clay, loam or silt. If any sample of fine aggregate show more than five percent of clay, loam silt in one hour's settlement, after shaking in an excess of water, the material represented by the sample will be rejected. If necessary, silt test shall be taken by the Engineer.

All fine aggregate shall be stored on the works in such a manner as to prevent the intrusion of foreign matter. The fine aggregate shall conform to IS 383 (latest).

5.28.3 Coarse Aggregate

The whole of the ingredients of the coarse aggregate shall be Quality coarse consisting of crushed rock, gravel or other aggregate material. The particles of coarse aggregate shall be clean, hard, tough, durable material, free from vegetable or other deleterious substances and shall contain no soft flat or elongated pieces. All coarse aggregate shall be stored on the works in such a manner as to prevent the institution of foreign matter. If it is considered necessary, the Engineer may order it to be washed and screened. The contractor shall state in his tender the source from where he will obtain the aggregate and he shall also include in his price the cost of washing. If screening is necessary and the cost shall be borne by the contractor.

The coarse aggregate shall consist of the following as per IS 383:

Grading of Coarse: 1.

1	Metal No.2	$\frac{3}{4}$ " to 1"	20 to 25 mm. Aggregate
2	Metal No. 1	$\frac{1}{4}$ " to $\frac{1}{2}$ "	6 to 12 mm

The whole of the aggregate shall all pass a screen having meshes not greater than 1" (2.54 cm.) square and shall be retained on a screen having meshes $\frac{1}{4}$ " (6.35 mm) square. The materials may be tested for voids before the work is commenced and at intervals during the coarse of construction, as may be necessary and the proportion of the different grades in the coarse aggregate fixed by the Engineer so as to secure a well graded material varying from (1/4" to 1") 6.35 mm to 25.4 mm. The different grades of the coarse aggregate shall be measured by means of suitable boxes and in such proportion as may be approved by the Engineer.

5.28.4 Water

The water shall be clean and free from injurious amounts of oil, acid, alkali, organic or other deleterious substances, salt etc. The quality of water added to the materials for making concrete shall be properly under control and must be measured.

5.28.5 Reinforcement

The steel to be used in reinforced concrete work shall comply with the requirements of Indian Standard Specification I.S. No. 43 (Latest) for saline water use and refer IS Code 1786-2008 .IS-2062-2011.

If any steel does not in the opinion of the Engineer comply with any of the tests specified for the saline water environment, the Engineer may reject the lot or lots from which the sample or samples taken and the same shall not be used on the works but shall be removed from there.

All steel used for reinforcement shall be free from loose scales or rust, which must be removed with a stiff wire brush. Bars must also be free from oil or paint. The steel should be properly braced, supported and otherwise held in position strictly according to the contract and plans. This shall be looked after with proper care and checked over by a competent foreman personally and finally before pouring the concrete.

5.28.6 Polymers

The polymer modifier shall be a modified acrylic based compound suitable for use in marine environment. The product shall have minimum solids of 40% \pm 2%. The polymer shall be capable of being used both as a bonding agent having a pull off bond strength not less than 1 Mpa and also as an additive for preparation of polymer modified repair mortar.

5.28.7 Coal Tar Epoxy

It shall be high build pitch extended epoxy coating and shall be 100% solids, solvent free, tough abrasion resistant coating.

The product shall exhibit excellent bond strength with substrate exceeding 2.5Mpa as per ASTMD4541.

The product shall be formulated to have high build thickness exceeding 150 microns per coat on average to achieve overall thickness of 300 micron in 2 coats.

The product shall be formulated to resist exposure to accelerated weathering test as per ASTMD4587 and shall not exhibit any flaking or blistering.

5.28.8 Epoxy

The Non Toxic High build epoxy coating shall be solvent free, taint free, potable grade protective coating. The product shall exhibit bond strength exceeding 1.5Mpa tested as per ASTMD4541. Product shall be formulated to have a thickness of 200 microns per coat on average to achieve overall thickness of 400 microns in 2 coats. Product shall be approved by CTRI (Clinical Trials Registry of India) for use in contact with product water.

5.28.9 Waterproofing Membrane

Self-adhesive elastomeric SBS (Styrene-Butadiene-Styrene) bitumen based waterproofing membranes with high mechanical performance polypropylene mesh, finish of upper side and easily removable silicone film on underside. Thickness of membrane shall be minimum 1.5mm.

5.28.10 Polypropylene Fibres: (For Concrete work / Mortar Work)

The material shall be virgin high tenacity polypropylene mesh fibre and multifilament combination in 10mm length for use in water retaining structures concrete work.

Dosage should be minimum 125gms/bag of concrete as per specified dosage of Consulting Engineer.

The fibres shall be Alkali and Acid resistance, non absorbent, and chemically Inert having a density of 0.93gms/cc and should conform to ASTM C-1116. Lengths of strands shall be 10mm blended for plaster work Dosages shall be 100g/bag of cement.

5.28.11 Glass Fibres

The Glass fibres shall be Alkali Resistance Glass fibre specially developed for Cementitious Mortars and Concrete Mixes.

They shall be monofilament having diameter of 14μ and a specific gravity of 2.6, length 12mm and an Aspect ratio of 857:1 and a specific surface area of $105m^2/Kg$.

Dosage shall be minimum = 85g/per bag of cement but to be decided by the Employer's Representative.

5.28.12 Plasticizers

The liquid integral waterproofing shall be a ligno-sulphonate Polymer based waterproofing cum plasticizing admixture. The product shall comply with IS 2645:2005 when tested at a dosage of 100ml/50 kg bag of cement. The product must be free of chlorides and shall have a specific gravity of not less than 1.15 and shall comply to ASTM C 494 type A & D.

5.28.13 Pre-packed Ready-Made Plasters

The Prepacked ready-made plasters shall be coarse / fine water resistance mortar for internal / external use.

The blend shall be made of fillers which are silt free precisely graded sand with OP cement as binder and additives to improve workability water retention durability and adhesion of mortar.

The blend shall have PP (poly-propylene) fiber in proportion not exceeding 125gms / 50kg cement and fly ash not exceeding 25% as substitution of cement.

5.28.14 Expansion Joint Sealing Tape

The joint shall be treated with a highly elastic (having elongation > 600%) and share a hardness of 80 with special epoxy as adhesives. The expansion tape shall be supported by single component gun graded quality PU (poly-urethane) sealant followed by a backing material of polyethylene.

Width of expansion joints shall not exceed 150mm. Thickness of joint sealing tape shall be minimum 2mm.

The tape shall have tensile strength exceeding 6Mpa and resistance to cracking exceeding 600N/cm when tested as per DIN 53363.

5.29 SURGE CONTROL SYSTEMS

5.29.1 Design of Control System

Surge analysis for the sea water intake and pure water main, along with the design and provision of the required surge protection devices, shall be the responsibility of the Contractor. The surge control systems shall be designed so as to ensure that:

- the maximum residual surge shall be restricted to 10% of the maximum surge which would have developed without the surge control devices at any point in the pipeline or 10% of the design pump head, whichever is more; and
- the vacuum pressure developed in the pipeline at any place shall be restricted to -3 m (minus 3 meters); and
- the surge protection system provides adequate protection against damage for the valves, pipe delivery systems and pumps.

The surge analysis and design for surge protection system shall be got done from the Indian Institute of Science, Bangalore, or any other qualified agency approved by Employer's Representative. The detailed designs and drawings of the surge protection system shall be submitted for the approval of the Employer's Representative, but any such approval shall not relieve the Contractor from his responsibility for the safety of the system.

The feasible surge protection system in such a case shall be in the form of one way surge tanks, surge shaft, air vessel or any other better system as approved by the Employer's Representative, or any other better system suggested by Contractor and acceptable to the Employer's

Representative.

The Contractor shall also check the requirements for any protection devices downstream of the pipelines away from the intake to control negative pressures. The design shall be suitable to cater to the space requirements for the surge protection systems and the size of the available spaces.

The design agency shall finalize all particulars of the surge control system and submit calculations, including the number and capacity of air vessels, surge shafts, orifice plate diameters, interconnection details with pumping main, etc., depending on the adopted system. The detailed specifications for the proposed surge protection system along with designs shall be submitted for approval from the Employer's Representative.

The equipment used for the surge protection system must be procured from manufacturers who have previous experience of manufacturing such systems. The manufacturer shall submit certificates of test results for at least two systems manufactured and installed by him with for pumping mains of not less than 2000 mm diameter. For air vessels, the manufacturer must produce test results on at least two completed schemes with volume of the vessel recommended by the contractor and acceptable to the Engineer. In case of the surge shaft/tanks, all valves used shall be of reputed and accepted makes with proper opening characteristics.

5.29.2 Pure Water Surge System

The Contractor is cautioned that the constraints for installation of surge tanks/ pressure vessel are particularly severe in the pure water system. The pipeline to be protected is to be laid above ground on pedestals in the initial stretch, detached from the road. Besides this, space for laying and jointing of the pipeline and connecting the pipeline to the surge tank is restricted and constrained by the topography.

5.29.3 Technical Specifications for Air Vessel System

The technical specifications provided herein cover surge control systems with air vessels. This, however, is not intended to imply that a surge control system using air vessels is the best or only alternative to be considered; the Contractor will be fully responsible to analyze the requirements and recommend the type of surge control systems that are the most suitable and effective for the pure water pumping systems. In case any alternative surge protection system is recommended by the designer, he shall also submit the detailed specifications of the same for approval from the Employer's Representative.

5.29.3.1 Air Vessel - General Specifications

Air vessels should be suitable to take care of the water hammer/ pressure surges which may occur in the pipeline systems on which they are proposed. The air vessels shall be manufactured out of MS plates as per IS 2062. The nozzles shall be seamless conforming to SA 106 Grade B. Flanges up to 250 NB shall be of weld neck type of forged quality conforming to SA 105. The design and fabrication will be carried out as per latest version of IS 2825. At least 10% of the weld joints on the vessel shall be spot radio graphed. 100% of the weld joints, if any, on the dish shall be radio graphed. Air vessels will be provided with manholes and water outlets at the

bottom, which will be connected to the rising mains along with an isolating valve and a differential orifice. Suitable drains are to be provided for maintenance. Air vessels will have standard fittings such as pressure relief valve, visual level indicators, control circuit inlets and outlets, etc., with isolating valves. Inspection for air vessels shall cover welding qualifications, radiography / UT / PT/ MT as applicable, Stage/ in-process inspection, and hydro/ leak tests.

Two air compressors shall be supplied along with each air vessel. These compressors will be operating at a slightly higher pressure than the pressure in the water main, and compressed air will be stored in the receiver from which requisite supply will be made to the air vessel. Inspection of compressors shall cover dimensional checks for mounting and overall dimensions, performance tests, and hydraulic leak tests.

The air vessel and air receiver will be painted internally and externally with zinc rich food grade epoxy paint.

The following additional equipment will be supplied as standard accessories for each air vessel:

- Receiver with compressor, with automatic on/off system.
- Visual water level indicator, covering full height or length of the air vessel.
- Isolating and drain valves for maintenance purpose

5.29.3.2 Surge Suppression System

The automatic control system shall be generally as described below. Contractor may propose alternative arrangement.

The surge protection system shall comprise of air compressors, common air receiver, surge vessel, field instruments and control panel with facilities for alarm annunciation and for operation and monitoring of compressor and air inlet valves of surge vessels. The surge vessels shall be connected with the common air header from the air receiver and at the base to the pumping station discharge header via the buffer manifold. The air inlet pipe to the surge vessels shall be provided with electrically / pneumatically operated valves to control air input to the surge vessels and an electrically / pneumatically operated valve to control air release from the surge vessel. For controlling the water level within the surge vessel, the vessel shall be provided with a conductivity type level switch. For continuous monitoring of water level within the surge vessel, capacitance type level measuring system shall be provided. A magnetic liquid level gauge shall also be provided to permit the visual monitoring of the water level in the surge vessels. The surge vessels shall be provided with safety air relief valve.

The electrically / pneumatically operated air inlet valve shall be provided in the air inlet line of the surge vessels to permit the entry and release of air from the surge vessels. Hand operated valves shall be provided in parallel with these valves for manual control of air addition and release.

5.29.3.3 Normal Operation

- The surge vessels are filled with water to a given level that is within a working level band. Air is added to the top of the surge vessels to act as a cushion and maintains the

water level in the surge vessels within the working band. During normal operation, air will slowly dissolve in the water causing a gradual rise of the water level in the surge vessels.

- The mean working level (i.e. between upper working level and lower working level) is maintained constant by allowing more air from the compressor air receiver to enter the surge vessels.
- When the pumps stop supplying water to the discharge header (due to normal stopping, tripping, power failure, etc.) the non-return valve at the pump outlets will close. The water column continues to move away from the pumping station and in doing so will create a negative pressure in the discharge header.
- Water from the surge vessels is drawn into the discharge header through the surge non-return valve in order to limit the magnitude of this negative pressure and in doing so prevent damage to the pipe-work. When water column reverses water enters the surge vessels through the NRV bypass line and the air in the surge vessels is compressed providing a cushioning effect to the returning water column. Energy of returning water column is absorbed due to compression of the air.
- The water level in the surge vessels shall be maintained within the working band during steady state pipeline flow conditions. The steady state water level in the surge vessels shall be maintained between the upper and lower working level settings.
- The limits of the bands between upper and lower working levels shall be fine tuned during commissioning.
- The status of the surge protection system and associated alarms shall be monitored at the ICP (Instrumentation and Control Panel).
- The starting and stopping of the compressor shall be automatic with a manual override facility. The compressor shall start when there is a low air pressure in the associated air receiver and stop when the required air pressure is reached. Separate pressure switches shall be provided on air receiver for starting and stopping of compressor. The air receiver shall be provided with pressure gauge and safety relief valve.
- Conductivity type level switches shall be provided for monitoring the following levels in the surge vessel:
 - Upper emergency level
 - Upper working level
 - Mean working level
 - Lower working level
 - Lower emergency level
- The level switches shall be provided on the 'stand pipe' of the surge vessel. When the level in the surge vessel reaches the 'upper working level' and remains there for certain duration of time (adjustable), the pneumatic/ electric operated air inlet valve shall open.

The valve shall close when the 'mean working level' is reached.

- When the level in the surge vessels reaches the 'lower working level' and remains there for certain duration of time (adjustable), the pneumatic/ electric operated air release valve shall open. The valve shall close when the 'mean working level' is reached.
- An orifice plate shall be provided to restrict the rate of air release to ensure restoration of the mean working level within approximately 30 minutes (to be decided during commissioning).
- A silencer shall be provided on the discharge to limit the noise made by air release. When 'upper emergency level' and 'lower emergency level' are detected by conductivity level switch, alarms shall be annunciated on the surge protection system control panel and on the main ICP. In addition water level high high and low low alarms shall be configured on the surge vessel water level analogue signal. These alarms will be used when the surge vessel water level is being controlled by hand such as when the surge vessel containing the level switches is taken out of service for maintenance. The high high and low low limits shall be set outside the digital alarm levels.
- Manual override facilities shall be provided for operating the compressor and the air inlet and air release valves. A non-return valve shall be provided on the air inlet line to the surge vessel to prevent back flow of water from the surge vessels to the air receiver.
 - A separate control panel shall be provided for operation and monitoring of the surge suppression system. The panel shall comprise the following:
 - Incoming isolator
 - Starters for compressors
 - Automatic-Off-Manual selector switch
 - Status indication
 - Start / stop pushbuttons for use in manual mode
 - Duty / standby compressor selector switch
 - Auto-manual selector switch for surge vessel air supply
 - Manual controls for air inlet and air release
 - Indication of surge vessel water level
 - Alarm annunciator to indicate the following alarms as a minimum
 - Surge vessel water level high
 - Surge vessel water level high
 - Surge vessel water level low
 - Surge vessel water level low

- Compressor faults for each compressor as appropriate i.e. fail, oil temperature high, etc.
- Low air pressure in receiver
- All the critical alarms and signals required for safe efficient operation of pumping station shall be connected to the main PLC (Programmable Logic Controller) in ICP.

5.29.3.4 Abnormal Operation

- In case working compressor fails, the standby compressor shall come into operation automatically and an alarm shall be annunciated on surge suppression control panel and ICP.
- In case the control supply to surge suppression control panel fails an alarm shall be enunciated at the ICP and the operator shall carry out the operation of surge suppression system manually.

5.29.4 Technical Specifications for Surge Tanks/Pipe

The surge tank/pipe shall be designed considering the space available. The surge tank / pipe shall be of adequate size and capacity as per the requirement and approved design. It shall be provided with the isolation valve at inlet. The overflow arrangement shall be provided with the adequate arrangement for disposal of overflow water. The construction shall be as per the standard specifications of civil works.

CHAPTER - 6

6. PIPELINES, PIPEWORK AND FITTINGS

6.1 Applicable Codes

The following general codes and standards unless specified herein shall be referred to, or equivalent to the approval of the Engineer. The specific codes and standards have been given in the specific chapters.

6.1.1 Materials

- IS:210 Specification for grey iron casting
- IS:456 Code of practice for plain and reinforced concrete
- IS:458 Specification for pre cast concrete pipes (with and without reinforcement)
- IS:516 Method of test for strength of concrete
- IS:638 Specification for sheet rubber jointing and rubber insertion jointing
- IS:783 Code of practice for laying of concrete pipes
- IS:816 Code of practice for use of metal arc welding for general construction in mild steel
- IS:1367 Technical supply conditions for threaded steel fasteners
- IS:1387 General requirements for the supply of metallurgical materials
- IS:1500 Method for Brinell hardness test for metallic materials
- IS:1536 Specification for centrifugally cast (spun) iron pressure pipes for water, gas and sewage
- IS:1537 Specification for vertically cast iron pressure pipes for water, gas and sewage
- IS:1538 Specification for cast iron fittings for pressure pipes for water, gas and sewage
- IS:1608 Metallic Material tensile testing at ambient temperature
- IS:1916 Specification for steel cylinder pipes with concrete lining and coating
- IS:3076 Specification for LDPE Pipes
- IS:3597 Method of tests for concrete pipes
- IS:3658 Code of practice for liquid penetrant flow detection
- IS:4984 Specification for high density polyethylene pipes for water supply
- IS:4985 Specification for PVC Pipes
- IS:5382 Specification for rubber sealing rings for gas mains, water mains and sewers

IS:5504	Specification for spiral welded pipes
IS:6392	Specification for steel pipe flanges
IS:6587	Specification for spun hemp yarn
IS:7322	Specification for specials for steel cylinder reinforced concrete pipes
IS:8008	Specification for moulded HDPE Fittings
IS:8360	Specification for fabricated HDPE Fittings
IS:12709	Specification for GRP pipes
BS:5480	Specifications for GRP pipes and fittings

Additional Indian and International code of practices and specifications have been given below which shall be followed as much possible with the consent of the Employer's representative.

6.1.2 Code of Practice

IS:783	Code of practice for laying of concrete pipes
IS:2379	Colour Code for Identification of Pipelines
IS:3114	Code of practice for laying pipes
IS:3764	Excavation work - Code of Safety
IS:4127	Code of practice for laying of glazed stoneware pipes
IS:5822	Code of practice for laying of electrically welded steel pipes for water supply.
IS:10221	Code of Practice for coating and wrapping of underground MS pipelines
IS:10990	Technical drawings – Simplified representation of pipelines
IS:11790	Code of Practice for preparation of Butt welding ends for valves, flanges and fittings

6.2 Materials for Pipelines

Each pipeline shall be constructed in a material compatible with the fluid conveyed through that pipeline, (i.e. the materials used in the pipes which are or can be in contact with the untreated or treated water, shall not contain any matter which could impart taste or odour or toxicity or otherwise be harmful to health or adversely affect the water conveyed). Pipes shall not be adversely affected by the fluid being conveyed through that pipe.

Pipework and valve materials of the suitable schedule for the following duties shall be as follows and equivalent to the approval of the Engineer.

The material of construction of pipes and fittings shall conform to the following specifications:

Table 6-1: List of Material of Construction of Pipes and Fittings

Application/Location	Material	Remarks
Intake and outfall pipeline	HDPE	Refer Specification below
Raw seawater pumping	GRP/HDPE	Refer Specification below
Brine line	GRP/ HDPE	Refer Specification below
Sludge lines	GRP	Refer Specification below
Air Lines	SS-316L suitable for high temperature	Refer Specification below
RO piping (seawater/ brine) for high pressure lines	Super Duplex SS PERN \geq 43	As per the application
Permeate line	GRP/HDPE	Refer Specification below
Service water	HDPE/ GRP/PVC/SS316	As per approval of the Engineer
Chemical dosing Lines	Rubber lined carbon steel/ cPVC /GRP/HDPE as	As per approval of the Engineer
Chlorine solution	HDPE Valves shall be ball type-polypropylene	
Sewage and stormwater	HDPE/GRP pipes as per application	As per approval of the Engineer
Nut & Bolts	SS-316L	Refer Specification below
Fasteners	SS-316/ Monel 410/ K500	As per the application

6.3 Pipework

- i) The term “pipework” means pipe of any description and includes associated flanges, dismantling joint adopters, couplings, jointing materials, fittings, supports, valves, traps and the like which are necessary to complete station pipework systems associated with pumping stations.
- ii) The Contractor shall design, manufacture, supply, fabricate, and install the pipework in accordance with the Specification and to satisfy pipework function of Pump Station

and other piping. The Contractor shall provide all the information given below clearly about the pipework. The Contractor's specification for the fabrication of pipework shall be submitted for the Employer's approval. The information provided shall be, when applicable, as listed below.

- a) Purpose
 - b) Contents
 - c) Related documents
 - d) Definitions
 - e) Application standards
 - f) Drawings
 - g) Materials
 - h) Fabrication - general
 - tolerance
 - preparation
 - fit-up
 - threading
 - bends
 - welding
 - heat treatment
 - after fabrication treatment
 - inspection
 - i) Preparation and protection finishing of surfaces
 - j) Marking and color coding for identification and matching
 - k) Acceptable welder's qualification
- iii) All pipes, fittings, bolts, nuts, jointing materials, pipe supports, thrust blocks and appurtenances for piping to be required for execution of the Works shall be manufactured and erected in accordance with the erection plans, specifications to be provided by the Contractor and approved by the Employer. All pipework and fittings shall be rated to the higher-pressure class in excess of the maximum pressure attained in service including any surge pressure. Minimum 2 mm corrosion allowance shall be considered. Where pipe material is specified as Mild steel, the pipe thickness shall be based on diameter and not be less than 12 mm. Buried pipes in addition to above, shall be designed to withstand external loading exerted by soil, water, and live loads as relevant. The external ground water shall be taken at ground level for design purposes.
- iv) Underground pipelines must be shown the location by a concrete pole that indicates its lay underground depth and its flow direction.
- v) The pipe-work installation shall be so arranged to offer ease of dismantling and removal of pumps or other major items of equipment. Expansion bellows which can take radial

and axial misalignment of minimum 1 percent of valve nominal size with tie rods shall be included in the suction and delivery pipe-work of all pumps as well as on delivery header for easy dismantling, and provision shall be made for a flexible joint arrangement to building structures. All loose flanges shall be secured to fixed flanges by suitable tie-bolts.

- vi) Support calculations shall be provided for piping considering the transient conditions and justifying the type of supports.
- vii) Transient studies shall be done for all large diameter pipes and suitable type of anchoring shall be provided.
- viii) All necessary supports, saddles, slings, fixing bolts and foundation bolts shall be supplied to support the pipe-work and its associated equipment in an approved manner. Valves, meters, strainers and other devices mounted in the pipe-work shall be supported independently of the pipes to which they connect. All brackets or other forms of support, which can conveniently be so designed, shall be rigidly built up of steel by welding and coated by paint after welding works.
- ix) All pipework shall be adequately supported with purpose-made fittings. When passing through walls, pipework shall incorporate a puddle flange or other suitable sealing device.
- x) Flange adapters and unions shall be supplied and fitted in pipework runs, wherever necessary, to permit the simple disconnection of flanges, valves and equipment. The final outlet connection of the pipework shall match the connecting point of the transmission main.
- xi) Flanged joints shall be made with minimum 3 mm thick full face, neoprene rubber gaskets, pierced to take the bolts, and the face of all flanges shall be machined to give a true angle of 90° to the centre line of the pipe or fittings. All necessary supports, saddles, slings, fixing bolts and foundation bolts shall be supplied to support the pipework and its associated equipment in an approved manner. Valves, meters and other devices mounted in the pipework shall be supported independently of the pipes to which they are connected.
- xii) Bolts for flange connection must be tightened using adequate force in compliance with international standards or approved by the Engineer.
- xiii) Facilities shall be provided for draining the pipe system and releasing air.
- xiv) The pipe-work layout within all process pumping area shall follow the recommendations of the pump manufacturer. Fluid velocities in suction pipework leading to pumps shall not exceed 1.5 m/s. Fluid velocities in delivery pipework leading from pumps shall not exceed 2.0 m/s except in case of HP piping for which up to 3 m/s may be permitted.
- xv) The Contractor shall ensure that the internal surface of all pipework is thoroughly cleaned before and during erection and before commissioning.

- xvi) Cleaning shall include removal of all dirt, rust, scale and welding slag due to Site welding. Before dispatch from the manufacturer's works, the ends of the pipes, branch pipes, etc., shall be suitably capped and covered to prevent any accumulation of dirt or damage. This protection shall not be removed until immediately prior to connecting adjacent pipes, valves or pumps. All small-bore pipes shall be blown through with compressed air before connection is made to instruments and other equipment. No point of passage of pipes through floors or walls shall be used as a point of support, except with the approval of the Employer.
- xvii) Hydraulic shop test for pipes and fittings shall be conducted as per relevant code/standard requirement. After erection at Site, complete pipes and fittings shall be hydrostatically tested for a pressure of 1.5 times design pressure.
- xviii) Flanges, if fabricated in segments shall be fully radiographed and stress relieved. If fabricated out of billets/bars by cold rolling, welded flanges shall be radiographed and normalized.
- xix) Protection for pipes laid underground shall be by coating and wrapping system giving a final coat thickness of 4.5 mm shall be employed. Such protection shall comprise 1.5 mm of coal tar primer application on a thoroughly cleaned surface, to be followed with fibre glass wraps set in coal tar enamel coats conforming to American Water Works Association Specification C/203/57 for a total thickness of 3 mm. Such lining shall meet a spark test to be approved with a holiday detector of 10000 Volts.
- xx) The Contractor shall indicate on his detailed drawings what thrust blocks are required to anchor pipework supplied by him. Particular care shall be taken to ensure that pipe-work thrusts are not transmitted to machinery or other associated apparatus. Surge and thrust calculations shall be provided to verify the location and size of thrust blocks.
- xxi) Puddle flanges shall be fitted to pipes where the structure through which they pass is required to take thrust resulting from the pipe. Puddle flanges shall also be fitted where a water barrier is required. All puddle flanges shall be clearly shown on the drawings and the resultant thrust clearly indicated. Puddle flanges shall only be fitted with the prior approval of the Engineer.
- xxii) Saddle type/ bracket type support wherever required shall be designed and supplied for the above ground pipelines. The Employer's Representative shall duly approve all supporting design.
- xxiii) Air release valve shall be provided to release air when backwash by air is stopped. Type of valve shall be rubber pinch and shall be solenoid controlled.
- xxiv) All pipelines shall be marked the flow direction, and print ink the name of liquid to be carried as well as name of the destination of facility.
- xxv) All pipelines shall be identified by stick-on 90-micron thick vinyl film labels showing the name of the material to be carried by the pipeline and an arrow indicating the direction of flow. Letters of titles shall be pre-spaced on carrier tape and the complete title protected by one-piece removable liners. Titles shall be at intervals not less than 8

m, but shall in any case be provided in every space through which the pipe passes. Locations of labels shall be subject to prior approval by the Employers Representative. Letter sizes shall be between 16 mm and 75 mm in height depending on the size of the pipe. Pipes smaller than 22 mm outside diameter shall be labelled by the use of tags instead of labels. Tags shall be made of brass no smaller than 65 m x 16 mm by 1.5 mm thick, with lettering etched and filled with black enamel. Titles shall also be provided on all equipment in locations and in sizes to be approved by the Employer's Representative.

- xxvi) The overhead portion of the pipeline inside building may be supported from the building structures, but in no case, support shall be taken from brick walls. The overhead pipe line wherein routed within the building shall have a clear head room of minimum 3.0 m from the operating floor.

6.4 GRP Pipes

The manufacturing, testing, supplying, joining and testing at work site of GRP pipes shall comply with all currently applicable statutes, regulations, standards and codes. In particular, the following standards unless otherwise specified here in, shall be referred. In all cases, the latest revision of the codes shall be referred to. If the requirements of this specification conflicts with the requirements of the codes and standards, this specification shall govern.

Design of GRP Pipes shall confirm to AWWA C-950/AWWA M45/ASTM 3517/ASTM 2310 or equivalent. The surfaces and edges of the pipes shall be well defined and true and shall have squareness of pipe ends as specified in IS: 14402 and ASTM D 3262.

The pressure class shall be established based on long term hydrostatic or pressure design basis in accordance with ASTM D 2992.

The resin and fiber glass to be used for pipe construction shall be suitable for handling fluid with deleterious effect for minimum 30 years and be in accordance with relevant clauses of IS 14402 and ASTM D 3262. The materials used shall be in accordance with the relevant clauses of IS : 6746, IS 14402, IS : 11320 and IS : 11551 and ASTM D 3262.

GRP Pipes shall be Filament wound, with inorganic filler, with Vinyl ester Resin, 1.6 mm Resin rich layer inside and outside, thickness to suit the pressure class requirements, Stiffness class of 2500 (min) for overground and 5000 (min) for underground pipes. Hand layup may be permitted for fittings.

Manufacturing method for the fittings shall be submitted for review and approval. Pipe thickness calculations shall be submitted for approval. Buried pipes shall have a soil cover of at least 1 meter above crown. Underground road crossings shall be either RCC encased or through culverts. Outdoor pipes above ground shall be with UV protection. Pump suction and discharge velocities shall not exceed 1.5 m/sec for suction and 2 m/sec for discharge. All support sand thrust blocks shall be designed and the calculations provided to the employer for review. Pipe joints shall be either through REKA coupling or Butt wrap. Further details are provided below.

6.4.1 Codes for GRP pipes

(i) I.S. 14402: 1996

Glass-fibre reinforced plastics (GRP) pipes, joints and fittings for use for Sewerage, Industrial waste & Water (other than potable)- specification

(ii) I.S. 12709: 1994

Specification for glass fibre reinforced plastics (GRP) pipes for use for water supply and sewerage.

(iii) I.S. 6746: 1972

Unsaturated, polyester resin systems for low pressure fibre reinforced plastics,

(iv) I.S. 11273: 1985

Woven roving fabrics of 'E' glass fibre,

(v) I.S. 11320: 1985

Glass fibre roving for the reinforcement of polyester and of epoxide resin systems.

(vi) I.S. 11551: 1986

Wherever for certain specific requirements the information given in above mentioned IS codes is found to be inadequate, following international codes shall be referred to. However, in case of any discrepancy, decision of Employer / Employer's Representative shall be final and implemented by the Contractor.

(vii) ASTMD2412:

W Standard test method for determination of external loading characteristics of plastic pipe by parallel plate loading."

(viii) ASTM D 3262:

Standard specification for reinforced plastic mortar sewer pipe,

(ix) ASTM D 3517:

Standard specification for glass fibre reinforced thermosetting resin pressure Pipe,

(x) ASTM D 3618:

Test for chemical resistance of reinforced thermosetting resin pipe in a deflected Condition.

(xi) ASTM D 3839:

Standard practice for underground installation of flexible reinforced Thermosetting resin pipe and reinforced plastic mortar pipe.

(xii)ASTM D4161:

Standard specification for "Fibre glass" (glass-fibre - reinforced thermosetting resin) pipe joints using flexible elastomeric seals.

(xiii) ASTM D 477:

Standard specification for elastomeric seals (Gaskets) for joining plastic pipe.

(xiv) ASNI/AWWA C 950-88

AWWA standard for fiber glass pressure pipe.

(xv) IS 13916: 1994

Installation of GRP piping system - code of practice

(xvi) IS 5382: 1985

Rubber sealing rings for gas mains, water mains and sewers.

(xvii) American Society for Testing & Material (ASTM) 2563

Standard practice for clarifying visual defects in glass reinforced plastic laminated parts,

(xviii) ASTM D 5421

Standard specification for contact molded "Fiber glass" flanges,

(xix) British Standard (BS) - 5480

Specification for Glass Fibre resin forced Plastic Pressure Pipes, Joints & Fittings.

6.4.2 Manufacturing of GRP pipes

The method of manufacturing of GRP pipes shall be such that the form and the dimensions of the finished pipes are accurate within the limits specified in the relevant clauses of the Design Standard. The pipe shall be machine with continuous moving/filament winding. Hand woven pipes are not acceptable. The pipes shall preferably be supplied in lengths of 12 meters.

The basic structure wall composition shall consist of thermo-setting resin, glass fibre reinforcement and inorganic filler. The resin shall be Vinyl Ester. Thermoplastic or thermosetting liner and / or surface layer may be included. UV protection shall be applied on above ground pipe. No glass fibre reinforcement shall penetrate the interior surface of the pipe line. The pipe shall meet minimum longitudinal tensile strength and hoop tensile strength as per relevant clauses of design standards.

The GRP pipes and joints shall be systematically checked for any manufacturing defects by experienced supervisors so as to maintain a high standard of quality. Each pipe should have permanent ISI mark. Employer/ Employer's Representative shall at all reasonable times have free access to the place where the pipes and joints are manufactured for the purpose of examining and testing the pipes and joints and of witnessing the test and manufacturing.

a) Dimensions

Pipes shall be designated by nominal standard diameters. The nominal diameters, minimum wall thickness, length of barrel, joints etc. Shall be within the tolerance limits specified in IS: 14402, ASTM D 3262 and ASTM D 3517.

b) Workmanship and Finish

The inside surface of each pipe shall not have any visible defects such as bulges, dents, ridges foreign inclusion, cracks, crazing, pin holes and bubbles of 1.3 mm and above to the extent that it does not detrimentally affect the performance of the interior surface of the pipe wall.

Joint sealing surfaces shall be free of dents, gauges and other surface irregularities that will affect the integrity of the joints.

c) Structural Properties

The minimum initial ring stiffness for withstanding above load conditions with maximum 5% of long-term deflection shall be appropriately determined by manufacturer for actual execution.

d) Beam Strength

The pipe shall meet or exceed the minimum longitudinal tensile / compressive strength as per relevant clauses of IS: 14402, ASTM D 4262 and ASTM D 3517.

e) Hoop Tensile Strength

The pipes shall meet or exceed the minimum hoop tensile strength as per relevant clauses of IS: 14402, ASTM 3262 and ASTM D 3517.

f) Hydraulic Properties

Each length of pipe including specials shall withstand without leakage or cracking the internal hydrostatic proof pressures as per relevant clauses of IS: 14402, ASTMD 3517

g) Sampling and Inspection

In any consignment all the pipes of same class and size and manufactured under similar conditions of production shall be grouped together to constitute a lot. The conformity of a lot to the requirements of this specification shall be ascertained on the basis of tests on pipes selected from it. Unless otherwise agreed upon between the purchaser and the supplier one lot shall consist of maximum of 100 m of each pressure class, stiffness class and size of pipe produced.

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

Each pipe shall be checked for dimensions, soundness, workmanship finish and deviation from straight.

The lot shall be declared as conforming to the requirements of this specification, if the sample pipe taken from the lot meets the requirements of all the tests, otherwise not.

6.4.3 Testing of GRP pipes

GRP pipes manufactured by the above process shall be subjected to the following tests.

All tests specified either in this specification or in the relevant clauses of Indian Standards or International Standards shall be performed by Supplier/ Contractor at his own cost and in presence of Employer / Employer's Representative if desired. For this, sufficient notice before testing of the pipes shall be given to Employer/ Employer's Representative. If the test is found unsatisfactory, Employer/ Employer's Representative may reject any or all pipes of that lot. The decision of Employer/ Employer's Representative shall be final and binding on Contractor and not subject to any arbitration or appeal.

(a) Testing of pipe at factory

After selecting pipe specimens randomly from the lot as per clause no. above they shall be tested at factory for following tests.

(b) Critical dimensions

All pipes will be measured for compliance with critical dimensions as specified in relevant clauses of IS 14407, ASTM D 3262 and ASTM D 3517 after allowing for the specified tolerances. The dimensions shall include diameter, wall thickness, squareness and length. Pipes not in compliance will be rejected.

(c) Visual Acceptance

Generally, the pipe shall be free from all defects, including de-laminations, bubbles, pinholes, cracks, pits, blisters, foreign inclusions and resin-starved areas that due to their nature, degree or extent, detrimentally affect the strength and serviceability of the pipe. The pipe shall be as uniform as commercially practicable in colour, capacity, density and other physical properties as per specification and standard BS 7152, AWWA, ASTM D2567, ASTM D3567 and ANSI B16.5.

Mechanical tests on spool shall be in accordance with ASTM- D.

(d) Tests for Specific Initial Ring Stiffness (SIRS)

Pipe ring samples shall be taken as discussed above from each diameter manufactured and tested for SIRS as per relevant clauses of IS 14407, ASTM D 2412 and ASTM D 3517. If a pipe sample from a lot fails to meet the required stiffness, a further two samples shall be tested from that lot. If they both pass, the lot will be accepted. If they fail Pipes will be tested on an individual basis and only pipes which pass will be accepted.

(e) Hydrostatic Soundness Test

The manufacturer shall hydrostatically test pipes by hydrostatic proof test in accordance with the relevant Clause of IS 14407 and ASTM D-3517. Pipes shall be tested for 1.5 times of maximum allowable working pressure (MAWP) that can be generated at any abnormal working condition foreseen by hydraulic surge study, etc. Piping shall be also tested against full vacuum. The procedure should be as follows:

Each length of pipe shall be placed in a hydrostatic pressure test machine which seals the ends and exert no end loads. The pipe shall be filled with water, expelling all air and an internal

water pressure shall be applied at a uniform rate not to exceed 300 Kpa/S until the test pressure of two times the pressure class is reached. This pressure shall be maintained for one minute. The pipe shall show no visual signs of weeping leakage or fracture of the structural wall. Integral bells, including reinforcement sleeves, if any, or affixed coupling shall be tested with the pipe. Any pipes failing to pass this test will be rejected. Rejected pipes may be repaired and retested, if they pass, they will then be accepted.

(f) Beam Strength Test

The manufacturer shall test the pipe for longitudinal tensile strength as per the relevant clauses in IS : 14407, ASTM D 2412, ASTM D 3262 and ASTM 3517. The sample size shall be selected as per clause above. If any sample should fail to meet the requisite value specified in the IS/ASTM codes, five (5) further samples should be taken and tested. If the results comply with requirement, all pipes will then be acceptable. However, if these five samples fail then all pipes from that lot will be rejected unless individually proven acceptable.

(g) Hoop Tensile Strength

The manufacturer shall test the pipe for hoop tensile strength as per relevant clauses in IS : 14407, ASTM D 3262, ASTM D 3517. The sample size shall be selected as per clause above. Every sample piece should meet or exceed the hoop tensile strength specified in IS : ASTM codes. If any sample fails to meet the requisite value five (5) further samples shall be taken and tested. If the results comply with requirement, all pipes will then be acceptable. However, if these five samples fail then all pipes from that lot will be rejected unless individually proven acceptable. Rejected pipes will, however, be acceptable for use at a lower working pressure as per the criteria stated in the specification.

(h) Long Term Hydrostatic Strain Test

The pressure classes as given in relevant clause shall be based on long term hydrostatic design pressure data obtained as per relevant clauses of IS: 14407, ASTM D 3262 and ASTM D 3517. For those products where no previous long term hydrostatic testing has been performed on similar products the full type testing shall be carried out to define design pressure classes based on extrapolated strengths at 50 years. When a hydrostatic design basis has already been established for a nominally similar pipe using the same manufacturing process, the manufacturer need only conduct the re-qualification test as described in the relevant clauses of IS : 12709.

(i) Test Certificate for Chemical resistance of GRP Pipes in a deflected Condition

The manufacturer / supplier / contractor shall produce a test certificate for chemical resistance of GRP pipes in a deflected condition that when installed within 5% deflection the pipes will last over 60 years under highly acidic and corrosive condition and stand guarantee for the same.

6.4.4 Marking

Both ends of each length of pipe and fitting shall be marked at least in letters not less than 12 mm in height and of bold type style in colour and type that remains legible under normal handling

and installation procedures. The marking shall be embedded under the final coat of resin on the pipe and shall be visible through the resin coating. The marking shall include the following:

Serial Number of Pipe

Proper quality documentation for traceability of the serial number shall be available.

All pipes and fittings shall have ISI mark.

6.4.5 Handling

The manufacturer / Supplier shall be responsible for safe delivery of pipes and fittings as per order place and as per the schedule. If the contractor for works is other than manufacturer / supplier, then M/s shall submit a complete manual of instruction/ guide / Procedure for handling of pipe before installation. Broadly following instructions/ procedures shall be followed. The pipes shall be fabricated and installed under the supervision of the manufacturer or by the manufacturer himself.

Rubber ring gasket shall be shipped separately from the couplings and shall be stored in the shade in their original packaging and shall not be exposed to sunlight except during utilisation. The gaskets shall also be protected from exposure to greases and oils which are petroleum derivatives and solvents and other deleterious substances.

Gasket lubricant shall be carefully stored to prevent damage to the container. Partially used buckets shall be prevented from contamination of the lubricant.

Unloading, lifting and lowering

Adequate control shall be ensured during unloading and lifting of pipes with guide ropes attached to pipes or packages. Spreader bars shall be sued when multiple locations are necessary. The pipes shall not be dropped to avoid impact or bump, particularly at pipe ends.

Non-utilised stack of pipes shall not be handled a single bundle. Non-utilised pipes shall be handled separately, one at a time. Pipes shall be handled or lifted with pliable straps, slings or ropes. Steel cables or ropes shall not be used for lifting and transportation of pipe. Ropes shall not pass through the section of pipe, end to end. If any time during handling or installation of pipe, any damage, such as gouge, crack or fracture occurs, the pipe shall be repaired or replaced as directed by Employer / Employer's Representative before installation.

6.4.6 Jointing Pipes

Pipe sections shall be jointed utilising double bell couplings and shall be assembled as indicated in the following paragraphs and as per the relevant clauses of ASTM D 3517, ASTM D 4161. The gasket used for jointing purpose shall be as per ASTM F447, specification for Elastomeric Seals (gasket) for joining plastic pipes.

(a) Clean Coupling

Double bell coupling grooves and rubber gasket ring shall be thoroughly cleaned to make sure no dirt or oil is present.

(b) Install Gaskets

The gasket shall be inserted into the grooves, leaving two to four uniform loops of rubber extending out of the groove. There should be a minimum of one loop for each 450 mm of gasket ring circumference.

(c) Lubricate Gaskets

Uniform pressure shall be applied to push each loop of the rubber gasket into the gasket groove. Then using a clean cloth, a thin film of lubricant shall be applied to the rubber gasket. Normal amount of lubricant consumed per joint shall be as follows

600 - 800 mm dia. -0.1 Kg

900 -1000 mm dia. -0.15 Kg

1100-1200 mm dia. - 0.20 Kg

1300-1400 mm dia. - 0.25 Kg

1500-1600 mm dia. - 0.30 Kg

1800 mm dia. - 0.35 Kg

(d) Clean and Lubricate Spigots

Pipe spigots shall be thoroughly cleaned to remove any dirt, grit, grease, etc. Using a clean cloth, a thin film of lubricant shall be applied to the spigots from the end of the pipe to the black positioning stripe.

(e) Fixing of Clamps

The first clamp is fixed anywhere on first pipe or left in position from previous joint. The second clamp is to be fixed on the pipe to be connected in the correct position relative to the alignment stripe on the spigot end so as also to act as a stopper. Clamp contact with the pipe shall be padded or otherwise protected to prevent damage to the pipe and have high friction resistance with the pipe surface. Care shall be taken in the alignment of the coupling.

(f) Pipe Placement

The pipe to be connected shall be placed on the bed with sufficient distance from the previously joined pipe to allow lowering the coupling into position.

(g) Join Coupling

Come along jacks shall be installed to connect the pipe clamps and two 10 cm x 10 cm timbers or similar (large diameters may require a bulkhead) are placed between the pipe previously connected and the coupling. While these are held in position, the

new pipe shall be entered into the coupling until it rests against the second pipe clamp. Come-along jack might need a protective plank in order not to rub against the pipe.

(h) Join Pipes

Come - along jacks shall be loosened and the timbers removed before retightening the jacks for entering the coupling onto the previously connected pipe. Correct position of the edge of the coupling to the alignment stripe home line shall be checked.

(i) Angular Deflection

Maximum angular deflection (turn) at each coupling joint shall not exceed the amounts given below. Also, the pipes should be joined in straight alignment and thereafter deflected angularly if necessary.

(j) Layup Joints

The manufacturer / tenderer shall provide full details of the layup joints and polymer resin which will be used for connection of pipes to Chambers/manholes.

Joining pipes with different wall thickness when two pipes of same diameter but of different wall thickness are required to be joined at the site, the contractor is required to execute the joint very precisely so as to have straight alignment of pipe invert. Facilities shall be provided for draining the pipe system and releasing air.

The pipe-work layout within all process pumping area shall have the approval of the pump manufacturer. Fluid velocities in suction pipework leading to pumps shall not exceed 1.5 m/s. Fluid velocities in delivery pipework leading from pumps shall not exceed 2.0 m/s.

The whole of the jointing work and materials necessary to fix and connect the pipes, including adequate and efficient pipe support shall be included in the Contract. The Contractor shall be responsible for ensuring that the internal surface of all pipework is thoroughly cleaned before and during erection and before commissioning.

Cleaning shall include removal of all dirt, rust, scale and welding slag due to Site welding. Before dispatch from the manufacturer's works, the ends of the pipes, branch pipes, etc., shall be suitably capped and covered to prevent any accumulation of dirt or damage. This protection shall not be removed until immediately prior to connecting adjacent pipes, valves or pumps. All small bore pipes shall be blown through with compressed air before connection is made to instruments and other equipment. No point of passage of pipes through floors or walls shall be used as a point of support, except with the approval of the Employer.

In the design of pipes above ground pipelines, the supports and guides for the pipe become important considerations because of thermal expansion. In addition to pressure resistance and life limitations, the effect of thermal expansion and contraction shall be considered while designing the pipe. Expansion joints shall be used whereas necessary to accommodate the changes in length associated with thermal expansion.

Hydraulic shop test for pipes and fittings shall be conducted as per relevant code/standard requirement. After erection at Site, complete pipes and fittings shall be hydrostatically tested for a pressure of 1.5 times design pressure.

Dimensions of all fittings should be approved by Employer's Representative. Each fitting shall be supplied with necessary coupling and flanges.

6.5 Super Duplex Piping and Fittings

For high pressure piping in SWRO system, Super Duplex Stainless Steel (SDSS) shall be used which will have PREN ≥ 43 and CF ≥ 35 . For low pressure piping in SWRO system, SDSS can have PREN > 41 . It can have Victaulic type quick release flexible coupling for pipe jointing for smaller diameters of the pipe (up to 250 mm) and flanges for larger diameter. Welding procedure shall be submitted for review and approval. Valve connections shall be dismantling type and shall be flange connected with valves above 250 mm. Flanges shall be weld-neck type with raised face. MOC of coupling shall be Duplex stainless steel and the fastener shall be SS 316 (minimum). Pipe thickness shall be calculated after deduction of groove depth for Victaulic joint. All supports/anchors shall be designed also considering transient conditions and calculations shall be provided to the Employer for review. Velocities in the pipes shall be less than 3 m/sec. The pipes and fittings shall be as further detailed below.

6.5.1 Manufacturing

The pipe shall be made by the seamless or an automatic welding process, with no addition of filler material in the welding process as per the ASTM A790 specification.

The pipe shall be pickled free from Scale. When bright annealing is used pickling is not necessary.

The pipes and joints shall be systematically checked for any manufacturing defects by experienced supervisors so as to maintain a high standard of quality. Employer/ Employer's Representative shall at all reasonable times have free access to the place where the pipes and joints are manufactured for the purpose of examining and testing the pipes and joints and of witnessing the test and manufacturing.

Care shall be taken that the resulting wall thickness does not become less than the minimum specified. If the wall thickness becomes less than the minimum specified, as per ANSI B36.19, the damaged portion should be cut out as cylinder and replaced by an undamaged piece of pipe at no extra cost to the Employer

6.5.2 General

This specification covers Seamless and straight seam welded Austenitic/ferritic steel pipe intended to use under corrosive service with particular emphasis on resistance to stress corrosion cracking.

The manufacturing, testing, supplying, joining and testing at work site of Super duplex pipes shall comply with all currently applicable statutes, regulations, standards and codes. In particular, the following standards unless otherwise specified here in, shall be referred. In all cases, the latest revision of the codes shall be referred to. If requirements of this specification conflicts with the requirements of the codes and standards, this specification shall govern.

6.5.3 Applicable Codes

ASTM A 815	Standard specification for Wrought ferritic, ferritic / Austenitic, and Martensitic stainless-steel fittings
ASTM A 262	Practice for detecting Susceptibility to intergranular Attack in Austenitic stainless Steel
ASTM A 388/ A388 M	Practice for ultrasonic examination of heavy steel forgings
ASTM A 960/A 960M	Specification for common requirements for wrought steel piping fittings
ASTM A 763	Practice for detecting Susceptibility to intergranular Attack in Ferritic Steel
ASTM A 234/ A 234M	Specification for piping fitting of wrought carbon steel and alloy for moderate and elevated temperatures
ASTM A 275/275M	Test method for magnetic particle examination of steel forgings
ASTM A 336/336M	Specification for steel forgings alloy for high press and high temperature parts
ASTM A 403/403A	Specification for Wrought austenitic stainless-steel piping fittings
ASTM A 479/A 479M	Specification for stainless and heat resistant bar and shapes for use in boilers and other pressure vessel
ASTM A 484/A 484M	Specification for general requirements for stainless steel and heat-resistant bars, billets and forgings
ASTM A 739	Specification for steel bars, Alloy, Hot-Wrought for elevated temperature for pressure containing parts, or both
ASTM A 751	Test methods practices, & terminology for Chem Analysis of steel products
MSS SP-43	Standard practice for light weight stainless butt-welding fittings
MSS SP-79	Socket welding reducer inserts
MSS SP-83	Steel pipe unions, Socket-Welding and threaded
MSS SP-95	Swage nipples and plugs
ASME B 16.9	Wrought Steel Butt-welding fittings
ASMEB 16.11	Forged Steel fittings, socket welding and threaded
ASME B 16.5	Dimensional Standard for steel pipe flanges and flanged fittings
ASMEB 16.10	Face-to-face and End-to-End Dimension of ferrous fittings

ASME Section IX- Welding Qualification	
SFA- 5.4	Specification for corrosion-resistance chromium and chromium-Nickel steel covered welding electrodes
SFA- 5.5	Specification for low-Alloy steel covered arc welding electrodes
SFA- 5.9	Specification for corrosion-resistance chromium and chromium-Nickel steel welding rods and electrodes

6.5.4 Properties

The material shall withstand under severe corrosive environment and pipe shall meet or exceed the minimum longitudinal tensile / compressive strength as per relevant clauses of ASTM A790 specification.

The material shall conform the chemical requirements as prescribed in ASTM A790 specification such that the PREN number should not be less than 41, The PREN number shall be calculated through the following formula:-

$$\text{PREN} = \% \text{Cr} + 3.3 \times \% \text{Mo} + 16 \times \% \text{N}, \text{Where Cr- Chromium, Mo- Molybdenum, N-Nitrogen}$$

The steel shall conform to the tensile and hardness properties prescribed in ASTM A790 specification.

6.5.5 Dimension

Pipes shall be designated by nominal standard diameters. The nominal diameters, minimum wall thickness/schedule number, length of barrel, joints etc. Shall be within the tolerance limits specified in ANSI B36.19/ASTM A999.

6.5.6 Heat Treatment

Unless otherwise stated in order, all pipes shall be furnished in the heat treated condition as specified in ASTM A790 specification.

For seamless pipe, as an alternative to final heat treatment in a continuous furnace or batch type furnace, immediately following hot forming while the temperature of the pipe is not less than the specified minimum solution treatment temperature, pipes shall be individually quenched in water or rapidly cooled by other means.

6.5.7 Workmanship and Finish

The finished pipe shall be reasonably straight and shall have a workmanlike finish. Imperfections may be removed by grinding, provided the wall thickness are not decrease to less than that permitted , in the permissible variation in wall thickness section of specification A999/A999M.

6.5.8 Testing

6.5.8.1 Mechanical Testing

One tension test shall be made on a specimen for lots of not more than 100 pipes. Tension test shall be made on specimens of more than 100 pipes.

For a pipe heat treated in a batch type furnace, flattening test shall be made on 5% of the pipe from each heat-treated lot. For a welded pipe with a diameter equal to or exceeding NPS 10, a transverse guided face bend test of weld may be conducted instead of a flattening test in accordance with the method outlined in the steel tubular product supplement of tests methods and definitions ASTM A 370. The ductility of the weld shall be acceptable when there is no evidence of cracks in the weld or between the base material after bending.

Brinell or Rockwell hardness tests shall be made on specimen from two pipes from each lot.

6.5.8.2 Hydrostatic / Non-destructive Electric Test

Each pipe shall be subjected to non-destructive electric or the hydrostatic test. The type of test to be used shall be at the option of the manufacturer, unless otherwise specified in purchase order. The hydrostatic test shall be in accordance with specification ASTM B31.3.

Non-destructive electric test shall be in accordance with practice ASTM E213.

For eddy current test the maximum eddy-current coil frequency used shall be as per the given value in ASTM A 790.

Pipes shall be tested for 1.5 times of maximum allowable working pressure (MAWP) that can be generated at any abnormal working condition foreseen by hydraulic surge study, etc. Piping shall be also tested against full vacuum.

6.5.8.3 Repairing by Welding

For welded pipes of size NPS 6 or larger with a specified wall thickness of 0.188 inch (4.8 mm) or more, weld repairs made with the addition of compatible filler metal may be made to the weld seam with the same procedure specified for plate defects in section on repair by welding of ASTM A999/A999M.

Weld repairs of the weld seam shall not exceed 20% of the seam length.

6.5.9 Marking

The following information shall be clearly marked on each pipe and special: Manufacturer's name or trademark.

Material identification, either the ASTM or ASME grade designation Schedule number or nominal wall thickness in mm

Size - the nominal pipe size (NPS) identification number related to the end connections shall be used.

Class of pipe (Grade or UNS number) and special with its serial number

6.5.10 Jointing

6.5.10.1 Flanged Joint

The flanges for pipes and specials shall be Weld-neck Raised Face, with suitable rating applicable for the designed pressure. Flanges shall be provided at the end of pipes or specials where valves, blank flanges etc. have to be introduced or flanged joints for the pipes are specified. The flanges shall have necessary bolt holes drilled. It might be necessary for contractor to follow the instructions and specifications given by the valve manufacturer. All bolts, nuts and packing material required for flanged joints shall be provided by the Contractor. Bolts /studs, nuts and washer shall conform to ANSI B 18.2.1/ANSI B 18.2.2. Whereas metallic gasket with flexible graphite filled with carbon steel outer ring of required thickness shall conform to ASME B 16.20.

All the piping flanges and counter flanges & their drilling shall generally conform to ANSI B 16.5 of relevant pressure & temperature class.

6.5.10.2 Welded Joint

Where pipes or fittings are joined together by welding, following process can be used to weld Tungsten arc welding/ Plasma arc welding/Submerge arc Welding/ Metal Arc welding or any similar approved welding process as per approved Welding procedure specification (WPS) & Procedure Qualification Record (PQR). All welding work shall be carried out by qualified welders as per standard code ASME Section IX.

Pipes below 50 NB shall be plain end and the same shall be square groove welded, whereas pipes 50 NB & above shall be butt welded.

For Duplex Stainless-steel fittings and flanges shall be forged (wrought) or casting having the same schedule and equivalent material of construction having similar grade

Welded duplex/super duplex stainless steel piping need not be stress relieved except where specified in PQR. Such stress relieving may be done by uniformly heating welded area with nichrome/induction coil to $660 \pm 15^\circ\text{C}$, holding the temperature for one hour for each 25 mm of wall thickness or fraction thereof, and then cooling at a rate not in excess of 315°C per hour in still air.

6.5.10.3 Dismantling Joints

The Contractor shall provide flexibility in the pipework at joints in the main structures and shall submit proposals for the approval of the Employer's Representative. Flexible joints shall also be provided for case of erection and future dismantling. Flexible couplings and flange adaptors shall be meeting with the requirements set forth by AWWA C 227 or similar approved pattern and be assembled in accordance with the manufacturer's instructions and protected.

Where steel and cast flanges are mated together the steel flange shall be machined over its full face, after welding to its respective pipe is completed.

Flexible joints shall be provided to facilitate installation and removal and or differential movement of plant. Where required, flexible joints shall be provided with tie bolts or other means to transfer longitudinal thrust along the pipework as a whole.

6.5.11 Pipe Fittings

The information under this clause covers the material specification, manufacturing, testing and other information for the piping fittings for the super duplex steel. Fittings shall be constructed of super duplex stainless steel material having PREN number equivalent to pipe system in which it is installed.

Fittings below 50 NB shall be forged fitting, and butt weld ends with relevant pressure rating not less than 3000#. The material shall be UNS S32750 as per ASTM A182/182M, Grade F 53 with PREN number not less than 41, the formula for calculating PREN number is given above in this document. The dimensional standard shall be as per ASMEB 16.11.

The ferritic steel may be made by the open hearth, electric furnace, or basic-oxygen process with separate degassing and refining optional. A sufficient discard shall be made to secure freedom from injurious piping and undue segregation.

After the hot working, forgings shall be cooled to a temperature below 538°C prior to heat treatment in accordance with the requirement as given in ASTM A182/182M.

The chemical properties/composition of the material shall be in accordance with ASTM A182/182M. Mechanical testing, cast analysis, product analysis, shall be governed by relevant ASTM specification.

Fittings 50 NB and above shall be wrought ferritic-austenitic stainless steel (seam welded) with butt-welded end. The material shall be UNS S32750 as per ASTM A815/ASTM 815M, Grade WP-W, with PREN number not less than 43, the formula for calculating PREN number is given above in this document. The dimensional standard shall be in accordance with ANSI B 16.9.

The fittings ordered as class WP-W shall meet the requirements of specification ASTM A 960/960M and shall have all welds made by fitting manufacturer of all pipe welds made with the filler material radio graphically examined throughout the entire length.

All welding shall be done prior to the heat treatment and all fittings shall be heat treated in accordance with the requirements specified in ASTM A815.

Fabricated elbows shall be made of a contiguous piece of pipe of the same material as the pipe system in which it is being installed. Cut grooves shall be integral on the elbow. No weld joints shall be accepted without X-ray inspection report of the weld. Groove must conform to coupling manufacturers published tolerances for cut grooves. No deviation shall be allowed. All Grooved Fittings must conform to an internationally recognized quality assurance program or meet and conform to ASTM B31.3 severe cycle standards. Certificate of conformance shall be provided.

Factory trained representative shall visit job site to verify proper installation of fittings and couplings. Couplings manufacturer's installation instructions for couplings and fittings shall be followed.

6.5.12 Pipe Flanges

All flanges shall be forged and Weld-neck Raised Face, the material for flanges shall be UNS S32750 as per ASTM A182/A182M with MOC of SDSS PREN \geq 43.

Flanges below 50 NB shall be Stub End + Lapped flange (FF) with pressure class rating of 600#, while Flanges 50 NB and above shall be RF with pressure Class 600#. Flanges shall be provided at the end of pipes or specials where valves, blank flanges etc. have to be introduced or flanged joints for the pipes are specified. The flanges shall have necessary bolt holes drilled. It might be necessary for contractor to follow the instructions and specifications given by the valve manufacturer.

All bolts, nuts and packing material required for flanged joints shall be provided by the Contractor. Bolts /studs, nuts and washer shall conform to ANSI B 18.2.1/ANSI B 18.2.2. Whereas metallic gasket with flexible graphite filled with carbon steel outer ring of required thickness shall conform to ASME B 16.20 as per table below.

All UNS 32750 material shall have a PREN \geq 43 in the table below.

Description	Size	Dim. Std.	Material	Remark
Pipe	Below 50 NB	B36.19	ASTM A790 UNS S32750	Seamless, PE
Pipe	50 NB and Above	B36.19	ASTM A790 UNS S32750	Seamless/Straight seam welded, BW end
Flange	Below 50 NB	ANSI B 16.5	ASTM A182 GRF53, UNS S32750	600#, WNRF
Flange	50 NB and Above	ANSI B 16.5	ASTM A182 GRF53, UNS S32750	600#, WNRF
Elbow 90	Below 50 NB	ANSI B 16.9	ASTM A815 UNS S32750 WP-W	1.5DBW
Elbow 90	50 NB and Above	ANSI B 16.9	ASTM A815 UNS S32750 WP-W	1.5D.BW
Tee	Below 50 NB	ANSI B 16.9	ASTM A815 UNS S32750 WP-W	BW
Tee	50 NB and Above	ANSI B 16.9	ASTM A815 UNS S32750 WP-W	BW
Reducer	Below 50 NB	ANSI B 16.9	ASTM A815 UNS S32750 WP-W	BW

Description	Size	Dim. Std.	Material	Remark
Reducer	50 NB and Above	ANSI B 16.9	ASTM A815 UNS S32750 WP-W	BW
Weldolet-Branch Butt Weld	Below 50 NB	MSS SP-97	ASTM A815 UNS S32750	Seamless
Gasket		B 16.20	3mm THK, spiral wound, SS 316, flexible graphite filled with carbon steel outer ring,	To suit Class 600#
Bolt / Stud, Nut & Washer		ANSI B 18.2.1/ANSI B 18.2.2	STUD: A193 GR.B8M. NUT: A194 GR.8M	

6.6 HDPE Piping

6.6.1 Applicable Codes

Polyethylene pipes shall comply with below mentioned Indian Standards /BS 6437.

The following Indian Standards /BS 6437, unless otherwise specified herein, shall be referred. In all cases the latest revision of the Codes shall be referred to. If requirements of this specifications conflict with the requirements of the standards /Codes, this specification shall govern. The welding method shall be adapted to international standard and contractor shall obtain the approval of the Engineer before proceeding with such works.

Code No.	Title/ Specification
ISO 4427E, EN12201	High Density polyethylene pipes
IS:2530	Methods of test for polyethylene moulding materials and polyethylene compounds
IS 4984 Amendment No. 21995	High Density polyethylene pipes for Water Supply
IS 5382	Rubber sealing rings for gas mains, water mains and sewers
IS:7328	High density polyethylene materials for moulding and extrusion
IS 7634	Laying & jointing of polyethylene (PE) pipes
IS 2530	Methods of test for polyethylene moulding materials and polyethylene compounds
IS 4905	Methods for random sampling

Code No.	Title/ Specification
IS 9845	Methods of analysis for the determination of specific and / or overall migration of constituents of plastics material and articles intended to come into contact with foodstuffs.
IS 10141	Positive list of constituents of polyethylene in contact with food stuffs, Pharmaceuticals and drinking water.

The High-Density Polyethylene (HDPE) Pipe shall be made from base polymer and shall conform to the requirements as specified in ISO4427. The base polymer shall be a single grade of polyethylene. All raw material used shall be approved and certified Pipe Grade material for the transportation of product water.

Pipes shall be of PE100. SDR requirements shall meet PN6 for gravity lines and PN 10 for any pressure line. Support arrangements shall be designed, and calculations provided for review. Supports shall be designed.

The Contractor shall provide the certified information (as per BIS) about the properties of PE-100 material as stated in the document for manufacturing the pipes for this project. Density, flexural strength, compressive strength, modulus of elasticity, short term and long term yield value, allowable circumferential stress in pipes intended for 40-50 years of service at normal temperature, volume resistivity, thermal conductivity, specific heat, linear coefficient of expansion, ignition by flame, burning rate, maximum operating temperature (under pressure) and any other properties which may affect the serviceability of pipe at project site. The Contractor shall submit original copy of the pipe manufacturer's sworn certificate of inspection and testing of all pipes and fittings used on the job. All pipes and fittings shall be subject to inspection and approval by the Engineer/ Employer's representative before and after delivery at the project site. Any pipe or fittings found to be unsatisfactory or otherwise damaged shall not be approved for use.

No additives that may contribute to toxic hazard, impair the fabrication of properties and chemical and physical properties in particular to long term mechanical and strength is allowed.

The colour of the pipes shall be black with blue stripes. Each pipe shall contain minimum three equi-spaced longitudinal stripes of width 3 mm (Min) in blue colour. These stripes shall be more than 0.2 mm in depth. The material of the stripes shall be of the same type of resin, as used in the base compound for the pipe.

All HDPE pipes shall conform to IS: 4984-1995 (with amendment) high density polyethylene pipes (HDPE) for product water supplies (Fourth Revision) or ISO 4427-1996 with nominal outside diameters. The pressure rating of the pipes shall be governed by the design. The raw material of pipes shall conform to ISO 4437. The produced pipes shall pass the internal pressure test (acceptance test) using the test method per EN 921.

The flanges system will follow systematically these requirements:

Nominal Pressure: 10 bars

Flange norms: ISO PN10, EN 1092-2 and ISO 7005-2.

The rubber gasket will follow these requirements:

Material: nitrile rubber

Thickness: min 4mm

For PN10 flanges

The bolts and nuts shall be Electro-galvanized steel;

Flanges will be used to fit together elements of different materials such as valves (in cast iron or ductile iron) with HDPE pipes through the use of a flange adaptor.

6.6.2 Appearance

The internal and external surfaces of pipes must smooth, clean and free from scoring, cavities and other surface defects which may affect pipe performance. The ends of pipe shall cut cleanly and square to the axis of the pipe. Appearance shall be checked at the point of manufacture.

Each straight length of pipe shall be clearly marked in indelible ink/paint on either end and for coil at both ends or hot embossed on white base every meter throughout the length of pipe/coil with the following information:

- a) Manufacturer's name and/or Trade-mark,
- b) Designation of pipe
- c) Lot No./Batch No.
- d) BIS certification marking on each pipe/Equivalent in case of Import.

Ovality shall be measured at the manufacturer's end as the difference between the maximum outside diameter and minimum outside diameter measured at the same cross section of the pipe, at 300mm away from the cut end. For pipes to be coiled, the ovality shall be measured prior to coiling. For coiled pipes, however, re-rounding of pipe shall be carried out prior to the measurement of ovality.

6.6.3 Pipe Fittings:

Pipe fittings shall be laid so as to form a close concentric joint with the adjoining pipe to avoid sudden offsets of the flow line. Pipe sections shall be joined together in accordance with the manufacturer's recommendations.

6.6.4 Butt Fusion Joining

Plain end pipe and fittings shall be made using butt fusion. The butt fusion procedures shall be in accordance with the manufacturer and the relevant codes. The fusion equipment operator shall receive training using the recommended procedure. The Contractor shall be responsible to verify that the fusion equipment is in good operating condition and that the operator has been

trained within the past twelve months. The fusion equipment shall be equipped with a Data logger. Records of the welds (heater temperature, fusion pressure, and a graph of the fusion cycle) shall be maintained for five (5) years. Fusion beads shall not be removed.

Butt fusion fittings shall have a manufacturing standard of ASTM D 3261. Molded & fabricated fittings shall have a pressure rating equal to the pipe unless otherwise specified in the plans.

Flange adapters shall be attached to pipe and fittings using butt fusion. The flanges adapters shall be aligned and centered relative to the pipe. Flange adapters should be square with the valve or other flange before tightening of bolts. Bolts should not be used to draw flanges into alignment. Bolt threads shall be lubricated, and flat washers shall be used under flange nuts. Bolts shall be tightened using a "star tightening pattern". Twenty-four hours after first tightening the flange bolts, they must be re-tightened using the same "star tightening pattern" used above. The final tightening torque shall be as indicated by the manufacturer.

Heat Fusion Training. The supplier of the pipe and fittings shall provide a person certified by the pipe manufacturer and the fusion equipment manufacturer to train contractor fusion equipment operators and inspectors representing the Owner.

Inspection

On both sides, the double bead should be rolled over to the surface, and be uniformly rounded and consistent in size all around the joint.

The gap between the two single beads must not be below the fusion surface throughout the entire circumference of the butt joint.

The displacement between the fused ends must not exceed 10% of the pipe/fitting minimum wall thickness.

For the intake pipes of HDPE material, the bead projection inside of the pipe shall be made suitable for "Pig" movement while cleaning.

6.6.5 Electrofusion Couplings.

Polyethylene pipe and fittings may be joined using approved electrofusion couplings. Electrofusion Fittings shall have a manufacturing standard of ASTM F 1055. Fittings shall have a pressure rating equal to the pipe unless otherwise specified on the plans. All electrofusion fittings shall be suitable for use as pressure conduits, and per AWWA C906, have nominal burst values of three and one-half times the Working Pressure Rating (WPR) of the fitting.

6.6.6 Pipe Manufacturer's Quality Control.

The pipe manufacturer shall have an ongoing Quality Control program for incoming and outgoing materials. High-density polyethylene (HDPE) resins for manufacturing of pipe shall be checked for density, melt flow rate, and contamination. The manufacturer of the HDPE resin shall certify the Cell Classification as per his format. These incoming resins shall be approved by plant Quality Control before being converted to pipe. Pipe shall be checked for outside diameter, wall thickness, length, roundness, and surface finish on the inside and outside and end cut. Testing Pressure testing shall be conducted in accordance with ASTM standard.

6.6.7 Transport and Handling

Vehicles for transporting HDPE pipes should have a clean flat bed, free from nails and other projections which might cause damage. Each pipe should be supported along its length but, where this is not possible; timber supports of at least 75mm bearing width and placed at most 60 cm apart should be used. The above recommendations may not apply when rigid bundles of pipes are being transported. In that case the overall height of the bundles should not exceed 2.5 m. Side supports should not be less than 1.5 m apart; they should be flat and have no sharp or rough edges. When loading pipes with integral sockets, the sockets should be placed at alternate ends of the vehicle in such a way that they do not make contact with the neighbouring pipes. When transporting a mixed load of pipes, it is important that the larger, generally thicker-walled, and thus heavier, pipes are placed at the bottom. Pipes should not be allowed to overhang the vehicle.

6.6.7.1 Pipe and Large Fitting Handling

HDPE pipes are light in weight, they are therefore easy to handle. With reasonable care, damage to the pipes can be easily avoided. Pipes should not be dragged along the ground nor should they be lowered on skids. Whenever mechanical handling techniques are used, all equipment coming into contact with the pipes should be made of a soft material. A nylon fabric choker sling capable of safely handling the weight of the pipe or fitting, shall be used to lift, place and move pipe and fittings or For example, textile slings and Hessian ropes may be used and it should be ensured that all metal hooks are covered.

While unloading pipes from vehicles, do not drop them on the ground. Pipes should always be carefully lowered onto the ground or stacked where they are to be stored. Whenever pipes have been transported one inside another, the inner pipes should always be removed first and stacked separately.

6.6.7.2 Storage

Generally, similar requirements apply to storage of HDPE and uPVC pipes.

Pipes may be stored in loose stacks up to a maximum height to 2 m.

When pipes are stored outside in climates having high ambient temperatures (greater than 23 °C), the following is recommended:

- a) The height of the stacks should not exceed 1 m;
- b) all stacks should be shielded from continuous and direct sunlight and shall be arranged to allow the free passage of air around the pipes; specials & fittings should always be stored in boxes or sacks manufactured so as to permit the free passage of air.
- c) When pipes are stacked in the form of rigid bundles, a maximum of three bundles having a height of 1 m each should be stacked on top of each other.

6.7 CPVC Pipe:

This specification outlines minimum manufacturing requirements for Chlorinated Polyvinyl Chloride (CPVC). This pipe is intended for use in applications where the fluid conveyed does

not exceed 140°F. This pipe meets and or exceeds the industry standards and requirements as set forth by the American Society for Testing and Materials (ASTM), ISO and the National Sanitation Foundation (NSF International).

The material used in the manufacture of the pipe shall be a rigid chlorinated polyvinyl chloride (CPVC) compound, Type IV Grade I, with a Cell Classification of 23447 as defined in ASTM D1784. This compound shall be light grey and shall be approved by NSF for use with product water. The pipe shall be manufactured in strict compliance to ASTM F441, consistently meeting the Quality Assurance test requirements of this standard with regard to material, workmanship, burst pressure, flattening, and extrusion quality. The chlorine content in pipe at a time shall not be less than 66.5%.

The pipes shall be as per IS 15778, latest edition for water supply.

Solvent-cemented joints should be utilized when working at or near maximum temperatures. The use of PVC for threaded connections at temperatures above 110°F; is not recommended, above the same flanged joints, unions, or roll grooved couplings where disassembly is necessary at elevated temperatures shall be used.

Thread only Schedule 80 or heavier walls. Threading requires a 50% reduction in pressure rating stated for plain end pipe @73°F. Threading of Schedule 40 PVC pipe is not a recommended practice due to insufficient wall thickness.

Chemical resistance data should be referenced for proper material selection and possible de-rating when working with fluids other than water.

6.8 Hydrotesting

6.8.1 Hydro-testing of HDPE/CPVC Pipes

Hydro pressure testing shall be done on the laid pipe length for a minimum pressure of 1.5 times the designed working pressure (but not less than 6 bar) for retaining period of 4 hours, and as mentioned in IS 4984 -1995 including its latest amendments. A report shall be prepared by the Contractor and submitted to the Employer's representative to provide the details of the pipe laid, source of water to be used for hydrotesting with the proposal of hydrotesting on a given date. The acceptance criteria for hydrostatic test are no permanent deformation of any part of the pipeline fitting or equipment and there shall not be any leakage through any of the joints.

All the necessary consumables, equipment, tools & tackles required for the testing & inspection has to be arranged by the Contractor.

Hydro pressure testing has to be done for all the valves as per IS 13095 -1991 including its latest, at the manufacturer's end and a report has to be submitted to the Employer's Representative.

6.8.2 Hydrotesting of Valves and Other Fittings

Suitable section shall be chosen for such testing in consultation with Employer's Representative from time to time during progress of the work and satisfactorily tested. All testing apparatus,

gauges, connections, etc. and water required for testing shall be arranged by the contractor at his cost. The water for testing has to be arranged by the Contractor after discussion with the Engineer.

Satisfactory hydraulic test shall be recorded when the section under test shall withstand the pressure for about 15 minutes without operating the test pump. The test pressure being maintained at the specified figures during that 15 minutes interval.

The field test pressure to be imposed should be not less than the maximum of following.

- a) 1.5 times the maximum sustained operating pressure.
- b) 1.5 times the maximum static pressure in the pipeline

During testing if any joints are found leaking, they shall be repaired and / or reinstalled by the Contractor at his cost till the test is found satisfactory. Similarly, any pipes collars, specials, show hair cracks, leaks etc. during testing the contractor shall replace them with sound pipes and specials etc. free of cost. The hydraulic test shall be carried out after noticing the Employer's Representative.

Water tightness of the valve joints shall be tested in the same manner as described for mains. These tests may be carried out along with the tests of the pipe mains and separate tests are not essential.

6.8.3 Testing of Pipes & Specials, Pipeline and Joints

All tests specified in this specification, relevant Indian Standards as per codes followed and manufacturer's instruction manual, applicable for HDPE and uPVC pipes respectively and specials, shall be carried out by the contractor at his own cost.

Before commencing the factory testing of pipes and specials and fittings, notice period of 15 days shall be given to the Employer's Representative.

Certificate from the manufacture, certifying compliance to all tests for all lots and diameter of pipe needs to be submitted before transporting the pipe to site.

The under given test shall be carried out for HDPE pipes:

(i) Resistance to internal pressure - Test method

The internal pressure test is standardized in ISO 1167. The test specifies a method for determination of the resistance to constant internal pressure at a constant temperature.

(ii) The Pipe notch test

The Pipe notch test is standardized in ISO 13479 as "Polyolefin pipes for the conveyance of fluids - Determination of resistance to crack propagation - Test method for slow crack growth on notched pipes (notch test)". The test simulates slow crack growth and record time to failure on notched pipes.

(iii) The Small-scale steady-state test

The small-scale steady-state test (S4 test) is standardized in ISO 13477 "Thermoplastics pipes for the conveyance of fluids - Determination of resistance to rapid crack

propagation (RCP)." The test simulates the phenomenon of RCP in plastic pipes and measures the determination of arrest or propagation of an initiated crack. In pipelines RCP, caused by a brittle crack, could undergo the length of several hundred meters almost at the sound of speed.

Flanges, if fabricated in segments shall be fully radiographed and stress relieved. If fabricated out of billets/bars by cold rolling, welded flanges shall be radiographed and normalized.

Protection for pipes laid underground shall be by coating and wrapping system giving a final coat thickness of 4.5 mm shall be employed. Such protection shall comprise 1.5 mm of coal tar primer application on a thoroughly cleaned surface, to be followed with fiber glass wraps set in coal tar enamel coats conforming to American Water Works Association Specification C/203/57 for a total thickness of 3 mm. Such lining shall meet a spark test to be approved with a holiday detector of 10000 Volts.

The Contractor shall indicate on his detailed drawings what thrust blocks are required to anchor pipework supplied by him. Particular care shall be taken to ensure that pipework thrusts are, as far as possible, not transmitted to machinery or other associated apparatus.

Puddle flanges shall be fitted to pipes where the structure through which they pass is required to take thrust resulting from the pipe. Puddle flanges shall also be fitted where a water barrier is required. All puddle flanges shall be clearly shown on the drawings and the resultant thrust clearly indicated. Puddle flanges shall only be fitted with the prior approval of the Employer.

6.9 Ductile Iron Pipes and Fittings

6.9.1 Pipes and Fittings

6.9.1.1 General

Ductile iron pressure pipes and fittings (Class K9) shall comply with IS:8329 and IS:9523. All fittings shall be socketed unless specified otherwise.

6.9.1.2 Materials

The materials used in the manufacture pipes and fittings shall comply with IS:8329 and IS:9523.

6.9.1.3 Tests

Tests on pipes and fittings shall be carried out in accordance with IS:8329 and IS:9523. The test method shall be submitted for approval of the Engineer.

The Engineer shall be permitted free access to the place of manufacture for the purpose of examining, inspection and witnessing the testing of pipes and fittings

6.9.2 Joints

6.9.2.1 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.

6.9.2.2 Flanged Joints

These shall comply with dimensions and drilling details shall be to BS EN 1092-2. All flanged joints of dissimilar material such as between steel and ductile iron pipe-work shall be electrically isolated joints. These shall have isolation gaskets between the flanges, isolation sleeves around all bolts and isolation washers under all bolt heads and nuts. All materials shall be supplied by a specialist manufacturer and be to the approval of the Engineer.

6.9.3 Linings

Ductile iron pipes and fittings shall have a cement mortar lining, in accordance with IS:11906 or ISO 4179. Pipe linings shall be inspected on site and any damage or defective areas made good to the satisfaction of the Engineer. The Contractor may use specialist mortars, mortar additives or curing agents only with the approval of the Engineer.

Certain sections are amplified as follows:

No additives shall be used without the written approval of the Engineer, and shall be used strictly in accordance with the manufacturer's recommendations.

The minimum thickness of the lining at one point shall not be less than that specified in IS:8329.

6.9.4 Coating

6.9.4.1 General

Ductile iron pipes and fittings shall be zinc coated with bitumen over coating, all in accordance with the following Specifications. Buried pipes and fittings shall also have a site or factory applied polythene sleeving. Pipe coatings shall be inspected on site and any damage or defective areas made good to the satisfaction of the Engineer.

6.9.4.2 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.

6.9.4.3 Bitumen Coating

Bitumen coating shall be of normal thickness 0.07 mm 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.

6.9.4.4 Polythene Sleeving

Where polythene sleeving is specified (generally for all buried DI pipes) 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.

6.10 Steel Cylinder Pipes and Specials

6.10.1 Design

In general, the design of steel cylinder pipes with concrete lining and coating shall conform to clause 8 of IS 1916. In addition to above, in case of buried pipeline, the pipe shall also be designed for the Earth load, and traffic load.

6.10.2 Manufacturing

6.10.2.1 General

Steel cylinder pipes and specials with concrete lining and coating shall be systematically checked for any manufacturing defects by experienced supervisors and a very high standard of quality shall be maintained. The pipes and specials shall be inspected by the Engineer at site and factory, and defects noticed, if any, such as protrusions, grooves, dents, notches, etc. shall be rectified, if agreed to by the Engineer. Care shall be taken that the resulting wall thickness does not become less than the minimum specified. If the wall thickness becomes less than the minimum specified, as per Table 1 of IS:1916, the damaged portion should be cut out as cylinder and replaced by an undamaged piece of pipe at no extra cost to the Engineer. The Engineer shall at all reasonable times have free access to the place where the pipes and specials are manufactured for the purpose of examining, inspection and testing the pipes and specials and for witnessing the test and manufacturing.

All tests specified either in this Engineer Requirement or in the relevant Indian Standards shall be performed by Supplier/Contractor at his own cost and in presence of the Engineer, if desired. For this sufficient notice before testing of the pipes and specials shall be given to the Engineer.

If the test is found unsatisfactory, the Engineer may reject any or all pipes and specials of that lot. The decision of the Engineer in this matter shall be final and binding on the Contractor.

6.10.2.2 Materials

All material shall conform to Clause 7 of IS:1916.

6.10.2.3 Manufacturing Process

Steel cylinder pipes with concrete lining and coating shall be manufactured as per Clause No.9 of IS:1916 and specials shall be manufactured as per Clause 7 of IS:7322. In case of spiral welded pipes, they shall be manufactured as per Clause 3 of IS:5504. Internal lining shall be up to the full length of the pipes and specials. However, external coating shall be done leaving about 100 mm length of the pipes and specials from their ends. The internal lining and external coating

to pipes and specials shall be done at factory. Before lining/coating by concrete/mortar the surface of pipes and specials shall be thoroughly cleaned. In the event that loose mill scale, tuberculation, or an accumulation of dirt, debris, oil or grease is present, it shall be removed from the surface by hand, by machine or both and given a coating of neat cement slurry.

6.10.2.4 Dimensions

The clear cover to the reinforcement whether steel cylinder or cage shall be not less than 9 mm for lining of pipe/special and 12 mm for coating of the pipe/special.

The permissible tolerance for diameter and length of pipe shall be as per Clause 4 of IS:1916, whereas for diameter, arm length and angular deviation of specials the tolerance limit shall be as per Clause 6 of IS:7322.

6.10.2.5 Workmanship and Finish

Workmanship and finish of pipe shall conform to Clause 4 of IS:1916.

6.10.2.6 Testing

Each steel cylinder shall be subjected before lining/coating to a hydrostatic test under a water pressure equivalent to the test pressure in accordance with Clause 10 of IS:1916 and relevant provisions of IS:3597, provided that the whole of the area of the calculated reinforcement is used in the steel cylinder. In the case of pipes where a part of the principal reinforcement is provided in the cage, the steel cylinder shall be subjected to proportionately less hydrostatic test pressure.

Manufacturer's standard specials shall be hydrostatically tested before lining/coating. Where feasible, other specials shall be hydrostatically tested (before lining/coating) at factory. However, when this is not practicable, at the discretion of the Engineer, the unlined specials shall be tested by penetration test as per IS:3658 or other approved means.

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

6.10.2.7 Penetration Test

A suitable liquid penetrant (kerosene oil/Dye) is applied to the surface of the portion under examination and is permitted to remain there for sufficient time to allow the liquid to penetrate into any defects open at the surface. After the penetrant time, the excess penetrant which remains on the surface is removed. Then a light-coloured powder absorbent called a developer is applied to the surface. This developer acts as a blotter and draws out a portion of the penetrant which had previously seeped into the surface openings. As the penetrant is drawn out it diffuses into the coating of the developer, forming indication of the surface discontinuities or flaws.

6.10.2.8 Marking

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

- Internal diameter, external diameter and thickness
- Class of pipe and special with its serial number
- Date of manufacture and
- Name of manufacturer or his registered trademark or both

6.10.3 Jointing

6.10.3.1 General

Jointing of steel cylinder pipes and specials with concrete lining and coating be done as per the relevant IS. After jointing, extraneous material if any shall be removed from the inside of the pipe and special. The welding of joints for pipes and specials at work sites shall comply with IS:816. Electrodes used for welding shall comply with IS:814.

6.10.3.2 Butt Welded Joint

After pipes and specials are laid in the trench, the faces of pipes/specials shall first be tack-welded alternately at one or more diametrically opposite pairs of points. After completing tack welding, full welding shall be carried out in suitable runs following a sequence of welding portions of segments diametrically opposite. After jointing the exposed surface of the steel cylinder of pipes and specials shall be coated with M20 cement concrete of sufficient thickness so as to make it flush with the adjoining both inner and outer faces of pipes and specials. The gap in the internal lining at the joints shall be filled with cement mortar (1:2) for pipes and specials larger than 600 mm diameter. The lining/coating shall be done after the field test in the section has been successfully completed.

6.10.3.3 Lap Welded Joint with Slip-in-ends

In the case of pipes with plain or slip-in-ends, swaged end of the steel cylinder may be formed by heating one of its ends and expanding it or rolling it out to the required shape. The minimum depth and maximum clearance between the swaged end and the plain end of pipes for field welding shall be provided as directed by the Engineer. Lap welding shall be done from the external face at the junction of pipe and socket. After jointing the exposed surface of the steel cylinder of pipes and specials shall be coated with M20 cement concrete of sufficient thickness so as to make it flush with the adjoining both inner and outer faces of pipes and specials. The gap in the internal lining at the joints shall be filled with cement mortar (1:2) for pipes and specials larger than 600 mm diameter. The lining/coating shall be done after the field test in the section has been successfully completed.

6.10.3.4 Flanged Joints

The flanges for steel cylinder pipes and specials shall be as per BS EN 1092-1. Flanges shall be provided at the end of pipes or specials where valves, blank flanges etc. have to be introduced or flanged joints for the pipes are specified. The flanges shall have necessary bolt holes drilled. It might be necessary for contractor to follow the instructions and specifications given by the valve manufacturer. All bolts, nuts and packing material required for flanged joints shall be

provided by the Contractor. Bolts and nuts shall conform to IS:1367 whereas rubber gasket of required thickness shall conform to IS:638.

The bolts shall be evenly tightened in comply with relevant BS standard. Random inspection shall be carried out by jointly the Engineer and the Contractor.

6.10.4 Cleaning of Pipes and Specials

Contractor shall ascertain that each stretch of pipeline is absolutely clear and without any obstruction by means of visual examination of the interior of pipeline suitably lighted by projected sunlight or otherwise. The open end of an incomplete stretch of pipeline shall be securely closed as may be directed by the Engineer to prevent entry of mud or silt etc.

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

6.10.5 Testing at Work Site

After laying and jointing of steel cylinder pipes and specials with concrete lining and coating is completed the pipeline shall be tested at work site as per the following Employer's Requirement and as directed by the Engineer. All equipment for testing at work site shall be supplied and erected by Contractor. Water for testing of pipes shall be arranged by him. Damage during testing shall be Contractor's responsibility and shall be rectified by him to the full satisfaction of the Engineer. Water used for test shall be removed from pipes and not released to the excavated trenches.

Each section of the pipeline shall be slowly filled with clean water and all air shall be expelled from the pipeline. The pressure in the pipeline should then be raised and maintained by means of pump to the test pressure. The test pressure should not be less than 1 1/2 times the working pressure at the lowest point or the static head pressure, whichever is higher. Under the test pressure no leak or sweating shall be visible at the welded joints. The duration of test shall be not less than 24 hours. The exposed joints shall be carefully examined and all such joints showing visible leaks shall be rewelded. Any cracked or defective pipes and specials in consequences of this pressure test shall be removed and replaced by sound material by Contractor and the test shall be repeated to the satisfaction of the Engineer. Proper arrangement of thrust blocks shall be provided during pressure testing or pipe laying works.

6.11 Steel Pipework

Pipe/fitting material and dimensional standard shall conform to following:

Size mm (NB)	Material Specification (Steel)	Dimensional Standard
Pipes upto 150 mm	1239 PT, ERW, Black PT-1	1239 ERW

Size mm (NB)	Material Specification (Steel)	Dimensional Standard
	HVY	
200 to 2400	2062	3589 – ERW 3589 for dimensions and minimum thickness. Pipe thickness shall be as per 2825
Elbows up to 25	ASTM-A 105	ANSI B 16.11 3000 # S.W.
40 to 150	ASTM-A 234 GR WPB	ANSI B 16.9
200 & above (meters)	2062	LR. BE. Sch 40 ANSI B 31.1
Coupling upto 25	ASTM-A 105	ANSI B 16.11 3000 # S.W.
Tees 40 to 200	ASTM – A 234 GR WPB	ANSI B 16.9 BE, Sch 40
Above 200	IS 2062	IS 2825 (min. Pipe thickness)
Reducers up to 25	ASTM-A 105	ANSI B 16.11 3000 S.W.
40 to 200	ASTM-A 234 GR WPB	ANSI B 16.9 BE, Sch 40
Above 200	2062	IS 2825 (min. Thickness for larger pipes)
Flanges	2062	BS EN 1092-1
Bolts and all nuts	1367 C1 4.6/4.0 (except under-water service which shall be in SS-316)	1364
Gaskets All	Natural Rubber to hardness 65+/- 5 shore A	3 mm thickness

Facilities shall be provided for draining the pipe system and releasing air.

The pipework layout within pump stations shall have the approval of the pump manufacturer. Fluid velocities in suction pipework leading to pumps shall not exceed 1.5 m/s. Fluid velocities in delivery pipework leading from pumps shall not exceed 2.4 m/s.

The whole of the jointing work and materials necessary to fix and connect the pipes, including adequate and efficient pipe support shall be included in the Contract. The Contractor shall be responsible for ensuring that the internal surface of all pipework is thoroughly cleaned before and during erection and before commissioning.

Cleaning shall include removal of all dirt, rust, scale and welding slag due to Site welding.

Before dispatch from the manufacturer's works, the ends of the pipes, branch pipes, etc., shall be suitably capped and covered to prevent any accumulation of dirt or damage. This protection shall not be removed until immediately prior to connecting adjacent pipes, valves or pumps. All small-bore pipes shall be blown through with compressed air before connection is made to instruments and other equipment. No point of passage of pipes through floors or walls shall be used as a point of support, except with the approval of the Engineer.

Hydrostatic shop test for pipes and fittings shall be as per code/standard requirement. After erection at site, complete pipes and fittings shall be hydrostatically tested for a pressure of 1.5 times operating pressure.

Flanges, if fabricated in segments shall be fully radiographed and stress relieved. If fabricated out of billets/bars by cold rolling, welded flanges shall be radiographed and normalized.

Protection for pipes laid underground shall be by coating and wrapping system giving a final coat thickness of 4.5 mm shall be employed. Such protection shall comprise 1.5 mm of coal tar primer application on a thoroughly cleaned surface, to be followed with fibre glass wraps set in coal tar enamel coats conforming to American Water Works Association Specification C/203/57 for a total thickness of 3 mm. Such lining shall meet a spark test to be approved with a holiday detector of 10000 Volts.

The Contractor shall indicate on his detailed drawings what thrust blocks are required to anchor pipe-work supplied by him. Particular care shall be taken to ensure that pipe-work thrusts are, as far as possible, not transmitted to machinery or other associated apparatus.

Puddle flanges shall be fitted to pipes where the structure through which they pass is required to take thrust resulting from the pipe. Puddle flanges shall also be fitted where a water barrier is required. All puddle flanges shall be clearly shown on the drawings and the resultant thrust clearly indicated. Puddle flanges shall only be fitted with the prior approval of the Engineer.

Buried pipes shall in addition be designed to withstand external loading exerted by soil, water, and live loads as relevant. The external ground water shall be taken at ground level for design purposes.

Saddle type/bracket type support wherever required shall be designed and supplied for the above ground pipelines.

All pipe joints shall be of the butt-welded type. End preparations and fabrication requirements shall generally conform to I.S. 2825. Flanges, if fabricated in segments, shall be fully radiographed and stress relieved.

Laying of welded steel pipes shall meet the requirements of I.S: 5822.

6.11.1 Welded Joints for Steel Pipes

Welding of joints in steel pipes shall be carried out manually by the metal arc welding process complying with AWWA Standard C206.

Before starting the welding of pipe joints in the Works the Contractor shall submit for the Engineer's approval details of the plant, methods and materials he proposes to use, including make and size of electrodes, number of runs, current strength and arrangements for air testing of individual joints.

Welding shall only be carried out by welders approved by the Engineer and each welder shall identify his work by means of a stencilled mark.

Welded joints other than for closing lengths shall be of the spherical spigot and socket type. For pipes of smaller than 600 mm diameter the pipe joint shall be welded externally. For pipes of 600 mm and larger, the pipe shall be welded internally, and a sealing weld made externally.

All parts to be welded shall have loose scale, slag, rust, paint and other foreign matter removed by means of a wire brush and shall be left clean and dry. All scale and slag shall be removed from each weld run when it is completed. Pipes manufactured with longitudinal or spiral welds shall be lined up before jointing so that these welds are at least 15° apart around the joint circumference.

For pipes larger than 900 mm diameter a triple run convex fillet weld shall be used. For pipes of 900 mm diameter or less a double run convex fillet weld shall be used. The minimum leg length of the fillet as deposited is to be equal to the full thickness of the pipe wall. The actual throat depth shall not be greater than 9/10th and not less than 7/10th of the minimum leg lengths as deposited. The depositing of the weld metal shall be carried out in such a manner as to ensure that all the welds have adequate root fusion and are of good clean metal free from cracks, gas holes, slag inclusions and all other impurities. The surface of the weld shall have an even contour with regular finish and shall indicate proper fusion with the parent metal. All slag shall be thoroughly removed after depositing each run of welding by light hammering with a chipping hammer followed by wire brushing. Any welds showing cracks or other cavities or in which the weld metal tends to overlap on to the parent metal without proper fusion or containing any other defects whatsoever shall be cut out and rewelded to the satisfaction of the Engineer at the Contractor's expense.

At closing lengths where two plain ended pipes are to be joined by a welded joint the gap between the two ends shall not exceed 75 mm. An external steel sleeve collar, of a thickness not less than that of the pipe itself and approximately 300 mm in length shall be placed centrally over the two ends to be jointed and the end of each pipe shall then be fillet welded to the sleeve collar in accordance with the above procedure.

No weld or adjacent parts of the pipe shall be painted prior to inspection by the Engineer.

6.11.2 Welder Performance Test

The Contractor shall submit for the Engineer's approval the names of persons whom he proposes to employ as welders with evidence that, as a minimum preliminary qualification, they have passed the qualifying tests prescribed in Clause 11 of BS 2633 and possessed certificates from an independent testing authority. The Engineer may further require any such person to perform

satisfactory test welds under Site conditions and on pipes similar to those for use in the Works, before approving his employment as a welder. The Contractor shall maintain an up-to-date list of welders approved by the Engineer and if ordered by the Engineer, he shall remove from the approved list any welder whose workmanship, as demonstrated by the results of air pressure tests on individual welded joints, is below a reasonable standard of quality of consistency in the Engineer's opinion.

6.11.3 Testing of Welded Joints

Where directed by the Engineer welded joints on pipes larger than 600 mm diameter shall be subject to a nitrogen gas test after welding.

A tapped hole (approximately 6 mm diameter) shall be made in the socket end of each pipe by the Contractor and shall be fitted with a suitable non-return valve. Nitrogen, at 400 kPa pressure, shall then be pumped into the annular space between the spigot and socket and the pump disconnected.

If no drop in pressure occurs over the ensuing period of 30 minutes the test shall be deemed to be successful. If the test pressure cannot be maintained for 30 minutes all defects in the weld shall be cut back and rewelded and the test reapplied until successful. The cost of initial and subsequent testing of defective welds shall be at the Contractor's own expense.

The Contractor shall provide all items necessary for the nitrogen tests including compressor, valves, gauges and tubing.

6.11.4 Hydraulic Losses

The frictional losses due to water flow in pipe-work shall be computed, as per the Hazen-William formula and as specified in the Central Public Health and Environmental Engineering Organisation (CPHEEO) Manual on Water Supply and Treatment, including losses in valves and specials, penstocks etc. c)Fittings, specials.

For specials like reducers, bell-mouths, tees, elbows, etc, the 'k' values shall be as recommended by the British Hydromechanics Research Association (BHRA), Volume 5, in the BHRA fluid Engineering Series.

6.11.5 Pipework Protection

All underground steel piping shall have their external surfaces protected by application of one coal tar enamel coat, wrapping of fibreglass, one more coat of enamel and a final wrap of enamel impregnated fibreglass. Pipe surface shall be thoroughly cleaned by shot or sand blasting. Primer paint recommended by the enamel manufacturer for the grade of enamel used shall be applied over this cleaned surface within four hours of cleaning. The primer paint shall be thoroughly mixed and applied as recommended by the manufacturer and the coating shall be free of bubbles, globules, drips and runs. The primer shall be thoroughly dry before enamel is applied, and the latter shall not be applied later than 3 days after application of primer. First flood coat of enamel shall be overlaid by a single spiral wrap of fibreglass overlapping at least 20 mm on pipe upto

250 mm diameter and 25 mm on larger diameter pipes. Enamel shall be heated slowly in clean kettles, equipped with indicating or recording thermometers (100°C to 350°C range), to the recommended temperature. The enamel shall be stirred continuously. It shall be seen that fibreglass impregnates in the flood coat. Second coat of enamel and second wrap of bitumen impregnated fibreglass shall be applied in the same way. The total thickness of the coating shall not be less than 4.5 mm. Each end of the pipe left bare for a distance of 150 mm for welding shall be hand coated and wrapped after field welding is completed and hydro tested. Testing of pipe protection shall be done as directed by the Engineer using elcometers, coating thickness gauges, bond test and holiday detectors.

For pipe-work partly below ground and partly above ground the protective wrapping provided for underground pipeline shall be extended 300 mm above FGL and suitable clamps shall be provided at the end of wrapping to secure it properly.

All underground pipe-work having a cover less than 0.9 m shall be encased with M 15 concrete of minimum 200 mm thick all around.

All above ground and steel pipes in galleries shall be externally painted with two coats of epoxy with minimum thickness of 180 microns for each coat.

6.11.6 Flexibility in Pipework

The Contractor shall provide flexibility in the pipework at joints in the main structures and shall submit proposals for the approval of the Engineer. Flexible joints or collars and cut pipes shall be allowed on all pipework where necessary to allow for some margin of error in the building work. Wherever possible, flexible joints shall be provided with tie bolts or other means to transfer longitudinal thrusts as a whole so that external anchorages may be kept to a minimum. Flexible joints shall also be provided for case of erection and future dismantling. Particular care shall be taken to ensure that pipework thrusts are not transmitted to machinery or associated apparatus. The Contractor shall indicate on his detailed drawings what thrust blocks are required.

6.11.7 Puddle Flanges

Puddle flanges shall be fitted to pipes where the structure through which they pass is required to take thrust resulting from the pipe. Puddle flanges shall also be fitted where a water barrier is required. All puddle flanges shall be clearly shown on the drawing and the resultant thrust clearly indicated. Puddle flanges shall only be fitted with the Engineer prior approval.

6.11.8 Small Bore Pipes and Hoses

Small bore pipes and hoses shall be of non-flame propagating materials. They shall be arranged for easy dismantling for cleaning where appropriate, and if screwed joint or joints formed by solvent welding are proposed for any chemical line, a sufficient number of flanged or flexible joints shall be provided to enable the pipe-work to be removed in sections without working from one end to the other of a particular run. Tees and cocks shall also be provided at convenient points for the connection of a pressure water supply to flush pipe-work through as required.

All pipes and hoses shall be labelled to enable individual lines to be identified throughout their run. Racks or trays shall be fixed to the duct walls or walls of tanks and buildings and the chemical pipes shall be fixed to these racks or trays with clips which can easily be removed without dismantling adjacent pipes. The Contract includes for the supply and fixing of all such racks or trays. Full details of the type of hoses, pipes and racks of trays proposed, shall be submitted at the time of tendering.

6.11.9 Support of Pipework and Accessories

All necessary supports, saddles, slings, fixing bolts and foundation bolts shall be supplied to support the pipe-work and its associated equipment in an approved manner. Valve, meters, strainers, and other devices mounted in the pipe-work shall be supported independently of the pipes to which they connect.

All brackets or other forms of supports, which can conveniently be so designed, shall be rigidly built up of steel by riveting or welding in preference to the use of castings.

No point of passage of pipes through floors or walls shall be used as a point of support, except with the approval of the Engineer.

After the collars and boxes or other fitting have been fixed in position, the floors, walls and roof structure shall be made good by the Contractor.

6.12 Pipes Identification and Site Testing

6.12.1 Marking

Each pipe and fitting shall have cast, stamped or indelibly painted on it the following appropriate marks:

- Nominal diameter
- Flow direction and line marks for installation
- Class reference
- Mass of pipe
- Date of manufacture and
- Manufacturer's name, initials or identification mark.

Marking shall be done as per relevant IS code.

6.12.2 Flanged Pipes

The gaskets used between flanges of pipes shall be compressed fibre board or natural/synthetic rubber conforming to IS:638, of thickness 3 mm. The fibre board shall be impregnated with chemically neutral mineral oil and shall have a smooth and hard surface. Its weight per square metre shall be not less than 112 g/mm thickness.

Each bolt should be tightened a little at a time taking care to tighten diametrically opposite bolts

alternately. The practice of fully tightening the bolts one after another is highly undesirable. The bolts shall be of mild steel unless otherwise specified.

6.12.3 Cleaning of Pipes and Fittings

The Contractor shall ascertain that each stretch of pipeline is clear and without any obstruction by means of visual examination of the interior of pipeline suitably lighted by projected sunlight or otherwise. The open end of an incomplete stretch of pipeline shall be securely closed as may be directed by the Engineer to prevent entry of mud or silt etc.

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

6.12.4 Testing at Work Site

After the pipes and fittings are laid, jointed and the trench partially backfilled except at the joints the stretch of pipeline as directed by the Engineer shall be subjected to pressure test and leakage test. Where any section of the pipeline is provided with concrete thrust blocks or anchorages, the pressure test shall not be made until at least five days have elapsed after the concrete was cast. If rapid hardening cement has been used in these blocks or anchorages, the tests shall not be made until at least two days have elapsed.

Each section of the pipeline shall be slowly filled with water and all air shall be expelled from the pipe by tapping at points of highest elevation before the test is made and plugs inserted after the tests have been completed. The specified test pressure based on the elevation of the lowest point of the line or section under test and corrected to the elevation of the test gauge, shall be applied by means of a pump connected to the pipe as directed by the Engineer.

The duration of test shall not be less than 5 minutes. The exposed joints shall be carefully examined and all such joints showing visible leaks shall be recalked until watertight. Any cracked or defective pipes and fittings in consequence of this pressure test shall be removed and replaced by sound material by Contractor at no extra cost to the Engineer and the test shall be repeated to the satisfaction of the Engineer.

After the satisfactory completion of pressure test, the section of pipeline shall be subjected to leakage test. The duration of test shall be 2 hours. No pipe installation shall be accepted until the leakage is less than the number of cm³/h as determined by the formula:

$$q_L = \frac{ND\sqrt{P}}{3.3}$$

Where,

q_L = The allowable leakage in cu. m/hr

- N = Number of joints in the length of the pipeline
 D = Diameter in mm, and
 P = The average test pressure during the leakage test in kg/sq.cm

Should any test of pipe laid indicate leakage greater than that specified above, the defective joints shall be repaired by Contractor at no extra cost to the Engineer until the leakage is within the specified allowance.

Necessary equipment and water used for testing shall be arranged by Contractor at his own cost. Damage during testing shall be Contractor's responsibility and shall be rectified by him at no extra cost to the Engineer. Water used for testing shall be removed from the pipe and not released in the excavated trenches.

After the tests mentioned above are completed to the satisfaction of the Engineer, the backfilling of trenches shall be done as per the Employer's Requirement specified elsewhere.

6.13 Unplasticized PVC Pipes and Fittings

Unplasticized polyvinyl chloride pipes, fittings and specials, gaskets shall be conforming to the below mentioned Indian Standards / BS 4346: Part 1 for product water.

IS:4985	Unplasticized PVC pipes for product water supplies
IS:12235	Methods of test for unplasticized PVC pipes for product water supplies
IS:5382	Rubber sealing rings for gas mains, water mains and sewers
IS:7328	High density polyethylene materials for mouldings and extrusion
IS:10151	PVC and its copolymers for its safe use in contact with foodstuffs, pharmaceuticals, and drinking water
ISO: 2045	Single socket for uPVC and uPVC pressure pipes with elastic sealing ring type joints - Minimum depth of engagement
ISO: 3603	Fittings for PVC pipe with elastic sealing ring joints pressure test for leak proofness

The pipes shall be of the spigot and socket type with approved gasket type flexible joint.

Where PVC pipes, fittings and specials are to be connected to Ductile iron, stainless steel or steel pipes, 'Viking Johnson' type flange adaptors or stepped couplings shall be used.

6.14 Rubber Hosing

Rubber hosing shall conform to BS 5119, Type 2. It shall be capable of handling chlorine and sulphur dioxide solutions at a working pressure of 12 bar.

6.15 Copper Tubes and Fittings

Copper tubing and fittings for work above ground level shall comply with BS 2871 and

BS 864: Part 2 respectively and be jointed with capillary joints. For underground location the copper pipe shall be to BS 2871: Part 1.

6.16 Flanged Joints

All flanges shall comply with BS EN 1092-1. The nominal pressure rating for particular flanges shall be at least equal to the highest-pressure rating of the pipes or fittings to which they are attached, but with a minimum nominal pressure of PN 10. All flanges shall be provided with all necessary nuts, bolts, washers and gaskets. In general, valves shall have flanged body ends.

All flanged joints which are buried or in chambers shall be protected with Densomastic and Densotape wrapping, applied in accordance with the manufacturer's instructions.

Flanges shall be installed on the pipes in the factory and field welding of flanges shall only be allowed with the approval of the Engineer.

Where pipework outside pumping stations and surge vessel chambers is cathodically protected, an insulated flange shall be incorporated at the first flange inside the structure. These flanges shall be tested to ensure that electrical insulation is achieved.

6.17 Gaskets and Joint Rings

Joint rings shall be manufactured to conform to BS 2494 or relevant Indian Standard and shall be of chloroprene rubber or other approved synthetic material suitable for temperatures up to 80°C.

Gaskets may be inside the bolt circle type and shall comply with BS 4865: Part 1. Alternatively the gasket shall be to the full diameter of the flange, drilled to suit the appropriate bolt provisions.

Chloroprene rubber with a hardness of 71 to 80 IRHD shall be used.

Joints shall be made in accordance with manufacturer's instructions or as specified herein.

Until immediately required for incorporation in a joint, each rubber ring or gasket shall be stored in the dark, free from the deleterious effects of heat or cold, and kept flat so as to prevent any part of the rubber being in tension.

Only lubricants recommended by the manufacturer shall be used in connection with rubber rings and these lubricants shall not contain any soluble constituent, shall be suitable for the climatic conditions at the Site and shall contain an approved bactericide.

After cleaning the flanges the gaskets shall be fitted smoothly to the flange and the joint shall be made by tightening the nuts to finger pressure first. Thereafter the final tightening of the nuts shall be made by gradually and evenly tightening bolts in diametrically opposite positions using standard spanners.

Graphite grease shall be applied to the threads of bolts before joints are made.

6.18 Flexible Couplings and Flange Adaptors

Flexible couplings and flange adaptors shall be of the Viking Johnson or similar approved pattern and be assembled in accordance with the manufacturer's instructions and protected, if buried or in chambers with Densomastic and Densotape wrapping applied in accordance with the manufacturers' instructions. Flexible joints shall be harnessed or tied where necessary.

6.19 Storage & Shipment

6.19.1 Protection of Pipes and Fittings for Shipment

Except where otherwise specified all items shall have received their complete protective coatings before dispatch from the manufacturer's works and shall be additionally protected by approved means for the period of transit, storage and erection, against corrosion and accidental damage.

For the protection of pipe linings and in particular for protecting cement mortar linings from drying out, protective metal or timber discs shall be fitted over the ends of pipes and fittings. Similar timber protective discs shall be attached to all flanges of pipes and fittings, by means of bolts specifically provided for the purpose and which shall be discarded when the item is incorporated in the Works. The sleeves and flanges of flexible joints shall be wired together in suitable bundles.

6.19.2 Storage of Pipeline Materials

Pipes and fittings shall be stored raised off the ground, and shall be carefully supported, cushioned and wedged. Pipes shall not rest directly on one another and shall not be stacked more than four pipes high or two pipes high in the case of pipes of 500 mm diameter or over. Special care shall be taken to ensure that flexible pipes are cradled and supported in a manner that prevents any distortion of the pipes.

Couplings and joints (and all components thereof) and other similar items shall be stored in dry conditions, raised from the ground in sheds or covered areas.

Storage areas shall be carefully set out to facilitate unloading, and checking of materials with different consignments stacked or stored separately with identification marks clearly visible.

Where items to be stored have a limited shelf life or require special storage arrangements, the method of storage shall be to the approval of the Engineer and in accordance with the manufacturer's instructions.

All pipes and fittings supplied as spares shall have end covers which are proof against the entry of sand and vermin. Mortar lined pipes and fittings shall have end covers which form a complete seal, provision being made to accommodate the effects of temperature changes. Pipes and fittings supplied as spares shall have a temporary white external finish and shall be stored sheltered from the direct rays of the sun.

End covers and protection shall not be removed until incorporation of the pipes and fittings into

the Works.

6.19.3 Transportation of Pipes and Fittings

Any vehicle on which pipes are transported shall have a body of such length that the pipes do not overhang. Large pipes shall be placed on cradles and the loads properly secured during transit. The pipes shall be handled in accordance with the manufacturer's recommendations.

Approved slings shall be used and all hooks and dogs and other metal devices shall be well padded. Hooks engaged on the inner wall surface at pipe ends shall not be used. Steadyng ropes shall be employed. The positions of lifting slings shall ensure that stresses and tendency towards deformation in the pipes are kept at a minimum.

Pipe handling equipment shall be maintained in good repair and any equipment which in the opinion of the Engineer may cause damage to the pipes shall be discarded. Under no circumstances shall pipes be dropped, be allowed to strike one other, be rolled freely or dragged along the ground.

6.20 Inspection of Pipes and Fittings

Before incorporating into the Works each pipe shall be brushed out and carefully examined for soundness. Damaged pipes, which in the opinion of the Engineer cannot be satisfactorily repaired, shall be rejected and removed from Site.

Damage to pipe coatings or linings shall be repaired to the satisfaction of the Engineer.

6.21 Built-in Pipework and other Plant

The pipes and other Plant in water retaining structures shall, wherever possible, be built in as the work on the structure proceeds. The Contractor shall ensure that delivery of the requisite pipe-work and other Plant is in accordance with the requirements of the programme.

Where a pipe subject to thrust passes through a concrete structure or where an external seal is required, a puddle flange shall be used. The puddle flange dimensions shall be to BS EN 1092-1 but shall be undrilled. The exterior of the pipe shall be cement washed symmetrically about the puddle flange by the manufacturer for a length at least equivalent to the thickness of the wall through which it passes.

The Contractor shall be responsible through every stage of the Works for checking the correctness of the setting of built-in Plant and shall satisfy himself they are positioned in accordance with his approved drawings.

6.22 Pipe Laying

6.22.1 Carting & Handling

Pipes and fittings /specials shall be transported from the factory to the work sites at places along the alignment of pipeline as directed by the Engineer. Contractor shall be responsible for the safety of pipes and fittings/specials in transit, loading/unloading. Every care shall be exercised

in handling pipes and fittings/specials to avoid damage. While unloading, the pipes and fittings/specials shall not be thrown down from the truck on to hard surfaces. They should be unloaded on timber skids with steadyng ropes or by any other approved means. Padding shall be provided between coated pipes, fittings/specials and timber skids to avoid damage to the coating. Suitable gaps between pipes should be left at intervals in order to permit access from one side to other. In case of spigot socket pipes, care should be taken regarding orientation of pipes while unloading. As far as possible, pipes shall be unloaded on one side of the trench only. The pipes shall be checked for any visible damage (such as broken edges, cracking or spalling of pipe) while unloading and shall be sorted out for reclamation. Any pipe which shows sufficient damage to preclude it from being used shall be discarded. Dragging of pipes and fittings/specials along concrete and similar pavement with hard surfaces shall be prohibited.

6.22.2 Storage

Each stack of pipes shall contain only pipes of same class and size, with consignment or batch number marked on it with particulars of suppliers wherever possible. Storage shall be done on firm level and clean ground and wedges shall be provided at the bottom layer to keep the stack stable. The stack shall be in pyramid shape or the pipes placed lengthwise and crosswise in alternate layers. The pyramid stack shall be made for smaller diameter pipes for conserving space in storing them. The height of the stock shall not exceed 1.5 m.

Fittings/Specials shall be stacked under cover and separated from pipes.

Rubber rings shall be stored in a clean, cool store away from windows, boiler, electrical equipment and petrol, oils or other chemicals. Particularly in the field, where the rubber rings are being used, it is desirable that they are not left out on the ground in the sun or overnight under heavy frost or snow conditions.

6.22.3 Laying

6.22.3.1 Excavation

Before excavating the trench the alignment of pipeline shall be approved by the Engineer. The excavation of trenches and pits for manholes/ chambers shall be carried out in accordance with the Employer's Requirement described elsewhere and shall be done such that it does not get far ahead of the laying operation as approved by the Engineer.

To protect persons from injury and to avoid damage to property, adequate barricades, construction signs, red lanterns and guards as required shall be placed and maintained during the progress of the construction work and until it is safe for the traffic to use the roadways. The relevant Indian Standards and the rules and regulations of local authorities in regard to safety provisions shall be observed.

Suitable fencing shall be provided along the sides of trenches and pits. The posts of fencing shall be of timber securely fixed in the ground not more than 3 m apart and they shall not be less than 75 mm in diameter or less than 1.2m above surface of the ground. There shall be two rails, one near the top of the post and the other about 450mm above the ground and each shall be from

50mm to 70mm in diameter and sufficiently long to run from post to post to which they shall be bound with strong rope. The method of projecting rails beyond the post and tying them together where they meet shall not be allowed on any account. All along the edges of the excavation trenches, a bank of earth about 1.2 m high shall be formed, where required by the Engineer for further protection.

The road metal and also the rubble packing shall first be stripped off for the whole width of the trench/pit and separately deposited in such place or places as may be determined by the Engineer.

During excavation, large stones and rubble shall be separated and removed from the excavated soil and stacked separately. The material from excavation shall be deposited on either side of the trench leaving adequate clear distance from the edges of the trench and pit, or as may be necessary to prevent the sides of the trench pit to slip or fall, or at such a distance and in such a manner as to avoid covering fire hydrants, sluice valves, manholes and covers etc. and so as to avoid abutting the wall or structure or causing inconvenience to the public and other service organizations or otherwise as the Engineer may direct.

Contractor shall take into account additional excavation if any as the Engineer may require in order locating the position of water pipes, drains, sewers etc. or any other works which may be met with, in or about the excavation of trenches/pits while quoting the rates of excavation. Such service lines if met with during excavation shall be properly maintained by Contractor, by means of shoring, strutting, planking over, padding or otherwise as the Engineer may direct, and shall be protected by the Contractor from damage during the progress of the work. All precautions shall be taken during excavation and laying operations to guard against possible damage to any existing structure /pipeline of water, gas, sewage etc.

Utmost care shall be taken to see that the width of the trench at the top of pipe is not more than the minimum requirement. In case additional width is required it shall be provided only in the top portion from the ground level up to 300 mm above the top of pipe. If any extra width is provided in the area below this portion, Contractor shall have to provide remedial measures in the form of lime concrete or rubble masonry otherwise at the discretion and to the satisfaction of the Engineer. If rock is met with, it shall be removed to 15 cm below the bottom of pipes and fittings/specials and the space resulting shall be refilled with granular materials and properly consolidated. Bottom of trenches/pits shall be saturated with water and well rammed wherever the Engineer may consider it necessary to do so.

Wherever a socket or collar of pipe or fitting/ special occurs, a grip is to be cut in the bottom of the trench or concrete bed to a depth of at least 75 mm below the bed of the pipe so that the pipe may have a fair bearing on its shaft and does not rest upon its socket. Such grip shall be of sufficient size in every respect to admit the hand all around the socket in order to make the joint and the grip shall be maintained clear until the joint has been approved by the Engineer.

When welding is to be carried out with the pipes and specials in the trench, additional excavation of not more than 60 cm in depth and 90 cm in length shall be made at joints in order to facilitate welding.

The excess excavated material shall be carried away from site of works to a place up to a distance as directed by the Engineer. This shall be done immediately so as not to cause any inconvenience to the public or traffic. If the instructions from Engineer are not implemented within seven days from the date of instructions to cart the materials and to clear the site, the same shall be carried out by the Engineer at the cost of Contractor and any claim or dispute shall not be entertained in this respect.

6.22.3.2 Dewatering

During the excavation, if subsoil water is met with, Contractor shall provide necessary equipment and labourers for dewatering the trenches. The Contractor shall also make necessary arrangement for the disposal of drained water to nearby storm water drain or in a pit if allowed by the Engineer. In no case the water shall be allowed to spread over the adjoining area. Before discharging this water into public sewer/drain, the Contractor shall take necessary permission from the local authorities.

6.22.3.3 Special Foundation in Poor Soil

Where the bottom of the trench and sub grade is found to consist of material which is unstable to such a degree that in the opinion of the Engineer, it cannot be removed and replaced with an approved material thoroughly compacted in place to support the pipe properly, a suitable foundation for the pipes, consisting of piling, timbers or other materials, in accordance with relevant drawings to be prepared by the Contractor and as instructed by the Engineer shall be constructed.

6.22.3.4 Wooden Shoring

Contractor shall suitably design polling boards, waling and struts to meet different soil conditions that might be encountered in excavating trenches/pits. The horizontal and vertical spacing of struts shall be such that not only the sides of trenches shall be prevented from collapse but also easy lowering of pipe in trenches shall be ensured without creating undue obstructions for the excavation of the work. Any inconvenience and/or delay that might be caused in lowering pipes in trenches, as a result of adopting improper spacing of struts by the Contractor, shall be his sole responsibility. No part of shoring shall at any time be removed by Contractor without obtaining permission from the Engineer. While taking out shoring planks the hollows of any form must simultaneously be filled in with soft earth well rammed with rammers and with water.

The Engineer may order portions of shoring to be left in the trenches /pits at such places, where it is found absolutely necessary to do so to avoid any damage which may be caused to buildings, cables, gas mains, water mains, sewers etc. in close proximity of the excavation, by pulling out the shoring from the excavations. The Contractor shall not claim on any reason whatsoever, for the shoring which may have been left in by him at his own discretion.

6.22.3.5 Steel Plate Shoring

Where the subsoil conditions are expected to be of a soft and unstable character in trench/pit excavation, the normal method of timbering may prove insufficient to avoid subsidence of the

adjoining road surfaces and other services. In such circumstances, the Contractor shall be required to use steel trench sheeting or sheet piling adequately supported by timber struts, waling etc., as per the instructions, manner and method directed by the Engineer. Contractor shall supply pitch, drive and subsequently remove trench sheeting or piling in accordance with other items of the Engineer's Requirements.

6.22.3.6 Boning Staves and Sight Rails

In laying the pipes and fittings/specials the centre for each manhole/chamber or pipeline shall be marked by a peg. Contractor shall dig holes for and set up two posts (about 100 x 100 x 1800 mm) at each manhole/chamber or junction of pipelines at nearly equal distance from the peg and at sufficient distances there from to be well clear of all intended excavation, so arranged that a sight rail when fixed at a certain level against the post shall cross the centre line of the manhole/chamber or pipelines. The sight rail shall not in any case be more than 30 m apart; intermediate rails shall be put up if directed by the Engineer.

Boning staves of 75 mm x 50 mm size shall be prepared by Contractor in various lengths, each length being of a certain whole number of metres and with a fixed tee head and fixed intermediate cross pieces, each about 300 mm long. The top-edge of the cross piece must be fixed below the top-edge of the tee-head at a distance equal to the outside diameter of the pipe or the thickness of the concrete bed to be laid as the case may be. The top of cross pieces shall indicate different levels such as excavation for pipeline, top of concrete bed, top of the pipe etc. as the case may be.

The sight rail of size 250 mm x 40 mm shall be screwed with the top edge resting against the level marks. The center line of the pipe shall be marked on the rail and this mark shall denote also the meeting point of the center lines of any converging pipes. A line drawn from the top edge of one rail to the top edge of the next rail shall be vertically parallel with the bed of the pipe, and the depth of the bed of pipe at any intermediate point may be determined by letting down the selected boning staff until the tee head comes in the line of sight from rail to rail.

The post and rails shall be perfectly square and planed smooth on all sides and edges. The rails shall be painted white on both sides, and the tee-heads and cross-piece of the boning staves shall be painted black.

For the pipes converging to a manhole/chamber at various levels, there shall be a rail fixed for every different level. When a rail comes within 0.60 m of the surface of the ground, a higher sight-rail shall be fixed for use with the rail over the next point.

The posts and rails shall in no case be removed until the trench is excavated, the pipes are laid and the Engineer gives permission to proceed with the backfilling.

6.22.3.7 Laying of Pipes and Fittings/Specials

All precautions shall be taken during excavation and laying operations to guard against possible damage to any existing structure/pipeline of water, gas, sewage etc. After excavation of trenches, pipes shall not be lowered unless the dimensions of trenches and bedding work for pipes at the

bottom of the trenches are approved and measured by Engineer's Representative. Pipes and fittings/specials shall be carefully lowered in the trenches. Special arrangements such as cranes, tripods with chain pulley block for lowering the pipes and fittings/specials shall be made by Contractor. In no case pipes and fittings/specials shall be dropped. Slings of canvas or equally non-abrasive material of suitable width or special attachment to fit the ends of pipes and fittings/specials shall be used to lift and lower the coated pipes and fittings/specials. The pipes and fittings /specials shall be inspected for defects and be rung with a light hammer preferably while suspended to detect cracks. If doubt persists, further confirmation shall be done by pouring a little kerosene/dye on the inside of the pipe at the suspected spot. No sign of kerosene/dye should appear on the outside surface. Pipes and fittings/specials damaged during lowering or aligning shall be rejected by the Engineer.

All the pipes are to be laid perfectly true both in alignment and to gradient specified. In case of spigot and socket pipes, the socket end of the pipe shall face upstream when laid on level ground, when the pipeline runs uphill, the socket ends should face the upgrade. The laying of pipes shall always proceed upgrade of a slope. After placing a pipe in the trench, the spigot end shall be centered in the socket and the pipe forced home and aligned to required gradient. The pipes shall be secured in place with approved backfill material tamped under it except at the socket. Pipes and fittings/specials which do not allow a sufficient and uniform space for joints shall be removed and replaced with pipes and fittings/specials of proper dimensions to ensure such uniform space. Precautions shall be taken to prevent dirt from entering the jointing space. At times when pipe laying is not in progress, the open ends of pipe shall be closed by a watertight plug or other means approved by the Engineer. During the period that the plug is on, the Contractor shall take proper precautions against floating of the pipe owing to entry of water into the trench. Wherever it is necessary to deflect pipe from a straight line, either in the vertical or horizontal plane, to avoid obstructions or where long radius curves are permitted the deflection allowed at joints shall not exceed $2\frac{1}{2}^{\circ}$. In case of pipes, with joint to be made with loose collars, the collars shall be slipped on before the next pipe is laid. The pipes shall be laid such that the marking on pipes appears at the top of the pipes.

The cutting of pipe for inserting valves, fittings, or specials shall be done in a neat and workman like manner without damage to the pipe so as to leave a smooth end at right angles to the axis of the pipe. For this purpose, pipe cutting machine shall be used.

6.22.3.8 Thrust Blocks

Thrust blocks shall be provided, to counteract hydraulic thrust, after due calculations of thrust force and the size of the thrust block wherever required.

6.22.3.9 Jointing

Jointing for pipes and fittings/specials shall be done in accordance with the relevant Employer's Requirement depending upon the type of pipes being used.

6.22.3.10 Testing and Commissioning

Testing and commissioning of pipes shall be done in accordance with the relevant Employer's

Requirement.

6.22.3.11 Backfilling

On completion of the pipe laying operations in any section, for a length of about 100 m and while further work is still in progress, refilling of trenches shall be started by the Contractor with a view of restricting the length of open trenches. Pipe laying shall closely follow the progress of trench excavation and the Contractor shall not permit unreasonably excessive lengths of trench excavation to remain open while awaiting testing of the pipeline. If the Engineer considers that the Contractor is not complying with any of the foregoing requirements, he may prohibit further trench excavation until he is satisfied with the progress of laying and testing of pipes and refilling of trenches. Filling to a level of 300 mm above the crown of the pipe shall be done in accordance with the requirements of the clause on bedding. Care shall be taken during backfilling, not to injure or disturb the pipes, joints or coating. Filling shall be carried out simultaneously on both sides of the pipes so that unequal pressure does not occur. Walking or working on the completed pipeline shall not be permitted unless the trench has been filled with the instructed bedding and surround material up to height of at least 300 mm over the top of the pipe except as may be necessary for tamping etc., during backfilling work.

The remaining portion of the trench shall be filled in with selected excavated material free from and topsoil, vegetation or boulders and clods of earth larger than 75 mm in size. Filling shall be done in layers not exceeding 150 mm in thickness accompanied by adequate watering, ramming etc., so as to be compacted to 90% of the maximum dry density as per Part 7 of IS:2720. The water contents of the soil shall be kept as near the optimum moisture content as possible. The trench shall be refilled so as to build up to the original ground level, keeping due allowance for subsequent settlement likely to take place. The surface of the refilled excavations shall be left slightly higher than the adjacent ground and be maintained by the Contractor to a smooth even slope.

The Engineer shall, at all times, have powers to decide which portion of the excavated materials shall be used for filling and in which portion of the site and in what manner it shall be so used.

If suitable material for refilling is not available from already excavated material, the Contractor shall import material of approved quality as directed by the Engineer.

Regular measurement of the field dry density shall be taken by the Contractor at various levels in the backfilling as required by the Engineer.

No mechanical plant other than approved compacting equipment shall run over or operate within the trench until backfilling has reached its final level or the approval for the Engineer has been obtained.

Should any subsidence take place either in the filling of the trenches or near about it during the works the Contractor shall make good the same at his own cost.

Surplus excavated material shall be used to fill in any low spots above the pipeline which are identified on the Drawings or are instructed by the Engineer. Such material shall be evenly

placed and compacted in layers not exceeding 200 mm thick after compaction. The method of compaction employed shall achieve not less than 90% maximum dry density as determined from IS:2720 (Part 7). Unless approved of by the Engineer, the width of areas to be filled shall not exceed 20m.

6.22.3.12 Reinstatement of Road/Footpath

Reinstatement of road/footpath shall be done as per the requirements of local authorities and the Employer's Requirement after completion of work.

6.22.3.13 Clearing of Site

All surplus materials, and all tools and temporary structures shall be removed from the site as directed by the Engineer and the construction site left clean to the satisfaction of the Engineer.

CHAPTER - 7

7. MECHANICAL REQUIREMENTS

7.1 Introduction

This part of the Employer's Requirements sets out the general standards for mechanical Plant used by the Contractor for the Works. Reference to any specific item does not necessarily imply that such plant is to be included in the Works. All Plant used for the Works shall, unless otherwise specified, comply with the provisions of this part. However, nothing in this Specification shall remove the Contractor's obligation from drawing the attention of the Employer's Representative to any feature of the Works which is not consistent with safety, or prevent him making proposals for incorporating equipment or designs which would increase the safety of plant equipment. In case the material of construction or type specified in this document for any equipment is not suitable for the particular use, it shall be changed by the Engineer/ Employer's representative during review of the specification at the time of procurement of the equipment. The Contractor shall ensure that the whole of the Works as installed is safe for use by the operating and maintenance staff, and by any other persons having access thereto. Guards, electrical safety devices, thermal insulation, noise-supervision devices, written notices, safety colours and the like shall be provided where necessary during erection permanently. The equipment layouts shall provide easy and safe assess to all operating devices, free from hazardous obstructions.

7.2 Noise Level and Vibration Limits

The noise level produced by any equipment like blowers, compressor sets, etc. shall not exceed 85 dBA measured at a distance of 1.0 m from the outer surface of the equipment. At the time of operation, the mechanical vibration of all rotating equipment shall not exceed the limits given in the Table below, at recommended points of measurement as per ISO 10816:1995.

Table 7-1: Vibration Limits

Equipment	Velocity of Vibration mm/sec
All rotating equipment not having reciprocating parts with motor kW less than or equal to 15 kW	1.12
All rotating equipment not having reciprocating parts with motor kW more than 15 KW and less than or equal to 75 kW	1.8
All rotating equipment not having reciprocating parts with motor kW greater than 75 kW	2.8

7.3 Design Criteria for Pumping Stations

The submergence shall be based on Hydraulic Institute Standard and American National

Standards for Intake. A baffle wall or other suitable corrective arrangement as recommended in Hydraulic Institute Standard, Pump handbook by Karassik or other recognised literature shall be provided in the suction sump to break vortices.

Level switches and indicators shall be provided for automatic start and stop operation of pumps. Necessary switches/alarms required for safe operation of plant shall be provided. Instruments provided shall be compatible with SCADA/DCS.

The clearance between pumps/piping/valves shall be not less than 900 mm. The total head of the pump shall be selected considering combined flow and mean design level in the wet well for normal conditions of operation, and checked for entire operating head range for satisfactory operation under extreme conditions of operation i.e. single pump operation at maximum WL and all duty pump operation in parallel corresponding to lowest WL. The pump capacity and head shall be selected such that the total pump output is as per design flow and the pump is suitable for the entire head range.

A minimum 15% margin over the power input to pump at duty point or 10% margin above maximum power input to the pump over the entire operating head range, whichever is higher shall be kept while selecting the motor rating.

Flanged pipe shall be provided at pump delivery. The pump delivery pipe shall be connected from side of the header. Dismantling joint suitable for pump duty shall be provided at pump delivery valves for ease of installation and dismantling.

Pump delivery butterfly valves shall be with electric actuators as these are to be opened and closed when pumps are started and stopped.

Quick closing dual plate check valve shall be provided at pump delivery pipe to prevent back flow. The check valve shall be located between pump and delivery valve.

Electrically operated travelling (EOT) crane or manually operated travelling (HOT) crane shall be provided as specified.

Ventilation shall be provided for the pumping stations based on six air changes per hour or to restrict temperature rise to 5°C above the shed temperature considering the heat dissipation of motor and installed equipment.

The design, materials, construction, manufacturing, inspection, testing and performance of all equipment shall comply with all currently applicable statutes, regulations and safety codes where the equipment is to be installed. The equipment shall also conform to the latest applicable Indian or equivalent standards for the type of water to be handled. Other International standards are also acceptable, if these are established to be equal or superior to the listed standards. Nothing in this specification shall be construed to relieve the Contractor of his responsibility to provide the appropriate equipment in all respect for the use.

7.4 Pumps

The pump shall be centrifugal, or VT pump as specified. Pumps shall be selected considering the fluid being pumped, using appropriate IS or international standard as appropriate.

Baffle wall shall be provided in the suction sump to prevent the sucking of air by the pumps when free fall of liquid occurs. Level switch and indicators shall be provided for automatic start and stop operation of pumps. Necessary switches/ alarms required for safe operation of plant shall be provided. Instruments provided shall be compatible with SCADA/DCS, when implemented in future.

The clearance between pumps/piping/valves shall be not less than 1000 mm. + 5% margin on the pump capacity shall be provided for all the pumps. The total head of the pump shall be selected considering peak flow and maximum design level in the wet well for normal conditions of operation and checked for satisfactory operation under extreme conditions of operation. The pump capacity and head shall be selected such that the total pump output is in excess of the design flow to ensure free flow at all flow conditions.

Flanged connection will be provided at pump delivery. The pump delivery pipe will be connected from side of the header.

Pump delivery Butterfly valves will be with auto actuators as these are to be opened and closed remotely when pumps are started and stopped for valves mainly bigger than DN 400 mm.

Quick closing Dual Plate check valve will be provided at pump delivery pipe to prevent back flow. Pumping stations requiring handling equipment up to 1 ton will be with manually operated travelling crane/hoist. Pumping stations requiring above 1 ton will be with electrically operated travelling crane (EOT).

Minimum velocity in rising main shall be 0.6 m/sec while operating one pump and maximum 2.0 m/sec while operating all working pumps will be ensured.

Electromagnetic full-bore Flow Meter, Dual Plate check valve, Butterfly valve with actuator (where required), and air valves (where needed) shall be provided on rising main outside the pumping station.

Ventilation shall be provided for the pumping station based on 6 air changes per hour.

The design, materials, construction, manufacturing, inspection, testing and performance of all equipment including pumps shall comply with all currently applicable statutes, regulations and safety codes in the locality where the equipment will be installed. The equipment shall also conform to the latest applicable Indian or equivalent standards. Other International standards are also acceptable, if these are established to be equal or superior to the listed standards. Nothing in this specification shall be construed to relieve the Contractor of this responsibility. Pumps shall be designed so that the impellers and other accessories of the pump is not damaged due to flow reversal. All pumps (casing, shaft and impeller) in contact of seawater shall be made of super duplex steel with PREN>41 and for product water with SS316.

For calculating the pump head, at-least 10% margin shall be taken over the pipe frictional losses.

List of Applicable Standards

IS: 1710 : Vertical Turbine Pumps for clear cold fresh water.

IS: 5120 : Technical requirement of rotor dynamic special purpose pumps.

HIS : Hydraulic Institute Standards U.S.A.

API: 610 : Centrifugal pumps for general refinery purposes.

IS: 1520 : Horizontal Centrifugal Pumps for clear cold fresh water.

IS: 5639 : Pumps Handling Chemicals & corrosion liquids.

IS: 5659 : Pumps for process water

ISO 5199: Technical specifications for centrifugal pumps -- Class II

ISO 9906: Roto dynamic pumps - Hydraulic performance acceptance tests -- Grades 1, 2 and 3

IS 9137: Code for acceptance tests for centrifugal, mixed flow and axial pumps - Class C

ASTM-l-165-65- Standard Methods for Liquid Penetration Inspection

In case of any contradiction with aforesaid standards and the stipulations as per technical specifications as specified hereinafter the stipulations of the technical proposal shall prevail unless the proposed material or type of the item is inferior to the aforesaid standards.

7.4.1 Centrifugal Pumps

Pumps shall generally comply with the requirements of standard codes as above. Pumps shall be so selected as to have a maximum capacity of not less than 125% of the rated capacity. Pump sets shall be suitable for the required duty conditions and shall be designed and constructed for 24-hours' continuous duty at full load.

Each pump shall be subject to performance test at the manufacture's work under near actual site conditions as far as possible as per ISO 9906.

7.4.1.1 Design Features

The pumps shall be designed for continuous operation at any point of the head capacity curve between 25% and 125% of pump rated flow without undue vibration or overheating.

Centrifugal pumps shall have stable head/quantity characteristics, which fall continuously from the maximum pressure at closed valve conditions. The design speed of any pump shall not exceed 1500 rpm (synchronous).

Pumps of a particular category shall be identical and shall be suitable for parallel operations with equal load distribution. The head Vs Capacity and BHP Vs Capacity Characteristics should match to ensure load sharing and trouble-free operations throughout the range. Components of identical pumps shall be interchangeable.

The pump shall preferably horizontal split casing with double suction impeller. Horizontal end suction pump shall be accepted in exceptional cases and only when horizontal split casing pumps are not in manufacturing range. The number of stages should not exceed two numbers.

The direction of rotation shall be clearly marked on the pump. Waterways through the pump shall be smooth in finish and free from recesses and obstructions. Impeller passageways shall be as large as possible. The leading edges of the impeller vanes shall be rounded and smooth.

Water velocities in the pump suction side shall not exceed 1.5 m/s and on delivery branches of a pump the velocity shall not exceed 2.0 m/s and within working range there shall be no discernible noise due to hydraulic turbulence or cavitation within either the pump or its associated pipe-work and valves.

The NPSH requirements of the pumps, based on the 3% output drop criterion shall be at least 2 m less than the NPSH available at every working condition.

Pumps shall run smooth without undue noise and vibration. Noise level produced individually or collectively shall not exceed 65 dB(A) measured at a distance of 1.0 meters from the source in any direction.

All parts exposed to wear shall be adequately protected by means of renewable sleeves, bushes, wear rings etc. which shall be arranged for easy inspection, adjustment, or replacement without removal of the pump casings, pipe-work etc. or the need to disturb the drive shaft alignment.

The pump thrust shall be taken by a combined thrust and radial type bearing assembly capable of taking the weight of the moving parts and the hydraulic loads under all conditions of operation with a minimum life of 100000 hours.

The pump casing and other parts of the pump subject to pressure shall be hydraulically tested by the manufacturer to at least one and a half times the shut off head.

Integral inlet and discharge flanges shall be provided, and integral lifting lugs shall be incorporated. Facilities shall be provided for the removal of air during priming and for draining. The pump may be fitted with mechanical seals or conventional soft packing. The arrangement shall be designed for easy adjustment and removal of the seal. When soft packed glands are used, suitable means shall be provided for collecting and preventing splashing of the gland leakage water. Drainage and gland leakage water shall be piped into the building drainage system. The shafts of pumps fitted with conventional packed glands shall be fitted with removable gland sleeves.

The rotating element of the pump and the motor shall be readily removable from the pump casing without the need to disconnect the adjoining pipework. The pump casing and other parts of the pump subject to pressure shall be hydraulically tested by the manufacturer to at least one and a half times (1.5 times) the maximum working pressure.

Rotating assemblies of pumps of 100 mm diameter inlet and over shall be statically and dynamically balanced and shall be designed so that the first critical speed is at least 50% greater than the maximum operating speed.

Lubrication arrangements shall be so designed that there is no contamination of the pumped fluid.

The pumps shall be horizontally mounted complete with drive motor on a common base plate. The pump/drive coupling shall be of flexible rubber bushing to facilitate removal of the pump rotating element and bearing housing without dismantling the pump casing, adjoining pipe-work or drive motor. End suction pumps may be used for filter backwash, chlorination motive water and service water pumping applications etc.

The dimensions of the pump shall be metric conforming to applicable IS. The velocity at the entrance to the pump impeller shall not exceed 3.5 m/s. The bedplate shall be of substantial fabricated steel construction with floor fixing bolt holes ready drilled. All holding down bolts etc. shall be supplied with the units.

The pumps and associated pipe-work shall be, wherever possible, arranged so that air can be completely expelled during priming. Where this is not possible, facilities shall be provided for the removal of the trapped air. Adequate facilities shall be provided for drainage of the pumps for inspection purposes.

Tapping shall be provided at both the suction and discharge flanges for pressure gauge equipment.

The minimum motor rating shall be larger of the following:

- a) 115% of the power requirement by pump at duty point
- b) 105% of the power input within any operating point between minimum and maximum resistance curves.

7.4.1.2 Construction Features

The pump shall be single stage double suction (split casing) type. Thrust bearing antifriction type at one end to take up thrust, should be provided in addition to bush bearings, if required.

In addition to static balancing, impeller and balancing drum shall be balanced dynamically at or near the operating speed. The impeller shall be keyed to the shaft and held tight. The impeller/s shall be independently retained against thrust (no applicable at submersible pumps). In case of impellers which are held tight by lock nuts and washer, the direction of threads of the shaft and nut shall be such that the nut shall tend to get tightened when the impeller is in motion. Pump shall be provided with renewable type casing ring.

Pump having capacity 1,000 m³/h and above, in case pump is provided with impeller wearing ring in addition to casing ring. The hardness of impeller ring shall be 50 BHN higher than that of casing ring.

Individual impellers and completed rotor assembly shall be subject to static and dynamic balancing test (as per ISO 1940 or JIS 0905 G6.3 or equivalent).

The casing shall be tested to withstand a pressure of 1.5 times the shut off pressure or twice the rated pressure whichever is higher. Delivery flange shall be as per ANSI B16.5

Bearing shall be oil-lubricated or grease-lubricated and shall have a life of 100,000 hours of working. In case of oil-lubricated bearing, constant oil leveller with magnetic drain plug shall be provided Replaceable shaft sleeves shall be provided to protect the shaft where it passes through stuffing box Stuffing box shall be of such design that it can be repacked without removing any part other than the gland and lantern ring. Mechanical seals shall be provided if needed. If required, a flushing line shall be furnished, complete with strainer and orifice, from the pump discharge to the sealing face. When pumping liquid is not suitable for this purpose, a flushing connection shall be provided so that it can be

connected to an external source. Auxiliary piping and plan shall be in accordance with Appendix - D of API 610.

For better efficiency Special Surface Treatment shall be provided to the inner surface of pump casing, if it is required for design conditions. The coating used for bringing about efficiency improvement shall be polymer-based system, which is a cold cured highly modified chemically resistant, two-pack resin system filled with stabilizing enforcement to improve flow characteristics.

The casing shall be provided with priming funnel and air release vent, Tapping shall be provided for installing suction and delivery pressure gauges. Each pump should be provided with combination gauge on suction side and suitable pressure gauge on delivery side. Gland leakage shall be laid to the channel provided in the pump house by bleeding SS-316L pipes.

All forging and casting shall be subject to 100 % UT or RT and MPE or DPT check, all welding subject to 100% UT or RT as per ASME sec VIII.

Impellers

Impeller shall be double suction enclosed type/ semi-enclosed as per usage specified, and balanced both statically and dynamically. Renewable wearing rings shall be provided on both impeller and casing, when required.

Pump Shaft

The critical speed of the pumps shall not be less than 130% of the normal operating speed of the pump.

The shaft shall be of one-piece construction solid type and will be designed to take all types of loads such as torsion, tensile, bending and dynamic etc. The pump shaft shall be hard chrome plated steel or alloy steel (SS-420) for pumps not in contact with seawater /brine. Super-duplex PREN > 41 shall be used for pumps in contact with seawater/brine as per the manufacturer's standard. Sleeves shall be of stainless-steel SS 316 L. The shaft be ground and polished to final dimensions and shall be adequately sized to withstand all stress from rotor weight, hydraulic loads, vibration and torque coming during operations.

Shaft Sleeves shall be fastened to the shaft to prevent any leakage or loosening. Shaft and Shaft Sleeve assembly should ensure concentric rotation. The impellers and shaft sleeves shall be secured to the shaft by means of a key or keys. The impeller retaining nut shall be fitted with a locking device. For product water, the pump casing shall be of Cast iron to IS:210 Gr. FG260, wearing rings shall be of Bronze to IS:318 Gr. LTB2 and shaft sleeve shall be of stainless steel to ASTM A 743 CA 15.

Pump Bearings

Pump bearings shall be of the antifriction type or plain bearing. The bearings shall be able to take normal thrust loads due to unbalanced hydraulic loads on the impellers plus the weight of all rotating parts of the pumps. Pump bearings shall be designed with a minimum life of 100,000 hours of continuous operations at maximum axial and radial loads and rated speed. Bearings

shall be easily accessible without disturbing the pump assembly. A drain plug shall be provided at the bottom of each bearing housing.

Proper lubricating arrangements for the bearings shall be provided such that lubricating element doesn't contaminate the liquid pumped.

Flexible Coupling:

The pump shaft shall be coupled to motor shaft through flexible coupling. The coupling shall comprise pin and rubber bushes or any other better than the proposed. Each half shall be statically and dynamically balanced for transmission of the power without vibration and shall be keyed to respective shaft. The coupling halves shall have precise machined surfaces for facilitating alignment. Suitable guard for coupling shall be provided.

Base Plate (Base Frame):

The pump and motor shall be installed on common base plate, to accommodate both pump and motor. Suitable machined sole pieces shall be welded on top of base plate for mounting pump and motor. The base plate shall be constructed from steel channels with suitable coating. The base plate shall be fabricated and supplied by pump manufacturer only. Base plate and pump supports shall be constructed, and the piping unit be so mounted to minimize misalignment caused by mechanical forces such as normal piping strain, internal differential thermal expansion and hydraulic piping strain, internal differential thermal expansion and hydraulic piping thrust. Suitable drain troughs and drip lip shall be provided.

Assembly and Dismantling

Assembly and Dismantling of each pump with drive motor shall be possible without disturbing the grouting base plate or alignment.

7.4.1.3 Material of Construction for Centrifugal Pumps

For HPP, ERD booster, RO and ERD feed Booster Pumps

Pump Casing : Super-duplex PREN ≥ 43

Pump Impeller : Super-duplex PREN ≥ 43

Pump Shaft : Super-duplex PREN ≥ 43

For CIP, Permeate Pumps

Pump Casing : AISI316L

Pump Impeller : AISI316

Pump Shaft : AISI316

For Product water Pumps

Pump Casing : Cast Iron

Pump Impeller : AISI316

Pump Shaft : AISI316

Motor

Motor	: Triphasic squirrel cage rotor
Nominal power (kW)	: As required
Speed (rpm)	: As required
Voltage	: As required
Drive type	: Fixed / Variable frequency (VFD)

7.4.2 Vertical Turbine Pumps

Vertical turbine pumps (VT), shall be with discharge head, column pipes and sole plate. The pump assembly includes pump and motor. The basic components of the pump are discharge head, column pipe and bowl assembly which will be combined and customized to match duty needs. The pump shall be self-water lubricated. Each column pipe shall be of maximum 1.5 m length. Column pipe shall be sized to velocity less than 2.25 m/s.

7.4.2.1 Design Features

The design, manufacture and performance of the VT pump shall comply with all currently applicable statutes, regulations and safety codes in the locality area where the equipment will be installed. The equipment shall also confirm to the latest applicable Indian Standards as under:

IS 1710 Vertical turbine pump for clear water.

IS 5120 Technical requirements for roto-dynamic special purpose pumps.

Pumping assembly including pump and motor shall be designed to operate within vibration and temperature limits specified over the full operation range of the pump performance. Provide pump with number of stages to meet the specified and indicated performance.

Provide room and facilities for inspection, repair and adjustment. Equipment pumping assembly with all specified and required accessories including lifting arrangements and pressure gauges.

Pumps shall generally comply with the requirements of IS: 5120 and IS:9137. Pumps shall be so selected as to have a maximum capacity of not less than 125% of the rated capacity.

Pump sets shall be suitable for the required duty conditions and shall be designed and constructed for 24-hours' continuous duty at full load. The pumps shall be designed for continuous operation at any point of the head capacity curve between 25% and 125% of pump rated flow without undue vibration or overheating. The pump shall be capable of developing the required bowl head at rated capacity for continuous operation.

Pump/Pump Motor shall be suitable for withstanding reverse rotation due to back-flow of water without mechanical damage to any component of the pump. Pumps of a particular category shall be identical and shall be suitable for parallel operation without any possibility of hunting. Components of the identical pumps shall be interchangeable.

For calculating the pump head, at-least 10% margin shall be taken over the pipe frictional losses.

For high flow rate above 2000 m³/h, the pump discharge header shall be kept at the ground floor of the pump house concrete building while motor and MCC to be placed at the first floor to allow more space for the maintenance of pump and motor. The load-bearing mounting of the

pump shall be done at the first floor.

The noise level shall not exceed 65 dBA measured at 1 m from the outline of pump set. Pumps shall be selected so as to have stable characteristics. The total head capacity curve shall be continuously rising towards shut-off, with the highest at shut off. Pumps shall operate at one of the standard motor speeds not exceeding 1000 rpm. The direction of rotation of the pumps shall be clockwise looking from drive-end. The direction of rotation shall be clearly marked on the pump. The critical speed of the pumps shall not be less than 130% of the normal operating speed of the pump. The impeller adjustment shall be such that the impellers run free in any installed condition despite extension of line shaft (caused by hydraulic down-thrust) the weight of shafting and weight of impellers. The minimum motor rating shall be larger of the following:

- a) 115% of the power requirement by pump at duty point
- b) 105% of the power input within any operating point between minimum and maximum resistance curves.

7.4.2.2 Construction Features

Pumps shall be of vertical, wet pit type complete with bowl, column and head assemblies. The bowl assembly shall consist of rotating impellers, which are housed in stationary bowls having guide vanes. The bowl shall also include the housing of the bottom pump shaft bearing. The column assembly shall consist of the column pipe to convey the liquid handled from bowl assembly to head assembly, shaft enclosing tube, if required, and shaft assemblies. If shaft-enclosing tube is called for the line shaft, bearing shall be supported from shaft enclosing tube. If shaft-enclosing tube is not specified, the line shaft bearings shall be supported from the column pipes.

Individual impellers and completed rotor assembly shall be subject to static and dynamic balancing test (as per ISO 1940 or JIS 0905 G6.3 or equivalent).

Head assembly shall consist of the base from which the column shaft assembly is suspended. The discharge can be surface discharge, or an underground discharge as required.

Bell Mouth and Strainer

A bell mouth shall be fitted to the suction nozzle to limit the velocity. Net opening area in strainer shall not be less than 3 times of entrance area of bell mouth. The bowls shall be cast, free from blowholes, sand holes and other detrimental defects.

The bowls shall be equipped with replaceable wearing rings on suction side of enclosed impellers. Liquid passage shall be smooth finished. The bowls shall contain bushes to serve as bearings for the impeller shaft. In case of oil lubricated units, the discharge casing shall be provided with means to prevent the leakage of liquid into the shaft enclosing tube. Suction bell shall be designed for smooth inflow of water with minimum losses. A pump bowl /bowls shall be flanged with machined matching of faces. The bell mouth to bowl assembly, to column and to discharge case i.e. all joints shall be flanged joints.

Impellers and Shaft

The impellers shall be statically and dynamically balanced so as not to cause any vibrations during operation.

The impeller shall be of the enclosed type and shall be properly balanced dynamically. The impeller shall be properly machined, with liquid passage hand finished. Impeller shall be adjustable vertically by means of an adjusting nut in the head assembly. Open impeller shall be offered, if close type is not suitable. In such a case, the pump shall be designed to take care of the additional thrust produced.

The Impeller shaft shall be straight within 0.125 mm for 3 metres length total dial indicator reading. The maximum permissible error in the axial alignment of the thread axis with the axis of the shaft shall be 0.05 mm in 150 mm.

The shaft shall be furnished with interchangeable sections. The butting faces of shaft shall be machined square to the shaft axis and the shaft ends shall be chamfered on the edges. Couplings shall be designed with a safety factor of 1.5 times the shaft safety factor and shall have threads to tighten during pump operation. The shaft shall be properly balanced so as not to cause any vibrations during operation. Line shaft bearings shall be external water or oil lubricated or self-lubricated type. For the self-water lubricated type a pre lubrication connection with all accessories shall be provided to wet the bearings. The selection of material for such bearings shall suit the quality of water to be pumped and suspension length. If shaft-enclosing tube is not specified, the shaft bearings shall be lubricated by the liquid being pumped.

The pumps shaft bearings i.e. bush bearings would be water lubricated. Extra-long bearing shall be provided for suction and discharge bowls. The hardness of bush bearing shall be less by at least 50 BHN than that of shaft.

Wearing Rings

Wearing rings shall be renewable type and shall be provided for both impeller as well as bowl. These shall be held in place by screwing against rotation, press fit or locked with pins, flanged and screwed. Hardness of wearing rings shall be less by at least 50 BHN than the impeller.

Lubrication System

Pumps, shall be self-water lubricated.

Shaft Enclosing Tube and Column Pipe

The standard length of these shall be same as that for the shaft. No part of the column pipe shall exceed the outside diameter of bowl. The size of the column pipe shall be such that the friction loss will be limited to 0.5 M per 10 M of length at rated capacity. The column shaft shall be of Super Duplex with PREN>41 and CF>35.

Discharge Head and Motor Stool

The discharge head shall have an arrow indicating the direction of rotation of shaft. For oil lubricated type, an automatic lubricator shall be installed for electric motor driven pumps and manual or other types of lubricator for engine driven pumps. A tube tension plate shall be

installed on the discharge to tighten up the shaft tubes for the purpose of aligning the shafts. A gland shall be provided at the tube tension plate to seal off any leakage from the discharge head. For water lubricated pumps, the discharge head shall have a stuffing box with a renewable bushing. The discharge elbow shall be designed to directly connect to the discharge pipe without reducer/expander.

It shall incorporate full diameter elbow, mounting flange of motor for solid shaft motor, stuffing box with renewable gland packing, & tapping for pressure gauge mounting etc. The discharge head shall be of robust construction and shall be designed to support entire load of pump assembly, water column and motor etc. & shall withstand all static, dynamic, torsional loads & hydraulic thrust imposed during operation from shut off to stipulated operating conditions and thrust due to change in direction of flow, without any vibrations. The power shall be transmitted from motor to vertical shafting through a flexible coupling. Both halves of the coupling shall be machined all over, securely keyed to their respective shafts. The pins shall be of stainless steels. The arrangement of two halves shall be suitable to check alignment and parallelism. A self-aligning thrust bearing shall be housed in the head gear adequately designed to accommodate entire weight of rotating parts and hydraulic thrust and shall be designed for 100000 hours life. The bearing shall be of oil-lubricated type and shall be provided with oil level gauges and suitably positioned temperature probes. Two sets of adjustable contacts shall be provided, one for an alarm and other for tripping the water pump motor. This shall be connected to scanner panel so the digital temperature can be read out with alarm and tripping.

Motor stool shall be provided for mounting the electric motor. The motor stool shall accommodate the pump thrust bearing and non-reversible ratchet or similar mechanism to prevent pump from rotation in reverse direction.

The motor stool shall be robust construction and of either cast iron or fabricated mild steel and adequately sized with openings to work on the flexible coupling.

Sole Plate

M.S. hot dip galvanized Sole plate arrangement shall be provided under the discharge head for precise horizontal and vertical alignment. Thickness of sole plate shall not be less than 40 mm. It shall be independent of the base plate integral with the discharge head. The contact surfaces of the sole-plate arrangement as under shall be machined for precise levelling and shall ensure vibration free operation of the pump.

All joints between machined contacts surfaces shall be with nut bolts/tapped studs/bolts. All contact surfaces shall be blue matched to ensure proper contact to the extent of 60% of contact area after necessary site finish if required. The opening in the sole-plate/frame shall be of adequate size to pass the bowl assembly etc. very easily. M.S. epoxy coated channels shall be anchored in the floor ensuring complete rigidity. Entire structural fabrication & foundation arrangement shall be designed & submitted for approval. M.S. plates grouted on pump supporting R.C.C. beams are to be provided in civil structure. The anchoring of channels shall be the responsibility of pumping machinery contractor with all related works.

Air Release Arrangement

Arrangement shall be made for release of Air in the column pipes of pumps. A flanged branched tee of required size and an air release Valve shall be provided in the pipe-work after discharge head for automatic air release arrangement. Size of the air-vent valve and piping shall suit the actual requirements of the installation and recommendation of the pump manufacturer. Check valve: Provide a check valve to prevent reverse rotation when stopping.

Driver

Pump shall be complete with base plate and foundation bolts. Pumps and motors shall be mounted on a fabricated common base-frame, on the first floor of the building for large pumps. The base-frame shall be stress relieved after fabrication and machined. The base-frame shall be adequately sized and shall be suitable for fixing coupling guard. Convenient access to the fixing bolts associated with the equipment and base-frame shall be ensured.

Flexible Coupling and Guard

The flexible coupling for connecting the two shaft ends shall be of tyre type conforming to IPSS-1-01-004-95. Removable coupling guards shall also be supplied and mounted. Guards shall be sufficiently heavy and rigid to provide adequate safety.

7.4.2.3 Materials of Construction for VT Pump and Motor

For Seawater Application

Bowl	: Super duplex PREN >41
Suction Bell	: Super duplex PREN >41
Column pipe	: Super duplex PREN >41
Pump Impeller	: Super duplex PREN >41
Pump Shaft	: Super duplex PREN >41
Motor	: Triphasic squirrel cage rotor
Nominal power (kW)	: As required
Voltage	: As required
Drive type	: Fixed / Variable frequency (VFD)

For product water Application:

- a) Pump bowl: Cast iron ASTM A48 Class 30, free from blow- holes, sand-holes and other defect and faults.
- b) Pump shaft: ASTM A126 Type 316 Stainless Steel

Impeller:

- a) Type – Turbine
- b) Bronze ASTM B584 C83600 or C875 or Stainless Steel 316.
- c) Provide a means of impeller adjustment through a top shaft adjusting nut.
- d) Dynamically balanced impeller

Suction Bell: ASTM A48 class 30 cast iron flared inlet, designed for velocity not exceeding 1.4m/sec.

Strainer: A bronze or stainless-steel strainer shall be furnished at the pump suction.

Suction bell bearing: Bronze ASTM 505 Alloy 932 and shall be grease packed.

Provide a sand collar of ASTM 505 C9300 Bronze attached to shaft with stainless steel 316 set screw arrangement.

Provide a suction bowl plug or cap of cast iron.

Intermediate bowl bearings: Provide bronze ASTM 505 Alloy 932 and shall be water lubricated.

Discharge bowl: Provide flanged discharge bowl of ASTM A48 class 30 cast iron

Discharge head:

- a) Type: above ground
- b) Material: ASTM A48 class 30
- c) Provide sole plate of cast iron ASTM A48 class 30 or fabricated steel ASTM A36.

Connections:

- a) Flanged, PN 10 standards.
- b) Provide pump head and base plate design to withstand all thrust conditions imposed by the pump & driver during the operation at the specified conditions and the future conditions.
- c) Provide Neoprene gasket between top column flange and discharge head.
- d) Provide 316 stainless steel guard & hardware.

Column and Shafting:

- a) Type: flanged with open line shaft
- b) Column size: the velocity shall not exceed 2.25 m/sec.
- c) Material ASTM A53 Grade B maximum section length of 300mm
- d) Provide a section of column and shafting to accommodate one future stage.
- e) Pipe thickness shall be in accordance with the AWWA standard.
- f) Line shaft coupling AISI type 316 stainless steel.
- g) Bearing retainer: Bronze ASTM B584 Alloy 836
- h) Line shaft sleeve at bearing: Type 316 stainless steel

Execution: Installation shall be done as per the manufacturer's printed instructions as specified.

7.4.3 Submersible Pumps

Submersible pumps shall be of the single-entry design supplied complete with boltless self-aligning duck-foot (not applicable for drainage /sump pumps) assemblies giving automatic connection to the discharge pipe-work.

Submersible pumps shall be used for thickener feed and waste wash water pumping applications.

For calculating the pump head, at-least 10% margin shall be taken over the pipe frictional losses.

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

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

Pumps shall run smoothly without undue noise & vibration. Noise level shall be limited to 65 dBA at 1.0 m.

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

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

7.4.3.1 Construction Features

- a) Pump shall be centrifugal, vertical spindle, wear resisting, and single stage type.
- b) Pump casing shall be of robust construction. Liquid passages shall be finished smooth and designed as to allow free passage of solids. The volute tongue shall be filed to a smooth rounded edge.
- c) Double mechanical seals shall be provided to protect the motor from ingress of liquid along the shaft. The preliminary and secondary seals shall be oil-lubricated with tungsten carbide or silicon-carbide faces and they shall be equipped with an electrical monitoring system for seal failure detection, for pumps higher than 50 kW. Sensors are to be provided to detect if leakage of liquid into the oil housing is above 30 % concentration.
- d) Impeller shall be non-clog enclosed type with smooth blunt edges and large waterways to allow free passage of the large size solids. It shall be free from sharp corners and projections likely to catch and hold rags and stringy materials. The number of impeller vanes for pumps up to 1000 m³/hr shall be limited to two and shall be limited to three for the pumps higher than 1000 m³/hr.
- e) The critical speed of the rotor shall be at least 20% above the operating speed.
- f) Pump sets shall have double bearings. The bearing life shall be minimum 100,000 hrs of operation.
- g) Each pump shall be complete with a cast iron delivery connection arrangement for fixing to the concrete floor of the suction well. All necessary stainless-steel fixtures required for guiding the pumps during lifting / lowering shall be provided. The installation

shall facilitate automatic installation and removal of pump without a person entering the wet well. Each pump shall be provided with a corrosion resistance material lifting chain with suitable provision for engaging the hook of the crane at 1 m interval.

- h) Each pump shall be provided with an automatic coupling device for attaching the chain pulley block hook to the pump at low level, even whilst the pump is submerged, without the need for personnel to enter the well. This automatic coupling device shall easily and automatically couple and uncouple the hoist hook and be complete with necessary accessories. All links and cables shall be corrosion resistance material.
- i) The submersible pumps shall be suitable for operation with or without submergence.
- j) The synchronous speed shall not exceed 1500 rpm at 50 Hz supply.

Material of construction of seawater shall be mostly super duplex steel with PREN>41 except for high pressure use where it will be PREN>43. Material test certificates shall be furnished by the Contractor and shall have the approval of Employer's Representative.

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

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

7.4.3.2 Materials of Construction

The materials of construction for submersible pumps for product water shall be as follows:

Sl. No.	Component	Material
1	Impeller	Stainless Steel: ASTM A 743 CF8M
2	Casing	Cast Iron to IS:210 Gr. FG 200 with 1.5 to 2% Nickel
3	Shaft	Stainless steel: AISI Gr.316
4	Guide System	Stainless Steel: AISI Gr. 316
5	Fasteners and Foundation Bolts	Stainless Steel: AISI Gr. 316

For seawater use, the Minimum Super Duplex PERN>41 shall be used as applicable for the above components.

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

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

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

7.4.4 Dewatering Pump

The pump motor shall be suitable for working with or without submergence in water/wastewater. The motor rating shall be more than the maximum power required by the pump.

Pump shall be vertical, centrifugal, submersible, non-clog & single stage type. The pump set shall be portable with necessary hooks.

The pump shall have double mechanical seals to prevent ingress of moisture in to the motor. The pump impeller shall be mounted on the extended shaft of the motor. The pump shall be supplied with flexible hose pipe of 80 mm dia. & 50 m length. Suitable cable of 50 M length shall be supplied with the pump.

7.4.5 Sump Drainage Pumps

Sump drainage pumps shall be of the open impeller centrifugal type vertically mounted close coupled to their fully submersible electric drive motors.

Sump pumps of 3 kW and under shall incorporate an integral level detector, control and motor starter and shall be powered only with a suitably fused three-phase or single-phase low voltage supply and with supply isolation at the building distribution board.

Sump pumps over 3 kW shall be controlled and started from the building distribution board and be fed with a 3-phase supply. Control shall be via adjustable float level switches mounted adjacent to the pump. Min. four nos. of Drainage pumps of 125 KW to drain the inlet sump shall be provided in addition to the required drainage pumps as required for proper drainage of site.

The pumps shall be supplied with all necessary discharge pipe-work, including nonreturn and isolating valves and suitable lifting gear for lowering and removing the pump from the sump. Pumps weighing 40 kg and more shall be lowered in the sump via guide rails and be located to their respective discharge pipe-work with an angle flange connection and self-locating clamps.

The pump impeller shall be designed to pass solids of sizes which pass through the inlet ports of the pump and shall be capable of pumping solids of up to 20 mm diameter.

7.4.6 Progressive Cavity Pumps

These pumps shall be used for handling thickened sludge transfer and BFP feed applications.

Pumps shall be of the type in which a pumping action is generated by a helical rotating eccentrically within a resilient stator in the form of a double internal helix. The eccentric motion of the rotor shall maintain a constant seal across the stator as it travels through the pump to give a uniform positive displacement.

Pumps shall be arranged generally with a single shaft seal at the suction end. Mechanical seals shall be used. If a flexible shaft is used to accommodate the eccentric motion, a corrosion resistant shroud shall be fitted to prevent fibre build-up on the shaft. Enlarged inspection access holes shall be fitted to the suction chambers of all pumps for periodic removal of accumulated debris.

For calculating the pump head, at-least 10% margin shall be taken over the pipe frictional losses.

The shaft bearing shall be positively isolated from the fluid being pumped.

The rotor material shall be selected for corrosion and abrasion resistance for the fluid being pumped, and for prolonged service life. Hard chrome or other approved coatings shall be not less than 250-micron thickness and shall be diffused into the base material. The rotor shall generally be single-stage and shall incorporate not less than 360° of twist, but for high-head applications, it may be necessary to use more than a single-stage. The stator shall be of a resilient material selected for chemical and abrasion resistance for the fluid being pumped.

Pump speed shall suit the application, where variable delivery output is needed; the pump shall be provided with a variable-speed drive. The size and speed range of the pump shall ensure that the highest expected duty point shall lie within the available speed range.

Pumps shall normally be driven by a fixed-speed electric motor through reduction gearing and the combined drive shall be continuously rated. Pump and motor shall preferably be mounted in-line on a common base plate. Alternatively, the drive motor may be top-mounted above the pump to minimize floor area and shall be connected by external V-belts and pulleys. V-belt drives shall have full guards of the type that allow the belts observed without the removal of the guard. Facilities shall be provided for ready adjustment of belt tension.

Coupling guards shall be provided, which shall be rigid, securely fixed, and designed so that removal is not necessary during normal operation, routine maintenance, and routine inspections. All motor enclosures shall be provided with ingress protection to IP55. Motor anti-condensation heaters shall be provided and shall be suitable for use on a 220V single-phase, 50Hz supply.

All bearing shall have a B10 design life of not less than 40,000 running hours and shall be designed for loading 20% in excess of calculated maximum loading. Pumps shall be fitted with individual dry-running protection to initiate pump trip. Dry-running protection by 'under-current' monitoring or 'pipeline-intrusive' device shall not be used.

7.4.6.1 Material of Construction for Progressive Cavity Pumps

MOC shall be suitable for sea water application.

7.4.7 Chemical Bulk Transfer Pumps

Pumps shall be selected taking into account the chemical being pumped, form of chemical, wear leakage and resistance to corrosion.

Typically, the MOCs shall be as below

1. Ferric Chloride Unloading / transfer pumps –
 - a. Casing & Impeller – FRP with Vinyl ester resin / Polypropylene
 - b. Shaft and all other wetted Parts - Suitable material for service
2. Sulfuric Acid Unloading / transfer pumps –
 - a. Casing and Impeller - Alloy 20
 - b. Shaft and all other wetted parts - Suitable material for service
3. Sodium Hypochlorite Unloading / transfer pumps –
 - a. Casing & Impeller – FRP with Vinyl ester resin / Polypropylene
 - b. Shaft and all other wetted Parts - Suitable material for service

Each pump shall be provided with inlet and outlet isolating valves and where necessary, with pressure relief and non-return valves and Pressure Gauges with stopcock.

A relief valve shall be incorporated in the delivery lines under conditions where the pump discharge pipe can be shut off or where pressure may rise to an excessive point. The relief valve shall be sized to handle the system pressure and to discharge maximum pump output freely and shall be located in the discharge line between the pump and the first downstream isolating valve. Relief valves when used on pumps handling non-hazardous chemicals shall discharge the vented liquid to waste. When used on hazardous chemicals the valve outlet shall be piped back to the suction supply tank or bunded-area. The open end of the return pipe shall be located where it is visible, so that any relief valve leakage/operation can be detected.

Pump transferring chemicals to systems under pressure shall incorporate a pressure gauge on the pump delivery. Air cocks shall be provided for release of air where necessary.

Flushing connections shall be provided at each pump inlet and flushing shall be manual. When flushing, water shall be discharged either locally through a drain valve or to the point of application of the chemical. Facilities shall also be provided for flushing chemical pump suction and delivery manifolds and delivery lines to point of application.

7.4.8 Chemical Dosing Pumps

Chemical Dosing Pumps shall be piston diaphragm or mechanical diaphragm type as specified. Pumps may be simplex or duplex arrangements to suit the capacity or process requirements. The pump design shall incorporate positive stroke return. The maximum stroking speed shall not exceed 100 strokes per minute (spm). Pump, motor and driving arrangement shall be mounted on a robust combined baseplate.

Pump liquid ends shall be selected for compatibility with the pumped liquid. Suction and discharge valves shall be the single ball type allowing a free flow self-cleaning action. Ball and seat materials shall be resistant to abrasion. Strainers shall be provided with each pump.

Pumps shall incorporate a variable stroke mechanism to allow the output to be varied while the pump is running. Stroke adjustment shall be manual or where specified by electrical or pneumatically controlled stroke positioner. A stroke length indicator and digital stroke counter shall be fitted. Pumps shall be driven by a flange mounted IP 55 motor, via an oil bath reduction gearbox and variable stroke mechanism giving stepless adjustment between zero and maximum stroke length. Where flow proportional dosing is required the variation of output shall be

achieved by varying the speed of the pump motor and not the pump stroke length.

The normal operating range of dosing pump shall be not less than 6:1.

- a. Mechanical Diaphragm rigidly coupled to the drive train. Single suction Pumps and discharge valves. Glandless. Accuracy: $\pm 3\%$ of stroke.
- b. Piston Diaphragm Pumps hydraulically operated by liquid displaced by a plunger and protected from excess pressure via a relief valve. Accuracy: $\pm 2\%$ of stroke.

Materials shall be selected to suit the chemicals being pumped. Liquid ends shall be polypropylene, AISI 316 stainless steel, glass, or Hastelloy C. Diaphragm materials shall be butyl rubber, PTFE, or Hypalon and glands shall be PTFE or Neoprene.

Each pump shall be provided with inlet and outlet isolating valves and where necessary, with pressure relief and non-return valves. Dosing pumps shall be provided with back pressure loading valves and pulsation dampeners in the delivery lines depending on the downstream conditions.

A relief valve shall be incorporated in the delivery lines under conditions where the pump discharge pipe can be shut off or where pressure may rise to an excessive point. The relief valve shall be sized to handle the system pressure and to discharge maximum pump output freely, and shall be located in the discharge line between the pump and the first downstream isolating valve or in the case of dosing pumps the back pressure loading valve. Relief valves when used on pumps handling non-hazardous chemicals shall discharge the vented liquid to waste. When used on hazardous chemicals the valve outlet shall be piped back to the suction supply tank or bunded area. The open end of the return pipe shall be located where it is visible, so that any relief valve leakage/operation can be detected.

Pump transferring/dosing chemicals to systems under pressure shall incorporate a pressure gauge on the pump delivery. Air cocks shall be provided for release of air where necessary. Unless otherwise specified flushing connections shall be provided at each pump inlet and flushing shall be manual. When flushing, water shall be discharged either locally through a drain valve or to the point of application of the chemical. Facilities shall also be provided for flushing chemical pump suction and delivery manifolds and delivery lines to point of application.

Dosing pumps and motors shall preferably incorporate an integral reduction gearbox drive which shall be totally enclosed and oil bath lubricated. The gear box shall incorporate the cams for the diaphragm drive and shall be provided with filling and drain connections and visible oil level indication.

7.4.9 Submittals

The Contractor shall submit minimum the following documents:

- (i) Certified shop and erection drawing.
- (ii) Equipment Manufacturer shall submit electronic files of the proposed equipment in the capacity, size, and arrangement as indicated and specified.

- (iii) Data regarding pump and motor characteristics and performance;
- (iv) Prior to fabrication and testing, provide guaranteed performance curves based on actual shop tests of mechanically duplicate pumps, showing they meet indicated and specified requirements for head, capacity, motor kW, efficiency and NPSH.
- (v) For units of same size and type, provide curves for a single unit only.
- (vi) Provide catalogue performance curves at maximum pump speed indicated and specified showing maximum and minimum impeller diameters and number of stages available.
- (vii) Results of shop performance tests as specified.
- (viii) Submit curves for guaranteed performance, and shop performance tests on A4 sheets one curve per sheet.
- (ix) Shop drawing data for accessory items.
- (x) Certified setting plans, with tolerances, for anchor bolts.
- (xi) Manufacturer's literature as needed to supplement certified data.
- (xii) Operation and Maintenance instructions and parts lists
- (xiii) Listing of reference installation as specified with contact names & details.
- (xiv) Certified results of hydrostatic testing.
- (xv) Certified results of dynamic balancing.
- (xvi) Bearing temperature operating range for the service condition specified.
- (xvii) Shop and field inspection reports.
- (xviii) Shop and field testing procedures and equipment to be used.
- (xix) Provide a scaled drawing showing the pumps, motors and hoist including equipment weights, lifting attachments and clearance for equipment removal and maintenance together with the location of discharge pressure gauges.
- (xx) Manufacturer's product data and specifications for painting.
- (xxi) The latest ISO 9001 certification.
- (xxii) Material Certification:
 - Provide certification from the equipment manufacturer that the material of construction specified and recommended and suitable for the service conditions specified and indicated.
 - When material is not specified, technical data and certification that the proposed material are recommended and suitable for the service conditions.

7.4.10 Pump Performance Guarantees

The pump performance guarantee shall relate to the flow rate, the total head and the efficiency of the pump when tested at the manufacturer's works and shall obtain approval of Engineer.

The pump shall operate at its design point within acceptance tolerances for flow rate and total head laid down in BS: EN ISO 9906:2000.

Each pump shall be tested at the manufacturer's factory in accordance with IS 9137 or other relevant standards in conjunction with one of the contract motors.

This test shall be carried out on at least one pump set using the flexible coupling and contract drive shaft arrangement to establish that the drive arrangement with supports and couplings operates satisfactorily under all operating conditions.

Where similar drive shaft arrangements have been installed by the Contractor and have been proven satisfactory in service this requirement may be withdrawn subject to the approval of the Engineer.

A test shall be carried out of the performance from closed valve to the maximum quantity that can be delivered under abnormally low discharge heads.

Sufficient readings shall be taken at each test to produce accurate curves of the heads, flow, pump speed and power required at pump coupling throughout the operating range of the pump.

Vibration and noise dB(A) levels shall be measured and shown to be acceptable levels as per the contract and shall have Employer's Representative approval. The Contractor shall have Employer's Representative approval and provide acceptable test certificates, showing the NPSH requirement for the pump is at least 2 m less than the NPSH available under all working conditions.

Proto type pump shall be tested over the full operating range, covering from minus 70 percent of the bowl head to the shut-off head. The duration of tests shall be minimum one hour. A minimum of five readings shall be taken for plotting the performance curves. Hydrostatic pressure test shall be conducted for 30 minutes for all pressure parts. The test pressure shall be minimum 1.5 times the pump shut off pressure

The Contractor shall have Engineer's approval and provide acceptable test certificates, showing the NPSH requirement for the pump is at least 2 m less than the NPSH available under all working conditions.

In the absence of the approved test certificates the supplier shall carry out a test on one pump of each type to verify the NPSH requirement based upon the 3% output drop criterion and shall take approval of the Engineer.

Test Certificates in duplicate shall be submitted to the Engineer immediately following each of the tests mentioned above. Performance curves shall also be incorporated in the Operation and Maintenance Manual.

7.4.11 Single/Parallel Pump Operation

- a) Head/quantity curve
- b) Motor kW input/quantity curve
- c) Overall efficiency/quantity curve
- d) NPSH required/quantity curve
- e) Vibration and Noise dB(A) levels
- f) Head/quantity curves for parallel operation of pumps superimposed on system head curve.

7.5 Vacuum Gauges and Pressure Gauges

Pressure gauges shall not be less than 150 mm in diameter and shall be in conformance with specification detailed in Particular Instrumentation specifications Vol 2, Part 8 & 9.

Pressure gauge on delivery pipe and compound gauge on suction pipe of each horizontal centrifugal pump set of suitable range. Pressure gauge on delivery pipe of each vertical turbine pump set of suitable range. The gauges with dial size of 100 mm diameter complete with 3-way cock, isolation valve and connecting pipe.

The maximum range of the Pressure gauge shall be appropriately selected taking into considerations all operating pressures including water hammer encountered.

Vacuum gauge shall be calibrated in mm Hg.

Unless otherwise specified, scales shall be calibrated in meters head of water, with zero representing atmospheric pressure. The lettering shall be in black.

Compound gauges shall read at least 5 m below atmospheric pressure using red lettering.

Where the working fluid is of a corrosive or dirty nature the pressure gauge shall be protected from the working fluid by a diaphragm or similar arrangement.

Each pressure gauge shall be fitted with a stopcock immediately adjacent to the gauge and all pressure gauge piping shall be fitted with an isolating valve at the point of connection to the main system. Where pressure gauges are mounted within or on a panel a suitable connection for a test gauge shall be provided.

7.6 Air Compressors and Blowers

7.6.1 Air Compressors

The operation of all valves and instruments will be done electrically. However, if a compressor system is required, it shall comprise compressors, after-coolers and refrigerant type air dryer, duty/standby air receivers together with control equipment, oil eliminating filters, flow regulators and oil mist lubricators and auto drain units as required.

Type of air compressor shall be reciprocating type.

Electrically driven air compressor sets shall operate up to minimum 10 bar working pressure. Working pressure and capacity shall be adequate for the required duties.

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

- a) Common base frame for Compressor & Motor
- b) Single stage air-cooled unit
- c) Isolating valves
- d) Air filter and silencer
- e) Pressure relief valve or excess pressure safety device
- f) Pressure reducing valves
- g) Pressure gauges
- h) Pressure switches
- i) Offloading piston
- j) Automatic changeover (failure of duty unit)
- k) Drain pipes
- l) Isolating valve
- m) V-belt drive arrangement with Belt Guard
- n) Stoppers
- o) Air-receivers
- p) Air dryer (refrigerant type with auto drain.
- q) Others necessary appurtenances

Compressors shall be arranged for automatic changeover on failure of the duty unit. Failure of the duty unit shall initiate an alarm. Control equipment shall include automatic unloading valves, pressure switches for duty standby and alarm, and lockable changeover switches. 1 duty & 1 standby after coolers shall be provided. Water-cooled or air blast types will be considered. Air receivers shall be designed and fabricated in accordance with relevant approved standards, they shall be mounted vertically on steel feet so that sufficient space is allowed for each access to the whole outside surface. Receivers shall be provided with drain cocks piped to drain pressure gauges and relief and check valves.

Supply of all necessary electrical components, devices, equipment, control panels. Etc. together with cabling, earthing provisions, etc. shall be 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.

Pipe hood shall be provided on the top of headstock to protect the spindle from damage, dirt, dust, water etc. The hood shall be made of transparent fracture resistant polycarbonate material. The hood shall have vent holes to prevent condensation. All pipe-works shall be SS-316 L

7.6.2 Air Blower for Backwash of Filter Beds

Air blowers twin lobe root type shall be provided for washing filter beds of each stage conforming to specifications hereunder:

- Twin lobe type Root Air blower shall have capacity to wash one filter bed at required pressure. Speed of blower shall not exceed 1500 RPM (synchronous)
- The number of blowers shall consider the number of filters provided, their backwashing sequence, and the number of blowers required with one under

maintenance and one on standby.

- The main body, side covers shall be manufactured from Graded Cast Iron as per I.S. 210 / FG – 260.
- The Rotors shall be of forged construction (with Integral Shafts) in Twin Lobe Compressors with EN-8 Shafts.
- All components shall be machined to accurate dimensions with extremely tight tolerance with guaranteed interchangeability. The Castings of Casing and main Covers (Bearing Housing) shall be stress relieved after pre-machining for dimensional stability at elevated temperature.
- The Lobes of Rotors shall have uniform clearances between rotor to rotor in any position of two rotors. The profile shall ensure uniform clearances between casing and Lobes.
- Sealing of main chamber shall be with labyrinth seal.
- Air blower shall be oil lubricated for driving and non-driving end. Grease lubrication shall not be acceptable. Both sides of casings shall be oil-filled. All bearings and gears shall be splash lubricated for increased life of bearings and gears.
- The Timing Gears shall be helical teeth, hardened and machined to ensure low noise level.
- The Gears as well as the bearings shall be oil lubricated on both sides (Driving and non-driving side) of the Blower.
- All the Blowers shall be individually tested as per IS-10431/ IS-5456 for capacity, pressure, power consumption, temperature rise, noise level and vibration level.
- Each Twin Lobe Blower shall be equipped with various accessories like Two Silencer (for Suction and Discharge), Suction Filters, Safety Valves, Non-Return Valves, Anti Vibration Pads, Flexible Bellows, Air pressure gauge with isolating valve for delivery side of air blower.
- Each air blower shall be driven with electrical motor as per specification detailed for the motor. The motor shall have at least 15 % margin over the power required.
- Both Air blower and Electric motor shall be installed on common base with rigid concrete foundation. Air blower shall be coupled with electric motor by love joy type couplings. Radial and axial alignment of Air blower and electric motor shall be perfect.
- The blowers shall be equipped with all piping, valves and automatic change over to start standby blower if duty blower fails to start.

7.6.2.1 General Design Requirements

The air blowers shall be of such design as to achieve energy efficient operation continuously over the range of design airflow rates at the discharge pressure that shall remain practically constant.

The sizing of the blower units shall ensure that the peak airflow demand can be met by one duty

blower with one unit on stand-by (two duty and one 50% standby will also be considered). Each blower shall be fitted with a variable speed motor and be capable of operating between 80% and 110% of its nominal peak airflow demand.

The discharge pressure shall be calculated by the Contractor dependent on the final design layout of the aeration system and of the delivery manifold.

The blowers shall also be capable of supplying the design "mass flow" rate at maximum ambient inlet temperature of 50°C.

Each of the blowers shall be capable of operating without surge in parallel with the other duty blower at the maximum mass flow against designed maximum gauge pressure at the outlet pipe. The Contractor shall demonstrate this during testing and commissioning. Performance curves for the blower system shall be submitted. Standard certified factory test sheets showing the results of each test shall be supplied in triplicate to the Employer's Representative prior to delivery of the blowers. The blower unit shall be capable to operate at maximum duty for continuous operation. The blower motor shall not exceed a maximum speed of 1500 rpm and the blower shall not exceed the manufacturer's recommended maximum speed.

Each blower shall be fitted with an acoustic enclosure. The arrangement shall be such that all blowers are accessible for operation and maintenance and the installation of additional blowers in the future is possible.

The inlet air to the blower house shall be filtered to suit the blowers and aeration diffusers selected. Vacuum switch, pressure switch, oil level indicator and any other monitoring device shall be mounted outside the acoustic enclosure. Inlet and outlet pressure gauges shall be mounted outside the acoustic enclosure. Vibration absorbing mounting pads shall be used.

A blower removal system shall be provided so that any one blower can be removed as a single unit and loaded on to a truck. The blower building shall be acoustically designed to minimize both noises inside the building and noise breaking out of the building. The building ventilation system shall be designed to limit the temperature rise not more than 3° C above ambient temperature.

Filters and Silencers

The blowers shall receive filtered air individual replaceable filter elements suitable for the intended duty.

The filter elements shall be housed in an airtight housing which shall allow easy replacement of the filter elements. Replacement of elements shall be possible without the use of tools.

If the filter/silencer elements supplied are located out of doors a weatherproof cover shall protect the filter element from rain.

The filter unit shall be fitted with suitable vacuum gauges to indicate the suction pressure into each blower. The gauges shall be industrial Bourdon or Schaffer type gauges with a nominal diameter of 150 mm. The scale shall be suitably selected and shall include a red line to indicate the point at which the filter elements require renewal.

Each blower intake shall be fitted with a differential pressure switch, which shall indicate an alarm signal in the event of excessive pressure drop in the blower intake.

Flexible Connections

The blower discharge shall be fitted with an approved flexible sleeve with fixing clamps and a flanged outlet spigot for connection to site pipework. If the blower inlet is via a common plenum the inlet pipe shall be also fitted with a flexible connection.

Sleeves shall be manufactured from an approved non-metallic material suitable for the duty and location in which the blowers are to be installed.

Pressure Relief Valve

The pressure relief valve shall be sized and adjusted to allow the full flow of the blower to be discharged in the event of a blockage or valve closure in the downstream pipeline and without overloading the drive motor.

Each blower shall be fitted with a suitable pressure switch, which shall shut down the blower in the event of excessive discharge pressure. The pressure setting shall be lower than the set pressure of the pressure relief valves.

The pressure relief valve shall be installed at a height above 2m from the floor and away from blower suction point. The pressure relief valve shall be fitted with a silencer.

Non-Return Valves

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

Isolating Valves

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

Temperature Measurement

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

Piping Vibration

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

7.6.2.2 Blower Noise limits

The blowers supplied under this Contract shall be quiet in operation. The Contractor shall guarantee that the total sound power noise emission for the aeration system shall be broad band and free from any tonal or intermittent components. Under any loading condition from no load to full rated, the blower supplied shall comply with the noise requirements.

7.6.2.3 Positive Displacement Blower

The air rotary positive displacement blowers (Roots type or equivalent) shall consist of lobed rotors rotating designed for continuous operation at the required pressures and flows. The blowers shall be controlled by variable speed drives. The blowers shall be able to operate over a speed range to deliver the range of airflow rates nominated above.

Rotors and shafts shall be of one-piece construction and shall be of forged steel or shall comprise cast iron rotors on steel shafts. The rotors shall have two or more lobes and shafts shall be geared together with timing gears so that the lobes do not make contact during operation.

Bearing housings and rotor shafts shall be fitted with suitable oil seals to exclude dirt and moisture and to prevent oil carryover into the discharge air. Where bearings are oil lubricated the housings shall be fitted with effective oil level indicators.

The blower and motor shall be mounted on a base frame incorporating an integral silencer, non-return valve, pressure relief valve, discharge connection with flexible joint and flexible mounting pads (vibration dampers shall be placed under blower mounts).

The complete assembly including drive motor and lubrication system shall be mounted and aligned on a substantial galvanised sub-frame. Heavy-duty anti-vibration mountings are to be located on the underside of the sub-frame.

7.6.2.4 Materials of Constructions

The materials of construction for the blowers shall be at least equal in quality to the following:

COMPONENT	MATERIAL
Casings	Cast Iron
Base plate	Steel, Galvanized
Rotor/impeller	SS316 or Manufacturer's std
Shaft	SS316 or Manufacturer's std
Nuts and Bolts	Stainless Steel 316

7.7 Pressure & Storage Vessels:

- i) Design of all vertical atmospheric storage tanks containing water, acid, alkali and other chemicals shall conform to IS:803 in case the material is carbon steel.
- ii) Atmospheric vertical storage tanks shall be fabricated of mild steel as per IS:2062-Tested quality. Plates shall be cold rolled through plate bending machine by several number of passes to true curvature and joined by welding.
- iii) Design of all pressure vessels shall conform to ASME Code Section VIII Design pressure should be the maximum expected pressure to which the vessels may be subjected plus 5% extra margin. Maximum expected pressure for vessels placed in the

- discharge line of pumps shall be based on the shut-off head of the pumps plus static head at pump suction.
- iv) Design temperature of vessels shall be 10 deg C higher than the maximum temperature that any part of the vessel is likely to attain in course of operation.
 - v) Block and bleed type arrangement shall be provided for storage tanks in hazardous area.
 - vi) All Carbon Steel vessels without inside rubber lining (including vessels with inside painting only) shall have a corrosion allowance of 2 mm (minimum) on shell and dished ends. Suitable mill allowance shall also be considered for shell and dished ends. Thinning/scaling allowance of 2 mm (minimum) shall be considered for dished ends. The minimum plate thickness of either pressure vessel or atmospheric storage tank shall be 6 mm.
 - vii) Manholes shall be provided in all vessels for providing easy access into the same. The size shall be minimum 500 mm and it will be provided with cover plate, nuts, bolts and gaskets to ensure leak tightness at the test pressure.
 - viii) Adequate supporting arrangements like straps, saddles, skirt boards, pillars etc. shall be provided to transfer all loads to civil foundation. All foundation bolts, inserts etc. will also be included.
 - ix) All vessels shall be provided with lifting lugs, eye bolts etc. for effective handling during erection.
 - x) Suitable seal shall be provided with the vent line of atmospheric tanks containing fuming liquids and also to prevent contamination from atmospheric air.

7.8 Sluice Gates and Electric Actuator

7.8.1 Sluice Gates

- a) **Design Requirements and Construction Features:** The construction of sluice gates shall be in accordance with the specification and generally as per AWWA C 560-00 /IS:13349-1992 or other applicable standard. All sluice gates shall be thimble mounted and of the rising spindle type.
- b) **Frame:** The frame shall be of the flange back type and shall be machined on the rear face to bolt directly to the machined face of the wall thimble.
- c) **Seating Faces:** Seating faces shall be made of full width, solid section; dove-tail strips of stainless steel. They shall be secured firmly by means of counter sunk fixings in finished dove-tail grooves in the frame and slide faces in such a way as to ensure that they will remain permanently in place, free from distortion and loosening during the life of the sluice gates.
- d) **Wedging Devices:** Sluice gates shall be equipped with adjustable side, top and bottom wedging devices as required to provide contact between the slide and frame facing when

the gate is in closed position.

e) Lifting Mechanisms

- Sluice gate shall be operated through suitable lifting mechanism which shall incorporate suitable gearing if required, to keep the torque requirement within 7 kg.m.
- Lifting mechanism shall incorporate a strong locking device suitable for use with a padlock or padlock and chain.
- Lift mechanism shall be provided with a suitable position indicator to show the position of the gate at all times.

f) **Wall Thimbles:** The cross section of the thimble shall have the shape of the letter 'F'.

g) **Lifting Lugs:** Lifting lugs shall be provided for all gates.

h) **Flush Bottom Seal:** When sluice gates are provided with flush bottom seals, the wedging device and facing along the bottom edge of the slide and frame shall be omitted. A solid square cornered, resilient rubber seal shall be provided on the bottom facing of slide. The seal shall be securely fastened to the bottom face of the slide by a retainer bar and corrosion resistant metal fasteners. The top surface of the bottom facing of frame shall be flush with invert of the gate opening. Bottom facing of the slide shall be accurately machined to make contact with the seal when the slide is closed.

- i) Suitable arrangement shall be made on all the sluice gates and actuators such that the actuator is capable of operating specific size of sluice gate, under this contract.
- j) Headstock meant for mounting on operating platform shall be supplied with a pedestal/floor stand to provide a convenient operating height of approximately 900mm. The pedestal of the headstock shall be provided with a covered window opening to enable cleaning and greasing of stem threads.
- k) All the Gears in the headstock shall be kept completely encased in cast iron housing to protect them from dirt. Dust, damage etc. and other atmospheric effects and thus ensure smooth operation. Grease nipples shall be provided at proper places for lubricating with grease.
- l) Pipe hood shall be provided on the top of headstock to protect the spindle from damage, dirt, dust, water etc. The hood shall be made of transparent fracture resistant polycarbonate material. The hood shall have vent holes to prevent condensation.
- m) The material of construction of sluice Gate suitable for sea water application. All inserts/embedment shall meet the PREN requirements for steel in contact with sea water.

7.8.2 Electric Actuator

Electric actuator for closing and opening of each sluice gate shall be provided as per the process requirement mentioned elsewhere in this document, so that the closing and opening operation time shall be maximum of 10 minutes. The local control shall be protected by a Lockable cover.

The Actuator shall be adequately sized to operate all the penstocks and be continuously rated to suit the modulating control required. The gear box shall be oil or grease filled, and capable of installation in any position. All operating spindles, gears and headstocks shall be provided with adequate points for lubrication.

The Actuator shall be capable of producing not less than one and half times the required torque and shall be suitable for at least 15 minutes continuous operation.

The Actuator starter shall be integrally housed with the Actuator in robustly constructed and totally enclosed weatherproof housing. The motor starter shall be capable of starting the motor under the most severe conditions.

The starter housing shall be fitted with contacts and terminals for power supply, remote control and remote positional indication.

Each starter shall be equipped as follows:

- a) Three phase magnetically operated line contactors with no-volt release and electrical and mechanical interlock.
- b) Three phase thermal cut-out device.
- c) Control circuit transformer fully protected by fuses on primary and secondary circuits.
- d) “Open”, “Close” and “Stop” push buttons.
- e) Local-off-Remote switch with padlocking facilities.
- f) Torque and Limit switches for “open” and “Close” positions.
- g) Auxiliary limit switches in each direction.
- h) Gate position indicator and Handwheel for Manual operation.
- i) Reduction Gear unit.

7.9 Valves

7.9.1 General

- a) Valves shall be as per internationally recognized standards. Flanges shall be machined on faces and edges and drilled to applicable IS.
- b) Valves shall be double flanged and the face shall be parallel to each other and flange face should be at right angles to the valve centerline. Backside of valve flanges shall be machined or spot faced for proper seating of the head and nut. Valve buried or installed in underground chamber, where access to a hand wheel would be impractical, shall be operated by means of extension spindle and/or keys. Valve shall be suitable for frequent operation as well as operation after long periods of idleness in either open or closed position.
- c) The valve stem, thrust washers, screws, nuts and all other components exposed to the product water shall be of a corrosion resistant grade of stainless steel 316/316L as needed. The valves in contact with sea water and /or brine shall be of nickel aluminum

bronzes, or 9010 Cu-Ni with 1.5% Chromium alloys or SDSS. All these alloys shall be characterized by good resistance to static seawater (necessary for shut-down conditions) and to flowing seawater. Valves shall be free from sharp projections. Large size butterfly and non-return valves shall be provided with bypass arrangement having rising spindle gate valves. Bypass may be integral with valve or connected between pipes. A positive seal between the lining and the stem is provided to prevent access of seawater to the cast iron body.

- d) The work of fixing appurtenances, i.e. butterfly valves, sluice valves, air valves, scour valves, etc. shall be carried out carefully so as not to damage them during handling, erection and fixing.
- e) All the butterfly valves and sluice valves for pumping plants and isolation valves on pumping main (except scour valves on pumping main and the isolation valves for air valves) shall be electrically operated. The valves shall have arrangement for manual operation also, operated through a suitable gearbox, by hand wheel. Valves for operation shall be so geared that under the operating conditions as specified herein, the maximum force on the rim of the hand wheel, crank, or other necessary for operation shall not exceed 10 kg and the maximum torque shall not exceed 5.5 kg/m. Operation must be possible by one man against maximum design working pressure. For butterfly valves the gearbox shall be provided with self-locking devices. A locking facility shall be provided for the BF valve in either the fully open, fully closed or intermediate position. Gate valves and butterfly valves shall be provided with position indicators, to show whether the valve is in the open or close position.
- f) Scour valves shall be provided with extension spindle with supports for operation from operating level / ground level.
- g) Gaskets shall be of NBR/Nitrile based rubber and ready-made matching with respective flanges. Gaskets cut out from rubber sheets are not acceptable.

7.9.2 Butterfly Valves

Butterfly valves shall be of double eccentric and resilient seated type generally as per IS:13095 and ASME B16.5 and should be tested as per ISO 5208-EN 1074.

Butterfly valves shall be suitable for bi-directional pressure testing with dead-tight shut off even after long period of operation of 5 years. The valves shall be of double flanged long type.

The valves shall be electrically/pneumatically and manual operated to suit the process requirement mentioned elsewhere in this tender document. The valve shall be free from induced vibrations. Valve shall be suitable for mounting in any position.

The valve seat shall be of replaceable design. When the valve is fully closed, the seal shall seat firmly. The seat surfaces shall be machined smooth to provide a long life for the seal. All fasteners shall be set flush so as to offer the least resistance possible to the flow through the valve.

The shaft shall be stainless steel with Bronze or equivalent seal with self-lubricating bearings.

Disc pins shall be stainless steel 316L. For seawater/brine, the shaft shall be of super duplex steel and disk pin be of Duplex/ Monel K 500 / Inconel 625 as applicable. Rings shall be bi-directional self-adjusting suitable for pressure or vacuum service. Removal and replacement of seals shall be possible without removing the operating mechanism, valve shaft and without removing the valve from the pipeline. Valve shafts shall be a one-piece unit extending completely through the valve disc, or of the "stub shaft" type, which comprises two separate shafts inserted into the valve disc hubs.

All valve spindles and hand wheels shall be positioned to give good access for operational personnel. Valve of diameter 450 mm and above shall be provided with enclosed gear arrangement for ease of operation. The gear box shall be of worm and worm wheel design type, totally enclosed, grease-filled and weatherproof. The operation gear shall be such that they can be opened and closed by one man against an unbalanced head of 1.15 times the specified rating. Valve and gearing shall be such as to permit manual operation in a reasonable time and not exceed a required rim pull of 200 N. All hand wheels shall be arranged to turn in a clockwise direction to close the valve, the direction of rotation for opening and closing being indicated on the hand wheels.

Material of construction of valves shall comply with following requirement:

Item	For product water application	For seawater application
Body	Cast Iron IS:210 Gr FG 220	DI with Ebonite lining / Cast 70-30 Cu-Ni/ SDSS
Disc	Cast Iron IS:210 Gr FG 220	ASTM A 890 Grade 5A (PREN>41 / PREN≥43)
Shaft	SS BS:970 Grade 431 S 29	254 SMO/ Super duplex steel
Body Seat	Nickel weld overlay micro-finished	Manufacturer spec
Seal	NBR/EPDM	NBR/EPDM
Seal Retaining ring	Stainless steel AISI 316	254 SMO/ manufacturer spec
Shaft Bearing	Bronze with EPDM 'O' ring seals	Manufacturer spec
Internal Fasteners	Stainless steel AISI 316	Duplex SS/ Monel K 500 / Inconel 625
Nuts, bolts & washers for pipe flanges	Stainless steel AISI 316/316L	Stainless steel AISI 316/316L

The disc shall be designed to withstand the maximum pressure differential across the valve in either direction of flow. The disc shall be contoured to ensure the lowest possible resistance to flow and shall be suitable for throttling operation.

Valves shall be capable of closing against the maximum flow that can occur in system. The shaft shall be designed to withstand the maximum torque that will be imposed by the operator. It shall

be secured to the discs by tapered stainless steel cotter pins.

Valves shall be provided with position indicator to show the position of the disc, mounted on the driven shaft end.

Rigid adjustable stop mechanism shall be provided within the gear box or elsewhere on the valve to prevent movement of the disc beyond the fully open or closed position (i.e. set points).

7.9.3 Sluice Valves

Sluice valve shall generally conform to IS:14846 and as per ASME B16.5. They shall be of non-rising spindle type except for the valves for bypass. The gate face rings shall be securely pegged over the full circumference. Valve of 400 mm and above shall be furnished with a bushing arrangement for replacement of packing without leakage. They shall also have renewable channel and shoe linings. The gap between the shoe and channel shall be limited to 1.5 mm. Valve of 200 mm and above shall be provided with thrust bearing arrangement for ease of operation.

Valve of diameter 400 mm and above shall be provided with enclosed gear arrangement for ease of operation. The operation gear of all valves shall be such that they can be opened and closed by one man against an unbalanced head 15% in excess of the maximum specified rating. Valve and any gearing shall be such as to permit manual operation in a reasonable time and not exceed a required rim pull of 200 N.

Valves spindles and hand-wheels shall be positioned to give good access for operational personnel. Hand-wheels shall be arranged to turn in a clockwise direction to close the valve, the direction of rotation for opening and closing being indicated on the hand wheels.

Valves shall have two position marked at the shut end of the scale, first one corresponding to the position of the gate tangential to the bore of the seating and the second position below the first, corresponding to the position of the gate as it sits on the seating after moving a further distance equal to the depth of the seating.

All valves on pump suction and delivery piping shall be with electrical actuators. Operation of valves shall be with electric actuators mounted on floor stand at motor floor. The remaining sluice valves shall be manually operated unless specified elsewhere in this tender document.

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

Headstock meant for mounting on operating platform shall be supplied with a pedestal/floor stand to provide a convenient operating height of approximately 900mm. The pedestal of the headstock shall be provided with a covered window opening to enable cleaning and greasing of stem threads.

All the Gears in the headstock shall be kept completely encased in cast iron housing with suitable coating to protect them from dirt. Dust, damage etc. and other atmospheric effects and thus ensure smooth operation. Grease nipples shall be provided at proper places for lubricating with grease.

All Sluice valves shall be open-end tested.

Bypasses for valves 400 mm and over shall be fitted with integral bypasses as per diameter in IS: 14846.

Material of construction shall comply with the requirements given below:

Item	For product water application	For seawater application
Body, Door, Dome, Bonnet	Cast Iron IS:210 Grade FG220	Cast 70-30 Cu-Ni/ 254 SMO/ ASTM A 890 Grade 5A
Wedge	Cast Iron IS:210 Grade FG220 Rubber lined with EPDM	ASTM A 890 Grade 5A (PREN>41 / PREN≥43) / manufacturer spec
Seat, Face ring	IS:318 Gr. LTB 2	254 SMO/ Monel K 500/ Cast 70-30 Cu-Ni
Spindle / Stem	SS: IS:6603 04 Cr17 Ni12 Mo2 / AISI 316L	254 SMO/ Monel K 500
Bonnet Gasket	NBR/EPDM	NBR/EPDM
Internal Fasteners	Stainless steel SS316L	Duplex SS/ Monel K 500 / Inconel 625
Nuts, bolts & washers for pipe flanges	High tensile steel Hot dip galvanized	Stainless steel AISI 316/316L

7.9.4 Plug Valves

This Specification covers the minimum requirements for design, manufacture and supply of plug valves of size DN 50 mm (2 inch) and above and ANSI Class 150# thru 600#.

All valves shall be manufactured and supplied in accordance with the American Petroleum Institute (API) Specification 6D, Twenty Second Edition, 2002 including supplement 1 & 2 thereof with additions and modifications as indicated in the following sections of this specification.

The ASME Boiler & Pressure Vessel Code, Section VIII, Division 1 shall be used to design the valve body. Allowable stress requirements shall comply the provisions of ASME B31.3. However, the minimum valve thickness shall not be less than the minimum requirement of ASME B16.34. The manufacturer should have valid license to use API monogram on valves manufactured as per API 6D.

Valves shall be provided with plug position indicator and stops of rugged construction at the fully open and fully closed positions. Valves shall have locking devices to lock the valve either in full open (LO) or full close (LC) position. Locking devices shall be permanently attached to the valve operator and shall not interfere with operation of the valve

Reference has also been made in this specification to the latest edition of the following Codes, Standards and Specifications.

ASME B3 1.3 - Process Piping.

ASME B 16.5 - Pipe Flanges and Flanged Fittings.

ASME B 16.25- Butt-welding Ends

ASME B 16.34- Valves - Flanged, Threaded and Welding Ends.

ASME B16.47 - Large Diameter Steel Flanges.

API 1104 - Welding Pipelines and Related Facilities.

ASME Sec IX - Boiler and Pressure Vessel Code.

ASTM A 370 - Test Methods and Definitions for Mechanical Testing of Steel Products.

MSS-SP-6 - Standard Finishes for Contact Faces of Pipe Flanges and Connecting-end Flanges of Valves and Fittings.

MSS-SP-44 - Steel Pipe Line Flanges.

V SSPC-VIS-I - Steel Structures Painting Council Visual Standard.

Design Characteristics

Fluid	: Sea water
Diameter	: According to service
Design pressure	: ANSI 600 Ib
Connections	: BW Sch 40S - flanged

MATERIALS

Body and stem : Super Duplex ASTM A-890 Gr 5A

Joint : PTFE

7.9.5 Non-Return Valves

- a) The valve shall be suitable for mounting on a horizontal pipeline and flow direction shall be clearly embossed on the valve body.
- b) Valves shall possess high speed closing characteristics and be designed for minimum slam condition when closing.
- c) Dual plate check valves shall conform to API 594 and API 598 (dimensions) and ASME B16.5 (connections). They shall have metal to metal sealing. The spring action shall optimize the equal closing rates of each plate especially when the friction coefficients are uneven due to one plate resting upon one another. The plates shall not drag on the seat while opening. The plates shall not vibrate under full or partial flow condition. Valves shall possess high speed closing characteristics and be designed for minimum slam condition when closing.
- d) The minimum body-wall thickness shall conform to those given in Table 1B of API

Standard 594. For low pressure piping, Class 150# and for high pressure piping Class 600# shall be used.

- e) The face-to-face dimensions of valves (including valves with ring-joint facings) shall conform to those mentioned in Table 2B of API Standard 594.
- f) The valve body shall be furnished with a clearly visible forged, machined-in, or die-stamped arrow to indicate the direction of flow through the valve.
- g) Maximum permissible seat leakage is 7cc/Hr/cm nominal diameter of valve.
- h) Material of construction of valves shall comply with IS code and as follows for seawater application.

Rating	Class#150/600 for low/high Pressure piping
Body	ASTM, A 890 5A with PERN>41 / PREN≥43 as applicable
Plate	ASTM, A 890 5A with PERN>41 / PREN≥43 as applicable
Hinge & Stop Pin	Inconel 625
Springs	Inconel 625
Seat	ASTM, A 890 5A with PERN>41 / PREN≥43 as applicable
Retainer	Inconel 625
End Connection	RF, 150# as per ANSI B 16.5/ for 600# Grooved
Tag/Name plate	316 Stainless Steel (Engraved)

7.9.6 Air Valve

The air valve shall be double orifice kinetic type and conform to IS 14845. The valve shall be capable of exhausting air from pipework automatically when being filled, the air being released at a sufficiently high rate to prevent the restriction of the inflow rate. Similarly, the valve shall be capable of ventilating pipework automatically when being emptied, the air inflow rate being sufficiently high to prevent the development of a vacuum in the pipelines. The valve shall also automatically release air accumulating in pipework during normal working conditions.

Air valves shall thus be designed to automatically operate so that they shall:

- positively open under internal pressure less than atmospheric pressure to admit air in bulk during pipeline draining operation.
- exhaust air in bulk and positively close as water, under low head, fills the body of the valve during filling operation.
- not blow shut under high velocity air discharge.
- exhaust accumulated air under pressure while the pipe is flowing full of water.

All air valves shall be constructed so that internal working parts which may become necessary for repairs shall be readily accessible, removable, and replaceable without use of special tools and removing the valve from the line.

Air valves shall be of single chamber double orifice type and tamper proof unless otherwise directed by the Engineer. A buoyant rigid float shall seal the large orifice and the chamber housing shall be designed to avoid premature closing of the valve by the air whilst being discharged. Small orifice shall discharge small air volume during operation under full internal pressures. All air valves shall be provided with isolating sluice valve and flanged end connection.

The aperture of valves must be properly designed for which the Contractor shall submit design calculations for necessary approvals before the procurement of valves.

All branched outlets including air valve tees shall be provided with one $\frac{1}{2}$ " BSP coupling duly plugged for measurement of pressure in due course. The closing plug shall be in Stainless Steel (AISI 304 or equivalent) with Hex. Head and shall be provided with copper washer for sealing.

Material of construction of air valve shall comply with following requirement.

Body, Bonnet and cover	SG Iron 1865 Gr 400/12 or Grade GGG 40
Float	Polycarbonate up to 50 NB and SS 316 Ti/ AISI 316 Ti for above 50 NB
Internal Linkages	Stainless Steel 316L
Seat Ring	Dexine (Nitrile Rubber) on Bronze seat
Gasket / Seal	EPDM/NBR
Shut off Device	Stainless Steel (ASTM A240 Grade 321/AISI 321)

Bidders are encouraged to submit alternative design. Alternative design of air valve is subjected to approval by the Engineer.

7.9.7 Pressure Relief Valve

- a) Pressure relief valves shall be capable of relieving pressure in the system to prevent the system being pressurised in excess of a preset maximum allowable pressure. The valves shall be drop tight under normal operating conditions.
- b) The valve operation shall be achieved by the interaction of the inlet pressure and an intermediate pressure produced by a pilot valve or relay system acting on the upper side of the main valves.
- c) The pilot valve or relay system shall be actuated by a diaphragm connected to the inlet pressure on its underside and a constant pressure on its upper side derived either from weight or from a spring.

7.9.8 Pressure Reducing Valves

- a) Pressure reducing valves shall be capable of maintaining a constant downstream pressure from a higher constant or variable upstream pressure and they shall be drop tight under no flow conditions.
- b) The valve operation shall be achieved by the interaction of the inlet pressure, outlet pressure and an intermediate pressure produced by a pilot valve or relay system acting on the upper side of the main valve.
- c) The pilot valve or relay system shall be actuated by a diaphragm connected to the outlet pressure on its underside and a constant pressure on its upper side derived either from weights or from a spring.
- d) Body ends shall be flanged and drilled to applicable IS.

7.9.9 Diaphragm Valves

Diaphragm valves shall be of the full-bore type to suit the maximum working pressure ratings required. Body ends shall be flanged and drilled to applicable IS or BS EN 1092-2.

Indicators shall be supplied where specified showing both OPEN and CLOSED positions shall be supplied, and provisions made for initiating the operation of remote indicator lights in the fully OPEN and CLOSED positions.

Valves used for toxic or hazardous fluids shall be provided with an additional 'O' ring seal of nitrite rubber or other approved material.

Diaphragms shall be composed of moulded reinforced, flexible material attached by studs to the compressor. Diaphragm materials shall, where required, be composed of corrosion resistant material.

7.9.10 Isolating Cocks

For isolation of small-bore pipework tapings for instrumentation equipment etc., and for individual component isolation, the cocks shall be stainless steel, 0.25 turn ball or plug valve with the operating handle arranged to indicate the open and closed positions. Where specified, means shall be provided for securing the valve body to a front panel or near surface.

7.9.11 Valve Actuators

Control actuators for fan dampers, control valves and miscellaneous modulating dampers can be electrical, pneumatic, hydraulic or hybrid, depending upon application requirement. For high torque/high thrust applications, electro-pneumatic/electrohydraulic actuators are used.

All control actuators shall have stalled torque rating of at least 150 per cent of the maximum required torque for the driven element.

7.9.11.1 Electric Actuators

The sluice valve on pump suction and discharge lines and butterfly valve on pump discharge

line and pumping main shall be operated by electric actuator and the operating mechanism shall consist of the following accessories:

- a) AC Electric Motor.
- b) Reduction gear unit.
- c) Torque switch mechanism
- d) Limit switch mechanism complete with set of limit switches and additional two spare sets for open/close position.
- e) Hand wheel, for manual operation.
- f) Valve position indicator.
- g) Hand-auto lever with suitable locking arrangement.
- h) Single phase space heater in the switch compartment
- i) Indication throughout the valve operation.
- j) Junction box for terminating power and control cables.

The actuator shall be suitable for operation on 415V, 3 phase, 50 Hz power supply in the climatic conditions given in the Specification. The motor winding insulation shall conform to Class B as per relevant BS and motor shall be protected by suitable thermal overload relays. The actuator shall be capable of producing not less than 1.5 times the required torque at the required time cycle of valve operation. The transmission shaft connecting the actuator to the valve shall be provided with 2 bearings one at actuator end and one at valve end with universal couplings at suitable places. Adequate no. of switch/contacts shall be provided to meet following requirements.

Valve close/open/in operation indications:

- a) To prevent starting of motor if discharge valve is not fully closed.
- b) To trip the motor, if the discharge valve fails to open within specified time.

Each motor shall be suitable for operation in the site climatic conditions. They shall also be suitable for operating on the specified electric supply and shall satisfactorily open and close the valve under variations of electric supply specified.

The electric motors shall be of the squirrel cage type as per IS: 325 with insulation to IS: 1271 Class B. The windings shall be impregnated to render them non-hygroscopic and oil resistant. All internal metal parts shall be painted. The motor shall be rated for 15 minutes.

Motor shall be protected by suitable overload protection device.

The reversing contactor starter and local controls shall be integral with the valve actuator. The starter shall comprise mechanically and electrically interlocked reversing contactors of appropriate rating transformer. The common connection of the contactor coils at the transformer shall be grounded. HRC cartridge type primary and secondary fuses shall be provided.

Local control shall comprise pushbuttons for open, close and stop operations and a Lockable Local/Remote/off selector switch. The control schematics shall be subject to approval.

Internal wiring shall be of 650/1100 Volt grade PVC insulated stranded copper conductor of minimum 1.5 sq. mm for control circuits and of minimum 4 sq.mm copper for the power circuit. Each wire shall be number identified at each end. The terminals shall be of stud type. Cable entries shall be suitable for PVC insulated/ sheathed, armoured cables. A separate terminal box shall be provided for the heater. A separate terminal box shall be provided for cabling to control circuits.

The actuator enclosure shall be fully weatherproof and hose proof to IP 67 and shall be fitted with an anti-condensation heater, which shall be switched off when the motor is running.

Reduction Gear Unit shall be of the totally enclosed oil bath lubricated type. The gear box shall be provided with the first charge of oil lubricants and appropriate filling and drain connections. Gearing shall be adequate to open and close the valves under full indicated maximum operating pressure differential at a speed sufficient to cover the full extent of travel.

The operator shall have a hammer-blow device to loosen stuck valve or retrieve jammed valve position.

The torque switch mechanism shall function as follows to stop the motor on closing or opening of the valve, or 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 the opening cycle or when the valve is fully open. The mechanism shall facilitate adjustment of the torque at which the switches are required to operate.

Non-adjustable limit switches shall stop the motor and give indication when the disc has attained the fully open or closed position.

The adjustable limit switches shall have control rated 2A, 48 V DC for specified system interlock, at the desired value position in both the opening and closing directions.

Motor operators shall be provided with clearly visible local valve position indicators mounted on the operator assembly to give an indication whether the valve is fully open, fully closed or in an intermediate position.

A hand wheel of Stainless-Steel construction shall be provided for emergency operation. The hand wheel 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.

7.9.11.2 Pneumatic Actuators

Pneumatic actuator shall operate the valve as per torque requirement of valve for the function and duty. Working temperature range: From - 20° to +80 °C.

Pneumatic actuators shall be provided complete with line filter, regulator, positioner when required, manual operating handle, solenoid valve and air lock system. Actuators shall be sized

for shut-off differential pressure. All pneumatic valve positioners shall be supplied with local pressure gauges to indicate supply pressure, control pressure and feed-back pressure. SMART valve positioners (with HART or field bus compatible) shall be considered wherever required. All pneumatic control valves shall have facility for position feedback (4-20 mA) for transmission to control room. For spring-opposed diaphragm type actuators, the spring shall be corrosion resistant and cadmium or nickel-plated.

- a) MOC
 - Body-Cast iron FG260
 - Fasteners-stainless steel
 - O rings/seals – BUNA-N (Nitrile)
 - Tonner – Aluminum Alloy LM4 / LM6
 - Shaft – Carbon steel
- b) These actuators shall be pneumatically operated, travelling a minimum of 90° in each direction and be able to over travel at 3° more in each direction past 90°. Pneumatic actuator shall develop required torque to operate of valve.
- c) The Actuator shall be totally enclosed and contained in a single enclosure with no external moving part.
- d) Air junction box shall be provided for opening and closing of valve. All pneumatic passageways must be integral to the actuator housings.
- e) Air junction box shall be having air control arrangement for inlet and outlet for connection of air inlet and outlet at least 10 mm dia size threaded connection arrangement shall be provided.
- f) Pneumatic Actuator shall be designed for the automation of ¼ turn valves (butterfly valve,) with double acting pneumatic arrangement.

Valve positioners or boosters may be considered for actuators for the following applications:

- To split the controller output to more than one valve.
- To amplify the controller output beyond the standard signal range (i.e., 0.2- 1kg/cm²), in case of actuators with greater thrust or stiffness is required.
- To achieve minimum overshoot and fast recovery in control action, as in the case when long control air lines have to be used.
- In all the above applications, whether or not a positioner or booster is to be used, shall depend on the speed of response of the system.
- Wherever required, boosters shall be used for systems with a fast response (e.g. Pressure and flow control loops etc.) and positioners shall be used for relatively slower control loops (e.g., temperature and level loops etc.).
- Actuator casing and diaphragm shall be designed to withstand at least twice the maximum pneumatic operating pressure of the control valve.

7.9.12 Control Valves Design

Control valves for modulation service shall generally be pneumatically or electrically operated.

Control valves shall be sized in accordance with ISA-S75-01. The noise level produced by any equipment like pump sets, compressor sets and blower sets etc. shall not exceed National Standards

Control valves shall be sized so that at minimum and maximum flow, the valve lift is always between 10% to 90% for equal% and 20% to 80% for linear characteristics.

Globe type control valves shall be, in general, used in throttling applications for valve applications up to 500 mm line size, when the line pressure is not very low & fluid is non-viscous.

Single seated globe valves with top guided plugs shall be generally used for low & medium flow applications & for clean fluid applications as well as fluid with suspended particle applications. Cascaded trim shall be used for cavitation services.

Globe valves with cage guided plugs are pressure balanced & shall be used for high flow applications where the fluid is clean or if there is a chance of flushing/cavitation. Generally, single seated globe valves with cage-guided plug shall be used from the viewpoint of maintenance & for better leakage class. However, double seated cage guided valves shall be used for better pressure balance, based on the process application.

Top & bottom guided double port double seated straight through type globe valves shall be used for very high flow applications & where wide range ability is required.

Wide range ability is possible, as the valve operation is quite steady throughout the stroke due to relatively low unbalanced force & because of the guiding at top & bottom. Another advantage of this type of valve is that valve action can be reversed without change of actuator.

Other types of valves (e.g. Butterfly, angle, eccentric-disk, ball, V-notch ball type, etc.) shall be used only when operating conditions do not allow globe type valves.

For high viscous liquids, V-notch ball valves shall be used.

Angle valves shall be used wherever piping layout so desires. It is devoid of dead pockets & possible to achieve fine control through it. It can be used in slurry application also. In case of high-pressure drop application, multistage single seated cage guided angle valves shall be used. In very high-pressure drop applications, the multi stage pressure reduction trim prevents the liquid pressure falling below the saturation pressure at vena contract, thereby eliminating the chance of cavitation. Due to its geometry, the chance of erosion & noise level is comparatively less than similarly constructed conventional globe type valves.

Three-way valve shall be used in mixing & diverting services

Butterfly valves may be used for modulating service but shall not be used for, shut-off service if the maximum differential pressure across the valve exceeds 3 kg/sq cm.

Concentric disc type/ eccentric disc type butterfly valves shall be used in large line sizes & mainly in low-pressure applications or where allowable pressure loss across the valve is very low. Concentric disc type butterfly valves shall be designed for maximum opening angle of 60°. The maximum permissible opening for eccentric disk type butterfly valves shall be 90°.

Applications where wide range ability is required, eccentric disc type butterfly valve shall be used instead of concentric disc type butterfly valves.

Flange facing and drilling shall, be according to either Indian or similar other international flange standard.

Control valves of sizes 40 mm and above shall have flanged end connections.

In general control valves of sizes 25 mm and below shall have screwed connection except as follows:

- i) Other types of end connections shall be used when required by piping specification.
- ii) Stainless steel valve bodies shall have flanged connection for sizes 25 mm and larger.

Valves sizes shall be based on specified allowable pressure drop at 130 percent of normal process design flow conditions.

Valves shall be sized so that the valve will operate properly when upstream pressure is 10 per cent above maximum inlet pressure and downstream pressure is atmospheric.

Extended bonnets and high temperature packings shall be used for high temperature application. Extension-bonnets shall be provided in control valves for services above 200°C or below (-) 30°C, or as recommended by the manufacturer. Teflon asbestos packing shall be used up to 200°C temperature and graphite lubricated asbestos shall be used for operating temperature higher than 200oC.

Valve trim for most application shall be stainless steel for pressure drops of up to 7 kg/sq cm. For pressure drops above 7 kg/sq cm hard trim shall be used. Other alloys shall be substituted if required for corrosive conditions.

Minimum valve size shall be 25 mm for line size 25 mm and larger, using reducers, if necessary.

Hand-wheels, isolating valves and by-pass valves shall in general be provided for each control valve application. Isolating valves shall be of line size whereas by-pass valves shall be of control valve size.

For on-off control in small pipelines below 50 mm diameter, 2-way or 3-way solenoid valves shall be provided. Coil voltage shall be 24 V DC or 110/240 V AC rating and shall be suitable for continuous operation.

Control valves used in safety shut-off service shall be single seated tight shut-off valve. Leakage class of all fuel gas safety shut off valves shall be as per ANSI Class-VI. For other media, the shut off valves shall be of Class-V/Class-VI. Leakage class for control valves used for modulating action shall be as per ANSI Class IV.

Noise level of the control valves shall be as per accepted standard and shall be within 65 dBA from 1 meter of valve body.

Wherever required, line mounted Solenoid Valves may be used up to line size of 50 mm beyond which, pneumatic valve with internal pilot operated solenoid valves made of stainless steel shall

be used.

Valve stem-position indicator shall be provided for all the control valves.

Solenoid valves installed in the control air supply line shall be of Universal type having minimum Class F insulation and shall be continuously rated direct-acting type. Solenoid valves shall be full-bore type with minimum bore size 3 mm.

7.9.13 Support of Pipe-work and Valves

Pipe-work, valves and other connected equipment, or forming part of the operating system, shall be provided with adequate supports, brackets, thrust blocks and fixtures, as necessary and in an approved manner, to restrict any induced vibration to a minimum, under any operating condition. Valves, meters, strainers and other devices mounted in the pipe-work shall be supported independently of the pipes to which they connect. All brackets or other forms of support, which can conveniently be so designed, shall be rigidly built up of steel by welding in preference to the use of castings. No point of passage of pipes through floors or walls shall be used as a point of support. Vibration measurements shall be taken on site by the Contractor at various points on each complete machine as defined above. If any item is found to be vibrating

beyond the level considered by the Engineer to be a reasonable minimum, the Contractor shall reduce the vibrations to the required level as specified in the relevant standards.

7.10 Hand Railing

Hand - railing shall be double rail 1100 mm high measured vertically from the nose of the tread. All components for hand railing shall be SS-316 with cathodic protection.

7.11 Adjustable Weir Plates

The adjustable weir plates shall be manufactured from suitable stainless steel/ GRP and the design shall have the approval of the Engineer.

Weir plates shall be complete with fixing nuts, bolts and washers and suitable for a total vertical adjustment of 100 mm. Fixings shall be designed for ease of accurately levelling the plates, securing the plates, and shall enable the plates to be adjusted during the life of the Works to accommodate differential settlement of the structure.

7.12 Mixers

All mixers supplied under this Contract shall be of a standard and proven design for which spare parts are readily available in India. The number, size and position (including depth and orientation) of mixers shall be designed to maintain a fully mixed homogeneous solution within the entire volume of the tank or zone being mixed. Solids shall remain in suspension in a homogenous mixture for each cell.

The design and arrangement of the mixer(s) shall be determined and verified by hydraulic and mixing performance modelling. All modelling and analysis shall be based on the specific mixer design proposed and all modelling results shall be submitted for approval. The performance modelling shall verify that the velocity profile across the entire floor area of the mixing

tank/zone shall be sufficiently high so as to eliminate potential "dead-spots". The effectiveness of the installed mixers shall be such that the % w/vol solids at any single point within the tank or zone do not vary by more than $\pm 10\%$. The mixer shall be designed so as not to entrain air or promote surface vortices. The Contractor shall design the necessary features to prevent any ragging in the mixer impeller. The mixers and shall comply with the following requirements:

- The mixers shall provide continuous operation at their calculated design duty point. All calculations and drawings shall be submitted.
- The continuous rated output of the electric motor driving the pump and mixers shall be at least 10% in excess of the maximum power required by the unit under all operating conditions.
- Each submersible mixer and its motor shall withstand without damage to the mixer or any other equipment the effects of reverse rotation up to 120% of normal direction rated speed.

The Contractor shall purchase mixers and driving units from one source (the mixer manufacturer) to ensure the parts are compatible mechanically and electrically.

The materials of construction for mixers shall be of the following quality:

- Impeller SMO 254/Solid GRP
- Shaft construction SMO 254/Solid GRP
- Mechanical Seal Silicon carbide/silicon carbide
- Guide Bar with Brackets, Lockplates Stainless steel: AISI 316L
- Fasteners Monel K 500/Incoloy 625

7.12.1 Submersible Mixers

Each submersible mixer shall be supplied complete with the following:

- Mounting arrangement, complete with coupling devices, guide rails and support brackets;
- Swivel mechanism for rotation of the mixer in horizontal and vertical planes;
- Placement / Removal Apparatus, including swing type lifting davit, stainless steel grade 316L lifting cable, stainless steel winch and shackles,
- Composite power and control cable length;

The mixers shall be provided with adjustment for depth and mixing direction. Mixers shall include a motor and impeller; in a close-coupled configuration, forming a compact, and robust mixing unit. Four-pole motors are preferred to multi pole motors.

Appropriate shroud arrangements shall be provided where necessary to prevent air entrainment and vortices. The design of the casing and propeller shall allow an uninterrupted flow across the units, allowing the mixing media not to be caught and allowing cooling of the mixer.

The mixers shall be manufactured from stainless steel materials selected by the manufacturer to suit the duty requirements, fluids and operating conditions. The guide rail arrangement shall permit easy adjustment of the submersible mixer orientation in the vertical and horizontal planes,

by an operator standing on the access platform.

Mixers shall be readily removable for inspection and maintenance using the lifting equipment, without the need for personnel to enter the tank. The lifting arrangement shall enable a single operator to easily lift each mixer from its installed location and place it on the access walkway/platform without removing the handrails. Similarly, a single operator shall be able to easily replace each mixer to its installed location. No portion of the mixer shall be permanently fixed to the base of the tank.

A stainless steel 316 lifting chain of sufficient length to reach from the mixer to the platform level shall be provided with each mixer. All holding down bolts shall be of 316 grade stainless steel. For lifting facilities by a davit, the mixer shall be fitted with stainless wire rope and brake winch.

Electrical cables for each mixer shall be suitably protected and supplied in place so as to prevent any damages.

The mixers shall have the following features:

- Can be used in every shape of tank.
- Self-cleaning & non-clogging propeller with Energy saving
- Hydrodynamic shape for optimum flow formation
- Drive unit optimised for mixing applications
- Little maintenance and long operating life.
- The mixer shall be driven by a high efficiency 3 phase motors IP68 Class F. Motor shaft and rotor shall be dynamically balanced.
- The mixers shall have the flexibility to be located at different depths and thereby avoiding dead zones.

The motor shaft shall be supported by two no's of single row double shielded anti-friction bearings with rating of life of minimum 100000 hours.

Scope of supply of each mixer shall include but not limited to Mixer with motor, Gear reducers, Seal monitoring relay, Moisture sensors, Guide mechanism complete with rope winch, power & control cable, chain, vibration dampeners and standard repair kit.

7.12.2 Flash Mixers and Top Entry Mixers

The mixers shall enter tanks vertically from the top and normally operate continuously.

The mixer shall be complete with mounting unit, reduction gearbox and motor. The design should be suitable for outdoor mounting and enclosure protection shall be provided to IP 55.

The mixer paddles and shafts shall be of Duplex stainless steel with PREN>40. The shafts shall be sufficiently rigid to prevent flexing. Maximum deflection shall be limited to shaft length/1000. The shafts shall be fitted to the gearboxes in a positive manner, which may take the form of keyed flanges with retaining bolts or equivalent. Mixers can be supported near the

blades.

7.12.3 Inline Static Mixers

Inline static mixer shall be provided as per the process requirement. The maximum pressure drop due to static mixers shall be restricted to 0.5 bar.

The materials of construction for mixers shall be of the following quality:

Impeller:	FRP/GRP
Body:	SMO 254/Super Duplex/GRP
Mechanical Seal:	Silicon carbide/silicon carbide
Fasteners:	Monel K 500/Incoloy 625

7.12.4 Shaft Seals

7.12.4.1 General Requirements

The Contractor shall provide all mixers with mechanical seals. The seals provided shall be capable of allowing the mixers to run. Two independent mechanical face seals assembled in tandem shall be fitted to provide reliable and durable sealing performance.

The seals shall be designed for a minimum operating life of 5 years under normal operating condition. Spare mechanical seals shall be supplied to the extent of the life of pumps. The seals shall be of the balanced type, cartridge mounted, incorporating bellows or multiple helical springs of stainless-steel grade 316 and high nitrile synthetic rubber or ethylene propylene static "O" rings. Seal faces shall be lapped flat to within two (2) helium light bands and the depth of interface roughness shall not exceed 0.3 microns.

7.12.4.2 Seal Failure Detection

Submersible type pumps and mixers shall be fitted with seal failure probes for moisture and oil leakage. The probe shall be fitted in the oil bath between the two mechanical seals and shall be arranged to detect the presence of water in the oil bath, e.g. to detect failure of the propeller seals. A moisture detection device shall be fitted in the motor stator housing and cable termination housing. Sensors shall be compatible with Tritronics RT1 relay.

7.12.4.3 Motor Protection

All mixers shall be protected from overheating by a positive temperature coefficient (PTC) thermistor in each phase of each stator winding. Each thermistor shall be connected in series to terminals adjacent to the stator terminals and encapsulated and compatible with motor selected; or sensors shall be compatible with Tritronics RT1 relay.

7.13 Glass-Fused-to-Steel Bolted Tank

7.13.1 Materials

Plates and sheets used in the construction of the tank shell, optional floor and roofs, shall comply with the minimum standards of ISO 28765:2008 Section 9.2. Such sheets shall be produced by

a hot rolling process and shall be sourced from reputable International steel mills.

Raw materials delivered to the Manufacturer's plant shall be tested / inspected to ensure compliance with the Manufacturer's requirements for strength.

Test Certificates issued and conducted by third party reputable international organization shall be available for the Engineers inspection if required. Such Certificates shall be requested before the time of issue of the Purchase Order.

7.13.2 Horizontal Wind Stiffeners

The top stiffener of the roof shall provide a flat, horizontal, continuous surface at tank rim level.

Wind stiffeners shall be steel, hot-dipped galvanised, rolled steel angle bar.

7.13.3 Bolt Fasteners

Bolts used in tank lap joints shall conform to BS 3692 and shall be V2" - 13 UNC-2A rolled thread with hot-dipped galvanised coating.

All bolts for tank shell and Glass-Fused-to-Steel roof (where applicable) shall be installed such that the head portion is located inside the tank and the washer and nut are on the exterior.

All lap joint bolts shall be properly selected such that threaded portions will not be excessively exposed in the "shear plane" between tank sheets. Also, bolt lengths shall be selected to achieve a neat and uniform appearance. The torque values (as set down in the Manufacturer's Construction Guide) shall not be exceeded during tank construction.

All lap joint bolts shall be designed to prevent rotation during tightening.

7.13.4 Bolt Head Encapsulation

All tank shell and Glass-Fused-to-Steel roof structure bolts shall have UV resistant polypropylene encapsulation of the bolt head and be certified to meet Regulation 31 or NSF Standard 61 for indirect additives.

All other bolts shall be hot deep galvanized conforming to BS 3692 and shall be Vz -13 UNC-2A rolled thread with hot-dipped galvanised coating.

7.13.5 Sealant

The sealant shall be used to seal lap joints, bolt connections and sheet edges. The sealant shall cure to a rubber-like consistency and have excellent adhesion to the glass coating, have low shrinkage, and be suitable for interior and exterior exposure. The sealant shall be a one component moisture cured polyurethane compound.

Where required, the sealant shall be suitable for contact with product water and meet Regulation 31 or NSF Standard 61 where specified.

Bidder should submit Certification of conformity of the Manufactured to Regulation 31 or NSF Standard 61 issued by NSF to ensure compliance to the above section.

EPDM or Neoprene gaskets and tape type sealer shall not be used other than for shell manway door/hatch.

7.13.6 Glass Coating

In cases where both the inside and outside surfaces of the sheet are in contact with the stored liquid both surfaces shall be treated as the inside surface for the purposes of this specification.

Coating Standards

The tank coating shall meet the quality requirements of ISO 28765:2008 and should conform to NSF Standards.

Surface Preparation

Sheets shall be steel grit-blasted to a silver-grey finish on both sides to remove mill scale and surface oxidation.

Grit blasting shall be performed to the equivalent of SA21/4 or SSPC-SP10.

The surface anchor pattern shall be in the range of 20um to 100um with a target value of 60um.

7.13.7 Cleaning

Immediately after fabrication and grit blasting and prior to application of the coating materials, all sheets shall be thoroughly cleaned by an alkali wash.

Following the alkali wash all sheets shall be rinsed in hot water containing a nitrite-based rust inhibitor.

The rust inhibition process shall be followed by heat drying to ensure the sheets are clean and dry ready to be coated.

7.13.8 Coating

All sheets shall receive a coat of catalytic nickel oxide-based pre-coat to both sides. The pre-coat application weight is controlled and measured and sheets that do not meet the required specification, in accordance with the Manufacturer's specified parameters, shall be rejected at this point.

All pre-coated sheets shall be heat dried to ensure that a moisture free surface has been achieved before the glass coating layer is applied.

A coat of cobalt rich glass slip shall be continuously applied to both sides of the sheet followed by heat drying.

The coated sheets shall be visually inspected and sheets with spray or glass defects shall be rejected at this point.

The thickness of the coating system shall be measured using an electronic instrument; the instrument shall have a valid calibration record. Interior and exterior dry film coating thicknesses are controlled and measured and sheets that do not meet the required specification, in accordance

with the Manufacturer's specified parameters, shall be rejected at this point.

After inspection the sheets shall be fired through the furnace at approximately 850°C in accordance with the Manufacturer's procedures.

The firing process shall form a composite glass surface having general acid/alkali resistance to solutions in the range pH 3 to pH 9, subject to temperature and chemical composition.

Tank inside sheet colour shall be as specified by the manufacturer. Tank external colour shall be Blue (20-C-40) or Green (12-B-29).

Sample tests shall be carried out by the Manufacturer to ensure that enamel materials meet the physical properties and chemical resistance characteristics as published in the Manufacturer's product Quality Standard. The Manufacturer shall provide published product Quality Standards detailing the International Standards used for testing.

Bidder should submit Manufacturer's Product Quality Standards detailing International Standards used for Manufacturing and Sheet Coating Procedure and Process.

7.14 Flocculation and Clarification

7.14.1 Flocculation

The flocculator shall be paddle type designed to achieve flow mixing in flocculation chamber to G ranging between 20^{-s} to 40^{-s}. The design shall be based on G value to be selected. Justification for G value selection shall be furnished. The electric motor shall be suitable for outdoor duty as per specification.

7.14.2 Clarification

Tube Settler process shall be provided.

Clarifier shall be single design for each work and shall be of concrete construction each with identical internal dimensions.

7.14.2.1 Tube settler

The media shall be in PVC construction, simple hexagonal configuration and robust. The tube module shall be kept at inclination 55-60° to horizontal. The media shall be supported on structural steel members in symmetrical manner.

7.14.2.2 Sludge Draw-off

The hopper shall be provided to collect the sludge in the hopper bottom under gravity. Sludge draw-off arrangement shall include the following:

- Sludge line of suitable diameter but not less than 200 mm from each hopper of the clarifier to common header
- Common header not less than 300 mm discharging into sludge balancing tank.
- The line from hopper to common header shall incorporate Tee and rising spindle type

sluice valve with electrical actuator.

- All connections in common header and line shall be with flange joint and flange adaptor to facilitate dismantling to manually remove clogging in the pipe.
- Sampling and rodding point for jet cleaning of the sludge line shall be provided.
- Sluice valve shall be provided in the pipeline below each hopper with remote ON/OFF facility.
- In common header, a knife value shall be provided with ON/OFF facility.
- Sufficient valve shall be provided to make the cleaning of a hopper using water jet.

7.14.2.3 Equipment for cleaning tubes in tube settler

The Contractor shall provide complete cleaning system for cleaning the tubes in place without removing the tubes. Conceptual arrangement is cleaning by jetting.

The length of the hose provided shall be adequate to reach all the tube settlers.

7.15 Dissolved Air Floatation (DAF)

DAF shall be provided to treat clarified water to eliminate the rest over floating material. Sufficient provision shall be given to isolate and bypass the DAF in case not required. In case of bypassing the facility shall be provided to clean the DAF system completely so that seawater is fully drained and replaced by the product water to avoid the corrosion of the civil and mechanical system during idle condition.

7.16 Dual Media Filtration

Dual Media Filtration (DMF) shall be provided with all mechanical gates and valves. Minimum 8-10 valves/gates will be there in each filter. Each filter will have two beds. The mechanical items shall be provided as per the process details provided in Part-2 A3 of bid document.

7.17 RO System

RO system shall be constructed mostly of SS316L/ Duplex steel (PREN>41) in the low-pressure area and of Super Duplex Steel (PREN \geq 43) in the high-pressure area and GRP/FRP/HDPE for other associated items. The selection of materials for RO system shall be proposed after discussion with the Employer's representative. All material selection shall be approved by the Employer's representative before the procurement of equipment.

7.18 Thickeners

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

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

The thickeners shall have a full diameter fixed bridge complete with 1200mm walkway for personnel access to the centre, access stairs to ground level and hand railing, a motor-driven sludge scraper complete with all necessary controls, delivery pipe-work, a stilling well and overflow steel weir plates. Walkways, access steps etc shall be galvanised. Handrails shall be of tubular Type 316 steel construction and made of 32NB pipes. Especially where mild steel is proposed for underwater structure, the part shall be coated with polyurethane.

The scraping gear shall be supported from the tank base and from a fixed bridge carrying the central electrical drive for the rotating gear. The equipment including driving motor, gears, shafting and scrapers shall be designed for continuous operation and sized for the most arduous operating condition including starting from rest with an accumulation of sludge in the thickeners. The electric motor, gearbox etc., shall be provided with a sunshade.

The fixed bridge, access steps and the feed well shall be galvanised steel. The main drive shall be cast Iron construction and shall be enclosed in a dustproof enclosure with oil bath lubrication. All underwater hardware shall be of Type 316L stainless steel/ cupronickel. All fasteners shall be Monel 410/K500. All other material shall be corrosion resistant.

Suitable overload protection for the drive shall be provided to ensure that the sludge shall not overload the equipment and an emergency stop pushbutton shall be provided. The scrapers shall be fitted with rotation monitors and over torque protection to alarm in the event of a failure.

Corrosion allowance of 2 mm shall be taken in the structural sections of scraper arm, bridge etc. Structural design calculations shall be submitted for all structures including scraper arm, bridge etc. and also the calculation for drive head selection including the Torque Rating. V-notch weir in SS 316L construction of size minimum 4 mm thick and 250 mm wide shall be provided along the launders for uniform draw-off of the overflow. The weir plate shall be fixed to the launder by means SS 316L grade clamping plates and fasteners. The weir plate shall be adjustable to achieve uniform level.

The hydraulic equipment will consist of the SS 316L/Duplex SS inlet pipe (runs along the bridge) to the central feed well of the thickener; sludge draw-off pipe with an manual & Motorised Knife Gate valve (in Duplex SS material of construction) for intermittent operation according to an adjustable timer; a drain pipe with manually operated gate valve for the complete emptying of the unit; a discharge pipe from the peripheral collecting channel to the upstream of fine screens either by gravity flow or with pump.

The sludge thickener mechanism shall be generally in SS316L/Duplex SS/GRP/Polyurethane construction, suitable for installation in a circular RCC tank and shall include the following:

- a) Mechanism support beam spanning the diameter of the tank
- b) Walkway (GRP) and handrail SS316 from the edge to the centre of the tank
- c) Drive mechanism with internal gear type

- d) Reduction gear box
- e) Chain and sprocket with guard
- f) Central shaft with scrapper arm and picket fence
- g) Skimmer Scum Baffle and Scum trough
- h) Overflow weir:
 - i) Vertical pickets
 - j) Torque Indicating Device
 - k) Overload Alarm protection

7.19 Chlorine Solution (Hypochlorite) Delivery Pipe-work and Valves

The Contractor shall provide all necessary rigid pipe-work, valves and fittings for the delivery of the chlorine solution from pumps to the points of application.

The chlorine solution delivery lines shall be of HDPE/cPVC or approved equivalent. The pipe-work shall be adequately protected externally against corrosion and installed complete with necessary supports, thrust restraints, etc., and incorporate sufficient flexibility to allow for any thermal expansion effects.

When selecting material for pipe-work, consideration shall be given to the deteriorating effect on some synthetic materials due to the action of ultra-violet rays. Where such materials are employed, particularly in the case of uPVC, pipe-work shall be shielded from direct sunlight.

7.19.1 Safety Equipment

Materials and equipment necessary to ensure the safety of personnel working in the vicinity and others shall be provided at each chlorine storage area.

Each set of safety equipment shall be mounted in a glass-fronted, non-locking PVC coated steel cabinet in approved locations on the outside of the Chlorine building.

Emergency showers shall be provided and shall be installed near the Chlorine storage tank. The shower shall be operated automatically by a quick-acting hand or foot valve. Foot operating arrangement

Two eyewashes shall be supplied. One eyewash shall be adjacent to the shower. The eye bath unit shall be fitted with fine mesh filters with built-in pressure regulating device to ensure a safe rate of flow to prevent foreign matter being further embedded into the eye and instead flush away contamination.

Water for the shower, etc, shall be drawn from the service water supply.

Following safety aids shall be provided for safe handling of Chlorine system:

- a) Display of hazardous chemicals data sheet on plant entry gates and at the use / application in local language and in English,
- b) Emergency Toolbox and spares

- c) First Aid box
- d) Portable Emergency lights
- e) Display boards of telephone/ mobile of important plant personnel

All the applications, permission /license and other clearances for storage and operation of chlorination system from concerned govt. authority shall be under the scope of contractor.

In case of enclosed area where chlorine solution is stored shall be provided with a forced ventilation system. Air intakes shall be sized to allow uniform ventilation and positioned to prevent possible recirculation. Extract air shall be ducted from low level and discharged at high level.

The ventilation systems shall be designed to provide for general day to day use an air change rate of four per hour. Extract fans shall be heavy duty industrial pattern manufactured from chlorine resistant materials.

7.19.2 Chlorine Residual Monitors

One chlorine residual monitor shall be provided for monitoring the final water downstream of the each of the chlorine injection points.

The monitor installation shall be located in a covered location easily accessible for viewing and maintenance and shall be provided complete with sample pumps as necessary to ensure the continuity of the sample.

The sampling pipework complete with isolation valves, etc. shall be designed to ensure the sample reaches the monitor in a time not greater than 1 minute. The monitor drainage pipework shall permit the visual checking of the presence of flow and shall discharge to the plant drain. Sample water not passed through the monitor shall be returned to the process. The residual signals shall be displayed at the local control panel and at the central HMI. High and low chlorine residual levels shall raise alarms at the local control panel and at the central HMI.

7.19.3 Chlorination Power and Control

A combined MCC and control panel shall be provided at each chlorination plant and located in a suitable location protected from the weather and the effects of the process. The control panel shall provide facilities for the:

- display status and values associated with the chlorination systems
- duty pump selection
- annunciate alarms associated with the chlorination systems
- operator adjustment of process set points

The chlorination systems shall operate using a fixed manually/automated set dose rate. The quantity of chlorine dosed shall therefore be adjusted in direct proportion to the process flow at the dosing point through PLC/SCADA. The chlorine residual monitor to be provided shall be used for monitoring and alarm purposes.

The duty booster pumps shall be manually started at the control panel. The action of starting the duty booster pump shall start the chlorination process concerned. The operation of the room ventilation and fume detection systems shall be independent of any PLC controls and shall operate in any mode. Cable support systems throughout the chlorine installation shall be constructed of u-PVC or GRP.

7.20 Belt Filter Presses

Continuous-feed dewatering belt filter press (BFP) that uses the principles of chemical conditioning, gravity draining, and mechanically applied pressure shall be used for the sludge dewatering operations. Sludge shall be first conditioned using polymer prior to dewatering on the belt filter press. The optimum polymer dosage shall range up to 5 kg/1000 kg of dry solids. Polymer (non-food grade) shall be dosed to the sludge flow via an in-line static mixer. The conditioned sludge shall be first introduced on a gravity drainage section where it is allowed to thicken. Following gravity drainage, pressure is applied on the opposing porous belts where sludge is squeezed and dewatered.

Each belt press shall be designed and sufficiently automated to involve minimal operator attention. The operation of each BFP shall be controlled by the operator at a unit control panel. Operation of each BFP and its associated dedicated sludge feed pumps, polymer dosing system, and belt washing system and other plant shall be automatic once the start-up procedure has been initiated by the operator. A low-level sensor in the thickened holding tank shall automatically stop the flow of sludge to the BFP.

The BFP shall produce a dewatered sludge cake of no less than 25% dried solids. At least 98% of the solids shall be in the dewatered cake and less than 2% of the solids shall be in the wash water. The wash water will be drained to the plant drain while the solid sludge from BFP will be transported out of the plant for appropriate disposal i.e. landfill.

The BFP shall comprise the following components. All component of the BFP will be made of SS316 or better as per application.

7.20.1 Main Structural Frame

The structural frame shall be of all welded construction and shall be fabricated from channel designed to adequately support all components. The design permits roll removal without requirement of disassembly of frame.

7.20.2 Extended Gravity Drainage Section

To maximize gravity water removal, adequate gravity drainage area shall be provided or vacuum system shall be provided to enhance drainage. A set of gravity dispersion device shall be provided to disperse sludge for effective removal of water. Dispersion devices shall be constructed of ultra-high molecular weight polyethylene. Each set of devices shall have the capability of being rotated out of the flow by handles, for maintenance purposes or process flexibility.

Sludge shall be contained within the drainage section by a barrier equipped with replaceable

rubber seals on each side. The gravity drainage belt shall be supported by polyethylene grids over the complete length and width of the gravity drainage section that are also used for effective removal of gravity and capillary water.

7.20.3 Adjustable Wedge

Following gravity dewatering, adjustable wedge section for process flexibility shall be incorporated into the press. Gradual increased pressure shall be applied as belt passes through the adjustable wedge section.

7.20.4 Pressure Section

A minimum diameter roll shall be used as the initial roll in contact with gravity concentrated sludge. A S-shaped roll configuration shall be used to apply maximum pressure and shear. To ensure optimum cake dryness, a minimum number of rolls shall be used in the pressure area.

7.20.5 Filtration Belts

Each belt shall be a continuous design woven from monofilament polyester strands. Each belt shall incorporate a mechanical seam that does not interfere with press operation and also allows simple, periodic belt replacement.

7.20.6 Doctor Blade

For removal of dewatered cake, the press shall incorporate a doctor blade for each filtration belt. Blade pressure shall be field adjustable against the belt by means of spring tensioning mechanism and shall be replaceable, reversible with two useable edges and fully accessible to the operator.

7.20.7 Rolls

All rolls, including guide and tracking, shall be of low deflection design.

7.20.8 Roller Bearings

All bearings shall be pillow block type with split, cast iron, two bolt housings. All bearings shall be capable of compensating for misalignment without seal distortion. Each bearing shall be grease lubricated.

7.20.9 Filtrate Collection

Drainage pans shall be located under all gravity and pressure section of the press. Drain pans with standard NPT connections shall collect gravity filtrate and pressure filtrate to common drainage points.

7.20.10 Belt Washing Device

Following cake discharge, each polyester belt shall be continuously washed using a high pressure, low volume steel shower assembly. A Y-strainer (stainless steel) to be provided in wash water line to remove any particles which may enter the shower assembly. Each shower

assembly shall have stainless steel nozzles. The shower assembly shall be designed to completely contain the high velocity water spray and remove any solids trapped in the belt.

Pumps required for belt washing shall be integral to the BFP system. The belt washing shall be automatic with minimum flow of water. Spent washwater shall be directed to the plant drain.

7.20.11Belt Tracking

Belt positioning for each belt shall be continuously and automatically monitored by an arrangement which shall be installed with guide devices. The guide device shall ride the edge of the polyester cloth belt. The micro-torque unit shall sense belt misalignment and shall automatically walk the belt back to the normal operating position by means of a live hydraulic tonner which shall be attached to tracking rolls. The opposite end of the tracking roll shall incorporate self-aligning pillow block bearings which allows the tracking rolls to pivot in a horizontal plane. Belt tracking shall be automatically operated by the hydraulic power pack. A limit switch shall be provided on each side of each belt to sense extreme belt travel and initiate a shut-down signal and sound an alarm. The limit switches for the pressure section shall be positioned to sense both belts simultaneously.

7.20.12Belt Tensioning

Each belt in the pressure section shall be equipped with a hydraulic tonner belt tension system operated by the hydraulic power pack to automatically ensure proper preset belt tension while dewatering varying thickness of sludge. The belt tension system shall assure parallel movement of the tension rolls by use of rack and pinion system.

7.20.13Belt Press Drive & Component Operation

The belt press drive shall comprise of an electric geared motor unit coupled to the drive roll through a flexible coupling. A local electrical control panel complete with control logic, variable frequency drive etc. shall also be supplied along with the belt filter press.

7.20.14Sludge Treatment and Disposal Power and Control

A combined MCC and control panel shall be provided. The control panel shall provide facilities for the:

- display status and values associated with the sludge treatment systems
- duty pump selection
- annunciate alarms associated with the sludge treatment systems
- all necessary controls for BFP installation
- The BFP manufacturers proprietary control panel/s may be provided in addition to the above providing the requirements for BFP status and alarm annunciation are fulfilled locally and at the central HMI.

7.20.15Conveyor System

- a) For the disposal of dewatered sludge, 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.
- b) 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.
- c) The belt material shall be two ply nylon or equivalent with minimum 3 mm neoprene covering on carrying side. Splicing shall be employed to make the belt endless. The belt shall operate over three roll twenty degree, troughing idlers. The idlers shall rotate on precision type, deep groove, single row ball bearing with built-in close-fitting triple labyrinth grease seal. The ends of the outer shell shall be counter bored and a full length centre tube journaled concentricity. The outer shell, centre tube and precision die formed steel ends shall be brazed into an integral unit to provide concentricity. The ends of the centre tube shall be bored concentrically with each other after roll assembly to provide correct bearing alignment and to provide 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.
- d) 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.
- e) Shafting for pulleys shall be of material suitable for seawater contact. They shall be forged, ground and polished to obtain close diameter tolerances. The head shaft shall be provided with roller bearing pillow blocks.
- f) 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.
- g) The conveyor shall be supported on appropriate 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.
- h) An adjustable belt scraper shall be provided on the hopper end of the conveyor belt. The scraper and attachments shall be of fibreglass/fibre-reinforced plastic/PVC.
- i) Sludge cake discharge Hoppers shall be provided to transfer the sludge cake from the BFP 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 belt sway switches shall be provided on conveyor.

7.21 Hoist and Crane

7.21.1 Electrically Operated Hoists

Electric hoists shall be complete with hoisting motor, wire rope drum, wire rope, hook, necessary gearing, sheaves, electromagnetic brake for hoisting motion, weather & dust-proof push button station, contractor panel, all wiring, limit switches, etc.

Electric hoists shall conform to IS:3938 and shall be suitable for outdoor application. All the parts of the hoist shall be designed to withstand surrounding atmospheric conditions without any deterioration.

Rope drums shall be either cast or welded to sustain concentrated loads resulting from rope pull. Drums shall be machine grooved right and left with grooves of a proper shape for the rope used.

Gears shall be cut from solid cast or forged steel blanks or shall be of stress-relieved welded steel construction or built-up from steel billets and welded together to form a one-piece gear section.

Hoist ropes shall be extra flexible, improved plough steel rope with a well lubricated hemp core and having six strands of 37 wires per strand with minimum ultimate tensile strength of 1.6×10^6 kN / sq. m.

Hooks shall be solid, forged, heat treated alloy or carbon steel of rugged construction of the single hook type and provided with a standard depress type safety latch.

Hoisting motor shall be equipped with electrically released, spring set, friction shoe type brakes having torque capable of holding 125% of the full rated hook load. Brake shall apply when either the motor controller or the main power switch is in 'OFF' position or in the event of power failure.

Drive motors shall be designed for frequent reversal, braking and acceleration and shall be as per IS:325. Pendant control switch, controllers and resistors, controls, electrical protective devices, cables and conductors, earthing guards etc. shall be as per IS:3938. Limit switches shall be provided for over-hoisting and over-lowering.

The electric hoists shall be of Class II duty.

A 25% overload test, speed tests, limit switch tests and brake test shall be conducted for the hoist and trolley at the manufacturer's works.

7.21.2 Hand Operated Hoists and Trolleys

Manual hoists shall be complete with hand-chain, trolley, pulley block, hook, hand and load chains, brake and other accessories. They shall comply with the latest applicable standards,

regulations and safety codes in the locality where equipment will be installed.

Each hoist shall be operated on a monorail (I-Beam). The factor of safety shall not be less than 5. The load chain may be heat-treated to give ductility, toughness and conforming to IS:3109/BS:1663/BS:3114. The load wheel is to be made from heavy duty malleable castings. The hand chain is to conform with BS:6405:1984 and hand chain wheel may be made from pressed sheet steel with roller type guarding. Gears shall be cut from solid cast or forged steel blanks or shall be stress – relieved welded steel construction. Pinions shall be of forged carbon or heat-treated alloy steel. Strength, Quality of Steel, heat treatment, face, pitch of teeth and design shall confirm to BS:436, BS:545 and BS:721. Spur and helical gears must comply with BS:436 and worm with BS:721. Bearing must be ball and roller type conforming to IS:2513/BS:2525-32:1954. Proper lubricating arrangements are to be provided for bearings and pinions. The brake for the lifting gear shall be automatic and always in action.

The proof testing of each chain pulley block is to be carried out as per latest applicable standards. The safe working load is to be marked in such way that is clearly visible from the operating level.

7.21.3 Hand Operated Travelling Crane

The crane bridge shall consist of a single bridge girder carrying two wheels at each end of the span. Steel used shall be tested quality steel conforming to IS 2062. The girder shall have enough strength to carry the test load without causing undue stress or deflection.

The long travel bridge wheels shall be rim toughened, heat treated carbon steel or low alloy steel or C.I. They shall be double flanged type. The wheels shall have antifriction ball/roller bearings. The wheels shall be machined on their treads to match the runway rail section. The bridge shall have a geared shaft and pulley connecting to opposite wheels of the span, to achieve the long travel motion of the bridge, by means of a chain. The runway rails of adequate strength and rigidity, rail clamps and other accessories for mounting the rails and suitable end stops for the bridge shall be supplied by the Contractor.

The chain pulley block shall be operated on the lower flange of the bridge girder.

The load chain shall be made of alloy steel as per IS:3109. It shall be heat treated to give ductility and toughness so that it will stretch before breaking. It shall be of welded construction with a factor of safety not less than 5.

The hand chains for the hoisting and traverse mechanism shall hang well clear of the hook and both the chains shall be on the same side. The hand chain wheel shall be made from pressed sheet steel and shall be provided with roller type guarding to prevent snagging and fouling of the chain.

All the gearings shall be totally encased. Proper lubricating arrangements shall be provided for bearings and pinions. Gears shall be cut from forged steel blanks. Pinions shall be of heat treated alloy steel. Gears shall be as per BS:436/IS:4460.

The trolley track wheels shall be rim toughened, heat treated carbon steel or low alloy steel or C.I. and shall be single flanged and shall have antifriction ball bearings. The wheels shall be

machined on their treads to match the flanges of the track joints.

The travelling trolley frame shall be made of rolled steel conforming to IS:2062. The side plates of trolley frame shall extend beyond wheel flanges, thus providing bumper protection for the wheels. The two side plates shall be connected by means of an equalising pin.

Axles and shafts shall be made of carbon steel and shall be accurately machined and properly supported.

The lifting hooks shall be forged, heat treated alloy or carbon steel of rugged construction. They shall be of single hook type provided with a standard depress type safety latch. They shall swivel and operate on antifriction bearings with hardened races. Locks to prevent hooks from swivelling shall be provided. Hook shall be as per IS:3815.

The brake for the lifting gear shall be automatic and always in action. It shall be of screw and friction disc type self-actuating load pressure brake. Brakes shall offer no resistance during hoisting.

Ratchet and Pawl mechanism shall be provided to arrest the full load from lowering due to gravity. The ratchet and pawl shall be of steel, hardened and tempered so as to attain required wear resistance and toughness.

7.21.4 Electrically Operated Overhead Travelling Crane

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

The crane bridge shall consist of bridge girders on which a wheeled trolley is to run. The bridge trucks and trolley frames shall be fabricated from structural steel. Access walkway with safe hand railing as 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, or relevant internationally approved standards. The bridge shall be designed to carry safely the loads specified in IS:807 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 100000 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 relevant internationally approved standards and shall have a safety latch to prevent rope coming off the hook.

Hoist rope shall be extra flexible, improved plough galvanized steel rope with well lubricated hemp core and having six strands of 37 wires per stand with minimum ultimate tensile strength of 1.6×10^6 kN/m² of Right Hand Ordinary (RHO) lay construction. The ropes shall have a 6:1 safety factor on the specified safe working load and shall conform to IS:2266. 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 applicable standards.

Name Plate showing the capacity, year of manufacture and rated capacity of hoist, in figures not less than 150 mm height, shall be placed on each side of the crane girder.

The maximum deflection under full load shall not exceed 1/900 of the span (as per IS:3177).

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

- a) 'Start' and 'Stop'.
- b) Long travel - 'Right' and 'Left'.
- c) Cross travel - 'To' and 'From'.
- d) Hook - 'Hoist' and 'Lower'.
- e) 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 overtravel for each of the following:

- a) For 'UP' and 'Down' motions of the hook.
- b) Long travel motion

c) 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.

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

Sufficient slings, ropes, shackles, lifting beams, etc shall be supplied to handle all items of plant covered by the crane. They shall be labelled or marked with the Safe Working Load (SWL) and the purpose for which they are intended.

The crane, and all slings, ropes, shackles and other lifting equipment supplied shall be tested by the manufacturer at his works. The tests shall be carried out at 125% of Safe Working Load, and Test Certificates shall be supplied.

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

All electrical equipment shall be fully tropicalised.

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

7.21.5 Jib Cranes

Fixed jib cranes shall be provided in for lowering/removal of equipment/parts. The crane capacity shall be 1.25 times the maximum weight to be handled or 1.5 Tonnes, whichever is more. The lift and reach of the cranes shall be suitable for the equipment/parts to be handled. The crane shall be capable of being swivelled by 360. Adjacent halves of clarifiers may be provided with common jib crane if feasible. All materials used in the construction shall be corrosion resistant. Mild steel used shall be galvanised. Ropes, chains and pulleys shall be of stainless-steel construction. Hardware shall be of SS 316. The Jib crane shall also be provided for handling submersible mixers in Wastewater balancing tank, thickened sludge sump (sludge holding tank) and Backwash recovery tank (Backwash Waste water tank).

7.22 Reduction Gear Units

Reduction gear units, wherever provided shall be double reduction units without V-belt and pulley. Gears shall be cut from solid cast or forged steel blanks or shall be of 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 applicable standards. Split gears shall not be used. Gears and pinions shall be pressed on and keyed to

shafts. All pinions and gears are to be of the totally enclosed type up to the last stage of reduction in all motions and shall be carried in fabricated steel gear cases which must be dust-proof and firmly sealed to prevent oil leakages and shall be oil bath lubricated. The gear boxes shall have covers split horizontally and arranged so that top half can be removed for inspection. They shall be fitted with bolted type machined inspection covers and with cast steel cartridge housings for carrying roller bearings. Dip sticks or indicator shall be provided for indicating the oil level. Guards shall be strong enough to retain the whole gear or any part that might otherwise fall. No overhanging gears shall be used. Drain plugs shall be provided on all gear cases. Lifting lugs shall be provided for handling purposing.

7.23 Ventilation System

7.23.1 Scope

The scope of work covers the design, manufacture, inspection and testing of performance at the manufacturer's and / or his sub-contractor's works delivery to site, storing and handling at site, erection, commissioning and carrying out acceptance tests at site of the Ventilation System for Desalination Plant and its buildings.

7.23.2 Code and Standard

The design, manufacture, inspection and testing of ventilation system shall comply with all currently applicable statutes, regulation and safety codes in the locality, where the equipment are to be installed. The equipment shall also conform to the latest applicable Indian / British / American Standard. Nothing in this specification shall be construed to relieve the contractor of his responsibility. In particular, the equipment shall conform to the latest edition of the following standard.

IS: 2312	Propeller type AC ventilation fans
IS: 3588	Specification for Electrical Axial flow fans
BS: 848	Fans: Part 1: Methods of testing performance; Part 2: Fan Noise Testing
AMCA: 210	Test Code for Air Moving Devices
BS:6540(Part-1)	Method of test for air filters used in air conditioning & General Ventilation.
BS: 3928	Sodium flame tests for air filters (other than for air supply to I.C. Engines & Compressors).
VS-FED-2098	Method of cold DOP & Hot DOP test MIL - STD-282 DOP smoke penetration method.
ASHRAE-5276	Method of testing air cleaning device used in general ventilation for removing particulate matter.

In case of any conflict in the standard and this specification, the decision of Employer shall be final and binding.

7.23.3 Description of Ventilation System

The inside dry bulb temperature (DBT) temperature to be maintained shall be limited to maximum 5 °C over than the ambient dry bulb temperature at all times of the year considering ambient air conditions mentioned above.

The following are the areas provided with mechanical type ventilation system with combination of supply air fans and / or exhaust air fans/TURBO ventilators (Roof ventilators, wall mounted type)

- a) All pump houses
- b) DAF and Lamella Buildings
- c) RO Buildings
- d) Chemical Houses
- e) Workshop and Warehouse
- f) Limestone Filters
- g) Toilets in all buildings including the following (30 Air Changes per Hour)

7.23.4 Design Philosophy

Number of air changes per hour in evaporative / mechanically ventilated areas shall be as follows.

S. No.	Area	Air Changes per hour
1.	Chemical Houses, Pump (enclose) houses & Other areas like toilets etc.	20
2.	RO buildings and over	40

However, in areas producing lot of heat, the temperature limitation should be the criteria, which is as follows:

- a. Inside dry bulb temperature shall be minimum 5 °C below the design ambient temperature during summer for evaporative cooled areas.
- b. Inside dry bulb Temperature shall be maximum 3 °C above the design ambient temperature during summer for mechanically ventilated areas.

The criterion which gives higher number of air changes / higher quantity of air in either of the conditions as mentioned above shall be the basis for selecting the required air flow for that area.

All ventilation systems shall operate on 100% fresh air. All mechanically ventilated areas shall be positively ventilated by means of supply air fans, generally in combination with exhaust fan / gravity operated back draft damper. The ventilation system shall be designed for continuous operation of 24 hours a day. All GS sheets shall be hot dip galvanized or spray galvanized unless otherwise specified and minimum zinc deposition shall conform to class 275 of IS 277.

7.23.5 Equipment Description

7.23.5.1 Axial Flow Fans

These fans shall have single piece cast aluminium impeller with blades of aerofoil design.

The fan casing shall be of heavy gauge sheet steel construction minimum thickness of 3 mm up to a fan diameter of 750 mm, 5 mm for fans with impeller diameter of 750 mm and above and the same shall be spray or hot dip galvanized.

Necessary rain protection cowl, inlet and outlet cones, bird protection screen, adjustable damper, vibration isolators, back draft dampers etc. shall be provided.

The speed of the fan shall not exceed 960 rpm for fan with impeller diameter above 450 mm and 1400 rpm for fan with impeller diameter 450 mm or less. However, for fans having static pressure of 30 mm WC or above the speed of the fan shall not exceed 1440 rpm for fan with impeller diameter of above 450 mm and 2800 rpm for fan with impeller diameter of 450 mm or less. The first critical speed of rotating assembly shall be at least 25% above the operating speed.

All other accessories like supporting structure etc. as required shall be provided.

7.23.5.2 Air Filters

a) Pre - filter

Filter medium shall be either fabric or metallic type consisting of

- i) Fibrous material (extruded polyethylene) or felt filter fabric Dry type with element of 5 ply construction for Fabric type.
- ii) V-fold galvanized wire mesh inters spaced with a flat layer of galvanized wire mesh for Metallic type pre-filters.

b) Frame

Gl sheet (minimum 18 gauge thick) or Aluminium alloy of (minimum 16 gauge) supported by galvanized steel wire mesh of 10 mm square with handles.

c) Other requirements

Suitable aluminium spacers be provided for uniform air flow; Casing shall be provided with neoprene sponge rubber sealing. Filter shall be capable of being cleaned by water flushing. Wire mesh edges shall be suitable hemmed to eliminate the danger of abrasion during handling.

d) Efficiency:

Average arrestance of 65 - 80% when tested in accordance with BS: 6540/ASHRAE -52 - 76.

e) Minimum thickness shall be 50 mm.

f) Face velocity shall not be more than 2.5 m/sec.

g) Pressure drop (Initial pressure drop) shall not exceed 5.0 mm WC at rated flow. Final Pressure drop - Up to 7.5 mm WC.

7.23.5.3 Fine Filter (Micro-vee type)

a) Construction -

By pleating a continuous sheet of filter medium into closely spaced plates separated by heavy corrugated aluminium spacers

b) Frame:

Aluminium alloy of (Minimum 16 gauge conforming to IS: 737) with handles.

c) Other requirements

A neoprene sponge rubber sealing shall be provided on either face of the filter frame. Shall be capable of being cleaned by air or water flushing.

d) Efficiency:

Average arrestance of 80-90% when tested in accordance with BS: 6540/ASHRAE -52 - 76.

e) Thickness:

150 or 300 mm

f) Face Velocity:

Not more than 1.2 m/sec for 150 mm and not more than 2.4 m/sec. for 300 mm size.

g) Pressure drop:

Initial pressure drop - not to exceed 10 mm WC at rated flow. Final pressure drop - up to 25 mm WC.

7.24 Fire Extinguishers

Portable fire extinguishers are to be provided for all units as per the requirement of Tariff Advisory Committee (TAC) or meeting the requirement of local regulations whichever is stringent. All the extinguishers shall have ISI mark / TAC approval.

7.24.1 Firefighting Water Pumping Subsystem

This subsystem is, basically, composed of the dedicated pump house and of the pumps and other equipment, such as Diesel fuel oil tank, etc. Fire Hydrant system shall be designed in line with the relevant codes and standards.

The following are the major equipment items:

- electrically driven firefighting pump
- diesel driven firefighting pump
- Minimum Two (2) Jockey pumps (One (1) for duty, One (1) for stand-by)
- Accessories: pipework, pump controller, etc.

7.24.2 Indoor and Outdoor Hydrants Subsystem

7.24.2.1 Indoor Hydrant subsystem

The indoor hydrants and the related hose reel cabinets will be provided inside the following buildings:

- Intake Pump house building
- Lamella and DAF Building
- Filter House
- R.O Building
- Chemical Dosing Building
- Electrical & Control room Building
- Switchyard, Transformers and cable alleys etc
- Workshop & Warehouse Building
- Air Compressor Building
- Fire Fighting Pump House
- Any Other building that is deemed necessary.

The indoor hydrant system shall be served by the hydrant main isolated pipe.

7.24.2.2 Outdoor Hydrant Subsystem

The outdoor hydrants subsystem is provided to protect the desalination units and remineralization plant areas etc. The outdoor hydrants and the related (fire) hydrant cabinets shall be located at strategic locations along the hydrant main. The spacing between the hydrants shall not exceed 80m.

7.24.3 Portable Fire-Fighting Subsystem

The fire Extinguishers distributed all over the water plant building shall be suitable to be operated by the operating personnel of the respective buildings. This will allow a quick response to fires at early stage. Various types of portable extinguisher shall be provided.

The following portable extinguishers shall be provided:

- Carbon Dioxide Extinguisher
- Dry Powder Extinguisher

The fire extinguishers will be reasonably provided inside the buildings according to the authorised norm.

All the extinguishers shall have ISI mark approved.

7.24.4 Fire Detection, Monitoring and Alarm System.

A manual and automatic fire detection and alarm system shall be provided with detection devices, selected to suit particular risks and with a control system designed to provide operation and fire brigade staff with sufficient information to identify and respond correctly to any fire detected.

To ensure that the fire is detected at an earlier stage, the areas of high risk shall be monitored with automatic fire detectors. The following types of detectors are used:

- Smoke detectors (Optical),
- Flame detectors,
- Heat detectors.

In addition to the automatic fire detectors, non-automatic fire alarms (manual push button alarms) shall be installed at the entrances to the acoustic enclosure and at the building exists.

Each fire detector and manual push-button alarm for the fire alarm system shall be labelled in such a way that it is possible to identify to which group the fire detector or manual push button alarm belongs.

A signal will initiate an alarm (in the central control room) and indicates the related fire detector. The detection / initiation signal of water plant from automatic / manual fire initiation devices will be summarized at local control panel, and zone fire alarm signal will be transferred to the main fire alarm panel at central control room.

The annunciator panel will be installed in the Central Control room.

In addition to the automatic fire detector, non-automatic fire alarms (manual push-button alarms) are installed at the entrances to the acoustic enclosure and at the building exits.

7.25 Propeller Exhaust Fan

The fan should comply with IS:2312. The blades shall be of mild steel and properly balanced so as to avoid noise and vibration. The blade and blade carriers shall be securely fixed so that they do not loosen in operation. The means provided for securing the fan mounting or fan casing to the wall partition or window shall be such as to provide a secure fixing without damage to the fan or wall.

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

The fan shall have protective insulation or be capable of being earthed. A fan with protective insulation may be of all insulated construction or have either double insulation or reinforced insulation. Each fan should be provided with a 10 sq.mm mesh bird screen. The sheet used for the cowl should be 14 G and Motors shall be TEFC, IP-54.

Fans used to extract from areas storing or handling chlorine/ chemicals shall be constructed from materials resistant to attack by chlorine/stored chemical.

7.26 Air-conditioning Equipment

The air conditioning units shall be of split type, with the outdoor condensing unit mounted on the terrace of the room or grouted on external side of the wall with suitable brackets. Unless otherwise specified, equipment shall conform to the latest applicable Indian or IEC Standard. Equipment Complying with other authoritative standards such as British, USA, ASHRAE etc. will also be considered if it ensures performance equivalent of superior to Indian Standard.

7.26.1 Proposed Areas to be Air Conditioned

- All Control rooms
- Complete Administrative building

- Laboratory rooms
- All MCC Rooms,
- Battery rooms in various buildings.

7.26.2 Type of Air Conditioning Units

7.26.2.1 Design Capacity up to 3TR

Split type AC unit: Non-ductable unit with outdoor type air Cooled condensing unit (2 x 100% capacity for each areas and fan-coil (evaporator) units (2x100%) distributed / placed at desired locations in the area which is air-conditioned. Condensing unit may be located in the roof of the building with local sunshade cover and approach through staircase up to the roof.

7.26.2.2 Design Capacity above 3 TR and up to 10 TR

Packaged Air Conditioner: Ductable with outdoor type Air (2 x 100% capacity) Cooled condensing (outdoor) units and indoor evaporator (2 x 100%) units placed inside the plenum area (in the space between ceiling and false - ceiling); Air supply distribution shall be through duct and return air shall be through plenum space to evaporator unit. Condensing unit may be located in the roof of the building with local sunshade cover and approach through stair case up to the roof.

7.26.2.3 Design Capacity above 10 TR up to 50 TR

Indoor type, ductable air cooled, Packaged Air (2 x 100% capacity) conditioners shall be provided for each area / building. The PAC room shall be located in proximity to the area to be air-conditioned.

The capacity of PAC and other equipment shall be designed as per the Design Philosophy & Equipment specification elaborated below. Sizing calculations for all the equipment shall be submitted for approval of Employer.

The Split (SAC) type AC & PAC units shall be air cooled type.

Number of fresh air changes per hour shall be minimum 1.5 or minimum 0.45 cum/min per person (16 cfm) whichever is higher for Conference rooms / common rooms.

The occupancy for general / office area shall be minimum one person per 10 sq. and for conference room the same shall be one per 3 sq. m for design of AC System. In the control rooms, control, equipment rooms etc., the occupancy may be one person per 25 sq. m (Minimum).

All the equipment of Air Conditioning system shall be designed for continuous duty. In Air conditioning system provided with ducts, false ceiling shall be provided with appropriate under deck insulation.

A minimum design margin of 15% shall be considered while sizing AC Plant Capacity.

All GS sheets (duct material) under Air conditioning system shall be not dip galvanised or spray galvanised unless otherwise specified and minimum zinc deposition shall conform to class 275

of IS:277.

7.27 Air Hose Apparatus

It shall consist of full vision face mask with inhalation and exhalation valve, connected to a corrugated tube ending in a manifold non-return valve, mounted on a harness belt worn around the waist, tested to applicable IS. The 50m long, 20mm canvas reinforced wire embedded hose, connected to the manifold shall be uncrushable and shall not kink.

The radial blower connected to the hose shall be housed in a strong carrying box which can hold the breathing apparatus with hose and fittings. The blower shall be suitable for supplying air to two people simultaneously.

7.28 Safety

Safety signs All signs providing health and safety information on instructions shall comply with BS: 5499-5:2002 and equivalent local standards. Signs shall be of durable quality and shall comprise a substrate of 22 gauge aluminium, predrilled for fixing and with radii corners free of burrs or sharp edges. Symbols and lettering shall be screen printed.

7.29 Quality

Product of an experienced Equipment manufacturer should satisfy the following criteria:

- a) Shall demonstrate equal or larger capacity installations using similar equipment.
- b) Equipment installed and successfully operating for at least five years having specified constructional features equal to or higher than the specified size and rating. This shall be supported by certificates from the end users.
- c) Provide names and phone numbers of contacts at referenced installations to verify performance.
- d) Demonstrate to satisfaction of the Engineer that equipment to be provided is equal to that specified.

7.30 Warranty

- a) Comply with the requirements of each type of equipment and specification mentioned elsewhere in this document.
- b) Warrant all components to be free of defects in materials or workmanship for 12 months from date of satisfactory completion of performance and process proving tests.
- c) Individual warranties by component manufacturer in lieu of single source responsibility by the main equipment manufacturer shall not be acceptable.
- d) Items which fail during the warranty period and the period of operation and maintenance under the Contract, excluding expendable items, shall be replaced without cost to the Employer.
- e) Provide manufacturer's guarantee and warranty certificates prior to equipment start-up.

7.31 Packing and Protection

Before any Plant is dispatched from a manufacturer's factory it shall be adequately protected and packed to ensure that it will arrive on the Site in an undamaged condition. The methods employed for protection and packing must be suitable for withstanding the conditions which may be experienced during shipment, delivery to the Site and prolonged periods of storage in the open, whether the items are shipped in packing cases, crates or only partially protected according to their nature.

Bright parts and bearing surfaces shall be protected from corrosion by applying a rust preventive lacquer, high melting point grease or similar temporary protection. A sufficient quantity of solvent shall be supplied with the plant to enable this coating to be removed on the Site.

All machined flanges and other mating surfaces shall be protected by means of wood templates. The bolts for securing these templates shall not be reused in the final installation.

No one crate or package shall contain items of Plant intended for incorporation in more than one part of the Works. All items of Plant shall be clearly marked for identification against the packing list, which shall be placed in a waterproof envelope inside every packing case or crate.

Every packing case and crate shall be indelibly marked to show its weight, serial number, top and bottom, shipping marks and handling instructions or sling marks. Electrical Plant shall be enclosed in sealed airtight packages with dehydrating material, before being placed in packing cases on shock-absorbent material and secured by means of battens.

CHAPTER - 8

8. ELECTRICAL REQUIREMENTS

8.1 Introduction

This section of the bid proposal shall cover the electrical requirements of the CP1 400MLD Sea Water Reverse Osmosis Desalination Plant and its Facilities.

Due to the high salinity and close proximity of the plant to the sea, a Gas Insulated Switchgear (GIS) Substation was envisaged for the project to prevent corrosion of the major electrical equipment.

To meet the power demand load of the 400 MLD Perur Sea Water Reverse Osmosis (SWRO) Desalination Plant (approximately 90MVA), the Gas Insulated Substation shall be fed with a 230kV Power Supply as per Tamil Nadu Electricity Board's latest Codes, Standards, and Regulations.

A Power Receiving Facility / Terminal Point as part of CP1 Contract Package was considered for this project to receive the TNEB 230kV Overhead Transmission Line including its Optical Ground Wire (OPGW).

The 230kV Overhead Transmission Line shall be terminated to the 230kV composite outdoor termination unit and outdoor type lightning arrester by the Overhead Line Contractor under CP5 Contract Package while the Optical Ground Wire (OPGW) provided under CP5 Contract Package shall be terminated to the terminal joint boxes by the Substation Contractor under CP1 Contract Package .

Bonding of the incoming OPGW to the station earthing screen, supply of earthing conductor and connection of the air terminal earth electrodes into the substation earth grid shall be carried out by the Substation Contractor under CP1 Contract Package.

The connection between OPGW joint boxes at 230 kV GIS Substation Receiving Gantry Area and Control Room building via underground optical fibre cables shall be carried out by the Substation Contractor under CP1 Contract Package which shall include supply & installation of fibre optic cable of size similar to OPGW.

The voice communication, teleprotection signaling and main distribution frame (MDF) for optical fibre cable shall be supplied and installed by the Substation Contractor under CP1 Contract Package. Necessary equipment for incorporating the 230kV and 110kV GIS Automation System into the SCADA system shall also be supplied and installed under CP1 Contract Package.

8.2 Scope of Works

The scope of work on this section includes Design, Supply, Delivery, Installation, Testing and Commissioning, Operation and Maintenance of all electrical equipment of the 400 MLD Sea Water Reverse Osmosis Desalination Plant which include but not limited to the following schedule of requirements:

- (i) Power Receiving Facility or Terminal Points of 230kV Overheadline Circuit Connections and Optical Ground Wire (OPGW) with Composite Outdoor Termination Unit, Outdoor Type Lightning Arrester, Steel Structures, and Clastra Block Wall Fencing with Corrossion Proof Steel Door, Lightning Protection and Earthing System.
- (ii) 230kV Gas Insulated Switchgear Double Bus Indoor Type 4000A, 50Hz, 3Ph 50kA/3sec. as per Key Single Line Diagram (Drwg No. 7061563/PMC400MLD/CP1/SLD/001).
- (iii) 230kV Cu/XLPE/AWA/HDPE Cables.
- (iv) 230kV Cable Sealing Ends, Cable Plug-in, Composite Outdoor Cable Termination Unit and Accessories, and Earth Link Boxes.
- (v) 110kV Gas Insulated Switchgear Double Bus Bar Indoor Type 3150A, 50Hz, 3 Ph, 40kA/3sec. as per Key Single Line Diagram (Drg. No.7061563/PMC400MLD/CP1/SLD /001).
- (vi) 110kV Cu/XLPE/AWA/HDPE Cables.
- (vii) 33kV and 11kV Cu/XLPE Cables and Cable Termination Accessories.
- (viii) 110kV Cable Sealing Ends, Cable Plug-in, Cable Termination Accessories, and Earth Link Boxes.
- (ix) 2 Nos. 230/110/33kV 150MVA ONAN/ONAF Auto Power Transformers with
- (x) Vector Group YNa0d1 and 2 Nos. 315kVA 33/0.415kV Earthing Transformers.
- (xi) 4 Nos. 110/11/11kV 50MVA ONAN/ONAF Auto Power Transformers with
- (xii) Vector Group YNd5 and 4 Nos. 315kVA 11/0.415kV Earthing Transformers.
- (xiii) Metering, Control and Protection.
- (xiv) Substation Automation System (IEC-61850)
- (xv) Digital Fault & Disturbance Recorder (DFDR)
- (xvi) Fiber Optic Multiplexer Equipment for Communication and Protection
- (xvii) SCADA system for Telecontrol and Telemetering
- (xviii) 110V DC & 48V DC and LVAC System
- (xix) Standby Diesel Generator Set
- (xx) UPS System
- (xxi) Subgrade Earthing System, Potential Gradient Earthing System, Above Ground
- (xxii) Earthing System, and Equipment Earthing System

- (xxiii) Lightning Protection System
- (xxiv) 33kV Outdoor Type Vacuum Circuit Breakers (for Earthing Transformers)
- (xxv) 33kV Outdoor Type Isolators (for Earthing Transformers)
- (xxvi) 11kV Outdoor Type Vacuum Circuit Breakers (for Earthing Transformer)
- (xxvii) 11kV Outdoor Type Isolators (for Earthing Transformer)
- (xxviii) 33kV Neutral Earthing Resistors
- (xxix) 11kV Neutral Earthing Resistors
- (xxx) 4000A, 3Ph, 3W, 50Hz, 50kA/3secs. 11kV Switchgears
- (xxxi) 1250A, 3Ph, 3W, 50Hz, 40kA/3secs. 11kV Switchgears
- (xxxii) 11/0.433kV Distribution Transformers
- (xxxiii) 11/0.69kV Converter Transformer
- (xxxiv) 11kV Capacitor Banks
- (xxxv) 11 kV Motors
- (xxxvi) 415V Capacitor Banks
- (xxxvii) 415V Low Voltage Switchgears
- (xxxviii) 415V Low Voltage Busducts
- (xxxix) 415V Motor Control Centers
- (xl) 690V Variable Frequency Drives / 11kV Soft Starters / 11kV Primary Resistance
- (xli) Starters / 11kV Variable Frequency Drives
- (xlii) 415 V Direct On Line Starters / Wye Delta Starters /
- (xliii) Variable Frequency Drives
- (xliv) Uninterruptible Power Supply (UPS)
- (xlv) Standby Diesel Generator Sets
- (xlvi) 415 / 240 V AC Distribution Boards
- (xlvii) 110V DC Distribution Boards
- (xlviii) 48V DC Distribution Boards
- (xlix) Lighting and Small Power System

- (l) Central Battery System
- (li) Street Lighting System
- (lii) Area Lighting System
- (liii) Tel/LAN System
- (liv) Low Voltage Power & Control Cables
- (lv) FM200 System
- (lvi) Auto Power Transformer Nitrogen Injection Fire Protection (NIFPS) System
- (lvii) De Luge Water Spray System

Supply of Mandatory Spares, Maintenance Tools & Test Equipment of Power Transformers, Earthing Transformers, Distribution Transformers, GIS Switchgears, Control Equipment, Protection Relays, Meters, 33kV & 11kV Vacuum Circuit Breakers, 33kV & 11kV Isolators, Battery Chargers, UPS, 11kV Switchgears, LV Switchgears, and Motor Control Centers shall be provided and shall be handed over to the Employer's Representative for safe keeping in designated store and warehouse.

Recommended Spare Parts for other equipment shall also be provided to the Employer's Representative for safekeeping.

Manufacturers who have minimum 15 years proven experience of manufacturing and supplying the above electrical equipment of similar capacity shall be considered for this proposal.

The respective equipment should have been manufactured, supplied, installed, commissioned successfully and should be running satisfactorily for the last 5 years continuously. Material approval and certificates from the end users, regarding their satisfactory performances, shall be submitted to the Employer's Representative for verification and approval.

8.2.1 Power Receiving Facility / Terminal Points

230 KV Overhead Line Circuit Connections

The 230kV Overhead slack spans including overhead earth conductor (OPGW) between the 230 kV terminal tower and the substation gantry structures shall be supplied and terminated by the Overhead Line Contractor under CP5 Contract Package to the composite type outdoor termination unit and the outdoor type lightning arrester. All required insulators and hardware's shall also be supplied by the Overhead Line Contractor under CP5 Contract Package.

Eyebolts / U-bolts or other suitable fixtures for terminating the slack spans on the substation gantry area shall be provided by the Substation Contractor under CP1 Contract Package.

The Substation Contractor under CP1 Contract Package shall provide all the jumpers from the slack span to the composite type outdoor termination unit and outdoor lightning arrester on the substation gantry area by fixing appropriate T-terminals on the slack span conductor or other

approved means. The supply of appropriate clamps and the actual termination of the jumper to the substation equipment shall be carried out under CP1 Contract Package.

Bonding of the incoming earth wire to the station earthing screen and supply of earthing conductor and connection of the terminal tower earth electrode into the substation earth grid shall be carried out by Substation Contractor under CP1 Contract Package.

The Substation Contractor under CP1 Contract Package shall terminate the OPGW at the substation gantry in the terminal joint boxes provided by the overhead line Contractor under CP5 Contract.

The connection between OPGW joint boxes at Substation gantry and control room building via underground optical fibre cables shall be carried out by the Substation Contractor under CP1 Contract Package which includes supply & installation of fibre optic cable of size similar to OPGW.

Communications and SCADA Equipment

The voice communication, teleprotection signalling and main distribution frame (MDF) for optical fibre cable shall be supplied and installed by the Substation Contractor under CP1 Contract Package. Necessary equipment for incorporating the 230kV & 110kV system into the SCADA system shall also be supplied and installed by the Substation Contractor under CP1Contract.

In order to provide the telecontrol & telemetering (SCADA) facilities required at the National Load Despatch Center (NLDC), all plant supplied under this Contract shall be equipped with potential free auxiliary contacts for indications and alarms. CT and VT circuits shall be fitted, where required, with the appropriate shorting and fused terminals. All required electrical signals shall be transmitted to the NLDC through the Industrial Gateway of the substation automation system. All GIS HV breakers, motorized disconnectors, tap changer, etc. shall be controlled from NLDC through the Gateway of the substation automation system using IEC 61850 protocol.

Necessary transducer, control & interposing relays, RTU's, etc. shall be used. Necessary interfacing between the Substation Automation gateway and the communication equipment is to be carried out.

In addition, to realize the complete SCADA system after completion of the Project, modification of the existing software in the master computer of the national load despatch centre, and modification of hardware (installing additional printed circuit cards etc. if required) shall be made under CP1 Contract Package.

8.2.2 Factory Acceptance Test Witness

The contract price shall include all costs of witnessing of factory acceptance tests by Employer's Representative. Total Sixteen (16) nos. of visit for witnessing of Factory Acceptance Tests by Employer's Representative(Two Engineers in each visit, and seven days for each visit) is required for the foll owing equipment:

1. 230/110/33kV 150 MVA Auto Power Transformer (2 Nos.)
110/11/11kV 50 MVA Auto Power transformers (4 Nos.)
2. 315kVA 33/0.433 kV Earthing Transformers (2 Nos.)
315kVA 11/0.433 kV Earthing Transformers (4 Nos.)
3. 11/0.690 kV Converter Transformers (104 Nos. of different kVA ratings)
4. 11/0.433 kV 630kVA / 2.0 MVA / 2.5MVA Distribution Transformers (12 Nos.)
5. 230kV Gas Insulated Switchgear Equipment
110kV Gas Insulated Switchgear Equipment
6. Substation Automation System, Control & Protection Equipment
Digital Fault & Disturbance Recorder (DFDR)
Fiber Optic Multiplexer Equipment for Communication and Protection
SCADA system for Telecontrol and Telemetering
7. 230kV, 110kV, 33kV, 11kV Cu/XLPE Power Cables
8. 33kV Outdoor Type Circuit Breakers & Isolators (For Earthing Transformers)
9. 11kV Switchgears
10. 11kV Motors
11. 11kV Soft Starters/Variable Frequency Drives/ Primary Resistance Starters
12. Low Voltage Switchgears
13. 110V DC and 48V DC Battery Chargers and Batteries
14. UPS System
15. Motor Control Centers, Soft Starters, Variable Frequency Drives, Wye-Delta Starters, Direct On Line Starters.
16. Standby Diesel Generator Sets

The Contractor shall be responsible for bearing all costs for the Employer's Representative, including air fares, accommodation, meal, healthcare, laundry, transportation, visa fees etc. together with payment of a daily allowance of US\$ 100 for each of the Employer's Representative.

8.2.3 Training

The Contractor shall be responsible for bearing all costs for the Employer's Engineers, including air fares, accommodation, meal, healthcare, laundry, transportation, visa fees etc. together with payment of a daily allowance for each of the Employer's Engineer. All travel and miscellaneous expenses outside Chennai, Tamilnadu shall be as per JICA's procurement guidelines

The contract price shall include all costs of foreign and local training for Employer's Engineer.

Foreign Training:

Plant visit by the Employer's Engineer as part of Foreign Training shall be arranged to similar projects in Asia that has been successfully executed by the Contractor for the past 10 years one month after the award of the Contract.

Overseas training of Employer's Representative (Two Engineers in each visit and two weeks for each visit excluding travel time) for each of the following subject at Manufacturer's Training Institute is required.

1. 230/110/33kV 150 MVA Auto Power Transformer (2 Nos.)
110/11/11kV 50 MVA Auto Power transformers (4 Nos.)

2. 315kVA 33/0.433 kV Earthing Transformers (2 Nos.)
315kVA 11/0.433 kV Earthing Transformers (4 Nos.)
3. 11/0.690 kV Converter Transformers (104 Nos. of different kVA ratings)
4. 11/0.433 kV 630kVA / 2.0 MVA / 2.5MVA Distribution Transformers (12 Nos.)
5. 230kV Gas Insulated Switchgear Equipment
110kV Gas Insulated Switchgear Equipment
6. Substation Automation System, Control & Protection Equipment
Digital Fault & Disturbance Recorder (DFDR)
Fiber Optic Multiplexer Equipment for Communication and Protection
SCADA system for Telecontrol and Telemetry
7. 230kV, 110kV, 33kV, 11kV Cu/XLPE Power Cables
8. 33kV Outdoor Type Circuit Breakers & Isolators (For Earthing Transformers)
9. 11kV Switchgears
10. 11kV Motors
11. 11kV Soft Starters/Variable Frequency Drives/ Primary Resistance Starters
12. Low Voltage Switchgears
13. 110V DC and 48V DC Battery Chargers and Batteries
14. UPS System
15. Motor Control Centers, Soft Starters, Variable Frequency Drives, Wye-Delta Starters, Direct On Line Starters.
16. Standby Diesel Generator Sets

Overseas training on Substation design for Employer's Representative(Two Engineers in one visit) at an internationally specialized training institute is also required and the duration of training shall be two weeks.

Training of the Employer's Representative shall be done first before any Factory Acceptance Test can proceed.

The Contractor shall be responsible for bearing all costs for the trainees, including air fares, accommodation, meal, healthcare, laundry, transportation, visa fees etc. together with payment of a daily allowance for each of the Employer's trainee. All travel and miscellaneous expenses outside Chennai, Tamilnadu shall be as per JICA's procurement guidelines

Local Training:

The Contractor shall be responsible for providing instruction and guidance to Employer's personnel in the operation and maintenance of the substation equipment. During the installation, the Contractor should provide minimum one trainer (Authorised by the Manufacturer) for training of Employer's personnel on site for minimum two weeks for training of GIS operation & maintenance and for two weeks for training of substation automation, control & protection system so that they could get a clear idea about operation, inspection and maintenance of the equipment. The number of trainee for each Training shall be 15 (fifteen) in each Training program. The contractor shall be responsible for providing lunch and training material to the trainees.

The Contractor shall be responsible for ensuring that all and any items of the electrical works required for the safe, efficient and satisfactory completion and functioning of the works, are included in the Bid Price whether they be described in the specification or not.

The Bid provides for all parts of the works to be completed in every respect for commercial operation to the requirements of the Employer's Representative. All details, accessories etc. required for the complete installation and satisfactory operation of the works not specifically mentioned in this Specification are deemed to be included in the contract price.

8.3 GENERAL CONDITIONS

- 8.3.1 All electrical works herein shall be carried out by a Professional Electrical Engineer and in strict compliance with the latest edition of International Electrotechnical Commission (IEC), British Standards (BS), European Standards, American Standards, Indian Standards (IS) and Tamil Nadu Electricity Boards (TNEB) Codes, Standards, and Regulations including the latest amendments and rulings. If there is any conflict between Codes, Regulations, and other standards, the most stringent rule shall apply.
- 8.3.2 All electrical works shall be directly supervised by a Professional Electrical ENGINEER with minimum 15 years experience in the 230kV/110kV/11kV Power System's Metering, Control, Protection Relays, and Substation Automation System as per IEC-61850 protocol specifically in Gas Insulated Switchgear (GIS) Substations and Sea Water Reverse Osmosis (SWRO) Desalination Plants Electrical Systems.
- 8.3.3 The works shall be carried out in accordance with the requirements of all authorities having jurisdiction over the works and/or approval required there from. Such notice shall be provided and the application shall be prepared accompanied by such plans and information as may be called for and /or obtain such approvals.
- 8.3.4 Reference Codes and Standards listed herein are applicable in respect of all materials and workmanship except where in conflict with the provisions of this specification. Where this specification expressly requires standards higher than or different from those applicable under the relevant standard or documents, this specification will take precedence.
- 8.3.5 Where special conditions exist which would make compliance with these specification unusually difficult, then details should be submitted in writing to the ENGINEER, who may grant an exemption. Any such exemption granted shall be obtained in writing from the ENGINEER by the party seeking the exemption.
- 8.3.6 Any items of equipment offered and not listed under Preferred Equipment List, must be approved by the ENGINEER and any such exemption granted shall be obtained in writing from the ENGINEER by the party supplying the equipment.
- 8.3.7 The contractor during the design stage of the plant shall carry out a **Risk Assessment** to determine the classification of any hazardous areas within the plant in accordance with Occupational Safety and Health Administration (OSHA) Standards. Classification shall be reviewed by the ENGINEER and the design and specification of all electrical equipment to be installed in the plant shall be in accordance with any hazardous area classifications determined by the risk assessment.
- 8.3.8 All permit and electrical fees required for this work shall be obtained by and at the expense of the Contractor. The Contractor shall furnish and transmit to ENGINEER, copies of Notification of Safety Precaution (NOSP) Certificates of Inspection and Approval after

completion of the work. The Contractor shall prepare all As-Built drawings, plans and all technical documents and paper works required by the approving authorities.

- 8.3.9 The drawings provided in the Bidding Document are indicative only and hence the entire scope of work is not fully reflected in those drawings. The Contractor shall develop the full set of drawings to reflect the requirements in the scope of works.
- 8.3.10 Within one month of the signing of the Contract, the Contractor shall submit a program schedule detailing the time required for the design, procurement, delivery, construction, testing and commissioning for the complete contract.

8.4 REFERENCES, CODES AND STANDARDS

8.4.1 IEC Standards

- 60034-1 Rotating Electrical Machines - Part 1: Rating and Performance
- 60038 IEC Standard Voltages
- 60051 Direct acting indicating analogue electrical measuring instruments
- 60059 IEC Standard Current Ratings
- 60072 Dimensions and output series for rotating electrical machines
- 60073 Coding principles for indicators and actuators
- 60079 Electrical apparatus for explosive gas atmospheres
- 60085 Thermal evaluation and designation of electrical insulation
- 60099-4 Metal-oxide surge arresters without gaps for a.c systems
- 60137 Bushings for alternating voltages above 1000 V
- 60168 Tests on indoor and outdoor post insulators of ceramic material or glass for systems with nominal voltages greater than 1000 V
- 60228 Conductors of insulated cables
- 60269 Low voltage fuses
- 60273 Characteristics of indoor & outdoor post insulators for systems with nominal voltages greater than 1000 V
- 60282 High voltage fuses
- 60296 Unused mineral insulating oils for transformers & switchgear
- 60305 Characteristics of string insulator units of the cap & pin type
- 60332 Tests on electric and optical fibre cables under fire conditions
- 60364 Electrical installations of buildings
- 60376 Specification and acceptance of new sulphur hexafluoride
- 60383 Insulators for overhead lines with a nominal voltage above 1000 V
- 60417 Graphical symbols for use on equipment
- 60423 Conduits systems for cable management
- 60433 Characteristics of string insulator units of the long rod type
- 60437 Radio interference test on high voltage insulators
- 60439 Low voltage switchgear and control gear assemblies
- 604552-2 Solventless polymersable resinous compounds used for electrical insulation
- 60480 Guideline for the checking of sulphur hexafluoride taken from electrical equipment
- 60502 Extruded solid dielectric insulated power cables from 1 - 30 kV
- 62052 Electricity metering equipment
- 60529 Degrees of protection provided by enclosures (IP Codes)

- 60587 Test methods for evaluating resistance to tracking
- 60621 Electrical installations for outdoor sites under heavy conditions
- 60644 Specification for high-voltage fuse links for motor circuit applications
- 60660 Tests on indoor post insulators of organic mats. between 1 - 300 kV
- 60672 Specification for ceramic & glass insulating mats.
- 60898 Circuit Breakers for overcurrent protection for households etc.
- 60947-1 Low voltage switchgear & control gear-General rules
- 60947-2 Circuit breakers
- 60947-3 Switches, disconnectors, switch-disconnectors, etc.
- 60947-5-1 Control circuit devices and switching elements
- 60981 Extra heavy duty electrical rigid steel conduits
- 61035 Specification for conduit fittings for electrical installations
- 61084 Cable trunking & ducting systems for electrical installations
- 62271-1 Common clauses for HV switchgear & control gear standards
- 62271-100 High voltage alternating circuit breakers
- 62271-200 AC metal - enclosed switchgear & control gear for 1 kV and up to including 52 kV
- 62271-203 Gas insulated metal-enclosed switchgear for rated voltages of 52 kV and above
- 62271-209 Cable connections for gas-insulated metal-enclosed switchgear for rated voltages of 52 kV and above

8.4.2 British Standards

- BS 29 Spec for Carbon steel forgings
- BS 182 Specification for galvanised line wire for telephone & telegraphic purposes
- BS 443 Specification for testing zinc coatings on steel wire
- BS 499 Welding terms & Symbols
- BS 709 Method & testing fusion welded joints
- BS 729 Specification for hot dip galvanised coatings on iron & steel articles
- BS 970 Specification for wrought steels for mechanical & allied ENGINEERing
- BS CP 1014 Tropicalisation
- BS 1224 Specification for electroplate coatings of nickel and chromium
- BS 1710 Specification for identification of pipelines & services
- BS 1780 Specification for Bordon tube pressure and vacuum gauges
- BS 1858 Specification for bitumen based filling compounds
- BS 2011 Environmental Testing
- BS 2569 Pt2 Protection of iron & steel against corrosion at elevated temp.
- BS 2600 Pt 1 Radiographic examination of fusion welded butt joints in steel
- BS 2765 Specification for dimensions of temperature detecting elements
- BS 2910 Radiographic examination of fusion welded circumferential butt joints
- BS 3858 Specification for sleeves for electric cables & wires
- BS 3923 Pt1 Methods of examination of fused welds and butt joints. &Pt2
- BS 4211 Specification for ladders for permanent access to chimneys, other high structures, silos and bins
- BS 4395-1-2 Specification for High Strength Grip Bolts
- BS 4479 Pts 1-9 Recommendations for coatings.
- BS 4592 Pt 1-4 Industrial type flooring, walkways and stair treads
- BS 4604 Pt 1-2 Spec for high strength friction bolts
- BS 4670 Spec for alloy steel forgings.

BS 4800 Schedule of Paint Colours for building
 BS 4675 Pt2 Mechanical vibration of rotating and reciprocating machinery
 BS 4872 Pt 1 Fusion welding of steel
 BS 5395-3 Code of Practice for the design of industrial type stairs, permanent ladders etc.
 BS 5493 Code of practice for protective coating of iron & steel structures against corrosion
 BS 6072 Method for penetrant flaw detection
 BS 6121-1 Specification for metallic cable glands
 BS 6121-2 Specification for polymeric cable glands
 BS 6121-3 Specification for special corrosion resistant cable glands
 BS 6180 Code of Practice for barriers in and about buildings
 BS 6231 Specification for PVC insulated cables for switch & control wiring
 BS 6443 Method of penetrant flaw detection.
 BS 7079 Preparation of steel substrates before application of paints

8.4.3 BS European Standards

BSEN 287 -1&-2 Approval testing of welders for fusion welding
 BSEN288-1 thru to.-8 Specification & Approval of welding procedures

8.4.4 American Standards

IPCEA	: Insulated Power Cable ENGINEERing Association
NEC	: National Electrical Code
NEMA	: National Electrical Manufacturers Association
IEEE std 141-1976	: Protection and Coordination
IEEE Pub. No. 142	: Grounding of Industrial Power System
IEEE	: Institute of Electrical and Electronic Engineers
NFPA	: National Fire Protection Association
UL	: Underwriters Laboratories, Inc.

8.4.5 Indian Standards

Air break switches, MCCBs, etc. for voltage not exceeding 1000 V AC or 1200 V DC	IS 13947
Current transformer	IS 2705 / IEC 60044
Voltage transformer	IS 3156 / IEC 60044, 60186
Electrical Relays	IS 3231, 3842 / IEC 60255
Contactors for voltage not exceeding 1000 V AC	IS 13947 / IEC 60947
Control Switches	IS 6875 / IEC 60947
High Voltage Fuses	IS 9385 / IEC 60282
Low voltage Fuse	IS 13703 / IEC 60269
Electrical direct acting indicating instruments	IS 1248 / IEC60051
AC electricity meters of induction type for voltage greater than 1000 volts	IS 722, 8530 / IEC 60145, IEC 60211
Porcelain post insulators for system with nominal voltages greater than 1000 volts	IS 2544
Specification for copper rods and bars for electrical purposes	IS 613

Specification for low voltage switchgear and control gear	IS 13947 / IEC 60947
Degree of protection provided by enclosures for low voltage switchgear and control gear	IS 13947 / IEC 60947
Marking and arrangement for switchgear, busbars, main connections and auxiliary wiring	IS 5578 / IS 11353
Code of practice for selection, installation and maintenance of switchgear and control gear	IS 10118
Miniature Circuit Breakers	IS 8828 / IEC 60898
Control Switches/ Push buttons	IS 6875

8.5 DEFINITIONS AND ABBREVIATIONS

For the purpose of these requirements the following abbreviations of electrical terms have been used.

Symbol	Abbreviations	Symbol	Abbreviations
GIS	Gas Insulated Switchgear	LV	Low Voltage
OHL	Over Head Line	ELV	Extra Low Voltage
OPGW	Optical Ground Wire	FLC	Full Load Current
EHV	Extra High Voltage	VCB	Vacuum Circuit Breaker
HV	High Voltage	MCB	Miniature Circuit Breaker
R	red phase	MCCB	Moulded Case Circuit Breaker
Y	yellow phase	ELCB	Earth Leakage Circuit Breaker
B	blue phase	RCD	Residual Current Device
ac	alternating current	MCC	Motor Control Centre
dc	direct current	PFC	Power Factor Correction
A	Amp	PF	Power Factor
mA	Milliamp	CP	Control Panel
V	Volt	LCP	Local Control Panel
W	Watts	LPBS	Local Push Button Station
kW	Kilowatt	UPS	Uninterruptible Power Supply
kWh	Kilowatt hour	PLC	Programmable Logic Controller
MW	Megawatt	SCADA	Supervisory Control And Data Acquisition
MWh	Megawatt hour	LAN	Local Area Network
VA	Volt Ampere	TEL	Telecommunication
kVA	kilovolt amp	I / O	Input / Output
MVA	Mega Volt Ampere	HMI	Human Machine Interface
MVAR	Mega Volt Ampere Reactive	OS	Operator Station
MVARh	Mega Volt Ampere Reactive Hour	R I / O	Remote Input / Output
XLPE	Cross Link Polyethylene	PVC	Polyvinyl Chloride
Hz	Hertz (cycles per second)	PC	Personal Computer
SP	Single Pole	SPD	Surge Protection Device

Symbol	Abbreviations	Symbol	Abbreviations
SPN	Single Pole and Neutral	LED	Light Emitting Diode
DP	Double Pole	UHF	Ultra High Frequency
TP	Triple Pole	HVAC	Heating Ventilation & Air Conditioning
TP&N	Triple Pole and Neutral		
SP&SwN	Single Pole and Switched Neutral		
TP&SwN	Triple Pole and Switched Neutral		
FOC	Fiber Optic Cable		

8.6 TECHNICAL SPECIFICATIONS

8.6.1 EXTRA HIGH VOLTAGE SYSTEM (EHV)

Rated Voltage	230 kV nominal
Highest System Voltage	245kV
Phases	3
Rated Frequency	50 Hz
Rated Short Duration Power Frequency Withstand Voltage (1 Min.)	460kV
Rated Lightning Impulse Withstand Voltage (1.2/50 μ s)	1050kV
Rated Normal Current Bus Bar	4,000 A
Rated Normal Current Feeder	4,000 A
Rated Short Circuit Breaking Current (<3 cycles)	50 kA

8.6.2 High Voltage System (HV)

Rated Voltage	110 kV nominal
Highest System Voltage	145kV
Phases	3
Rated Frequency	50 Hz
Rated Short Duration Power Frequency Withstand Voltage (1 Min.)	275kV
Rated Lightning Impulse Withstand Voltage (1.2/50 μ s)	650kV

Rated Normal Current Bus Bar	3,150 A
Rated Normal Current Feeder	3,150 A
Rated Short Circuit Breaking Current (<3 cycles)	40 kA

8.6.3 Medium Voltage System (MV)

Rated Voltage	11 kV nominal
Highest System Voltage	17.5 kV
Phases	3
Rated Frequency	50 Hz
Rated Short Circuit Breaking Current	50 kA
Rated Short Time Withstand Current	50 kA /3 sec.
Rated Short Circuit Making Current	125 kA
Rated Peak Withstand Current	125 kA
Rated Normal Current	4000 A

8.6.4 Low Voltage System

Phase to Phase Voltage	415 V
Phase to Neutral Voltage	240 V
Frequency	50 Hz
Connection	3 Phase 4 Wire
Off Load Transformer Secondary Voltage	433 V
System Earthing	TNS (Neutral Solidly Earthed)
Rated Normal Current	1250A / 4000A
415 V maximum fault level	50kA / 3sec.

8.6.5 Control Voltage for 230 and 110kV Gas Insulated Switchgears

Voltage : 110 V DC

8.6.6 Control Voltage for SCADA and Telecommunication Equipment

Voltage : 48 V DC

8.6.7 Space Heater Power Supply

Voltage : 240 V AC (UPS Power)
 Phases : 1
 Frequency : 50 Hz

8.6.8 Instrumentation Power Supply

Voltage : 240 V AC (UPS Power)
 Phases : 1
 Frequency : 50

8.6.9 PLC Input / Output circuits

Supply Voltage: 24V DC

i. Climatic Condition

All plant and equipment supplied under the Contract shall be entirely suitable for the climatic conditions mentioned below, and that will prevail over any data in the specification.

The project area and vicinity is close to sea and is in a humid and tropical climate. The ambient shade temperature variation is between 4°C and 45°C with periods of high humidity.

The project area is designated a zone of moderate intensity for earthquakes.

The seismic factor is 0.05 g to 0. 1 g.

Maximum ambient shade temperature	45°C
Minimum ambient shade temperature	4°C
Maximum daily average temperature	35°C
Maximum annual average temperature	25°C
Maximum wind velocity	160 Km/h
Minimum wind velocity for line rating purposes	3.2Km/h (110/230kV)
Solar radiation	100mW/sq.cm

Rainfall	2.5 m/annum
Relative humidity, maximum	95%
Relative humidity, average	80%
Altitude	less than 10 m
Atmospheric Pollution	light
Salinity Level	High
Soil type	Sandy / Alluvial
Soil temperature (at 1.1m)	30°C
Soil thermal resistivity	1.5°C m/W
Isokeraunic Level (Thunderstorm days/year)	80

8.6.1 230 KV & 110KV GAS INSULATED SWITCHGEAR

This specification shall describe the general technical requirements for the new 230kV & 110kV Gas Insulated Switchgear and shall be read in conjunction with the Schedule of Technical Requirements and Key Single Line Diagram Drawing.

The Contractor shall demonstrate that the switchgear has been designed, built and installed in accordance with the relevant international standards and specifications. It shall also operate and perform on site in accordance with the requirements of the specification and in the environment and climatic condition mentioned in this specification.

The design shall be proven by the submission of test certificates at the time of Bidding covering all specified tests deemed to be pertinent to the plant and to the conditions in which it will operate.

The requirement for switchgear spares, tools and appliances, including test, maintenance and handling equipment shall be as stated in the Bid document. All devices necessary for operation and earthing shall be provided within the Contract Price.

Design, Installation, Testing and Commissioning of the GIS switchgears shall be done by the Switchgear Manufacturer.

APPLICABLE STANDARDS

Except where modified by this specification, the switchgear / accessories shall be designed, manufactured and tested in accordance with following latest IEC Standards and other publications quoted in these Standards. Any international standards referenced in the specifications and our outdated shall be replaced with the corresponding replacement.

LIST OF STANDARDS

IEC62271-1	Common clauses for high voltage switchgear and control gear standards
IEC 62271-100	High voltage alternating circuit breakers
IEC62271-102	Alternating current disconnectors (isolators) and earthing switches
IEC62271-103	Switches for rated voltage above 1 kV and less than 52 kV
IEC 62271-104	Switches for rated voltage of 52 kV and above
IEC 62271-200	AC metal-enclosed switchgear and control gear for rated voltages above 1 kV and upto and including 52 kV
IEC62271-203	Gas insulated metal-enclosed switchgear for rated voltages 52 kV and above
IEC62271-209	Cable connections for gas insulated metal - enclosed switchgear for rated voltages of 52 kV and above
BS7354	Design of high voltage open terminal stations
IEC60376	Specification and acceptance of new Sulphur hexafluoride
IEC 60358	Coupling capacitors and capacitor dividers
IEC 60364	Electrical installation of buildings (Part-1: Scope, object and fundamental principles)
IEC 60364	Electrical installation of buildings (Part-2: Definitions- Chapter 21: Guide to general items)
IEC 60364	Electrical installation of buildings (Part-4: Protection for safety-Chapter 41: Protection against electric shock)
IEC 60071	Insulation co-ordination (Part-1: Definition, principles and rules, Part-2: Application guide)
IEC 60815	Guide for the selection of insulators in respect of polluted conditions IEC 60137 Bushings for alternating voltages
IEC 60099-4	Metal - Oxide surge arresters without gaps for a.c. systems IEC60044-1 Instrument transformers, Part-1: Current Transformers IEC 60044-2 Instrument transformers, Part-2:Voltage Transformers
IEC 60282	High voltage fuses.
IEC 60269	Low voltage fuses.
IEC 60865-1	Short-circuit currents – Calculation of effects (Part-1: Definitions and calculation methods)

IEC 61639 Direct connection between power transformers and gas insulated metal enclosed switchgear for rated voltages of 72.5 kV and above

TECHNICAL REQUIREMENTS

General design, material and manufacturing techniques used shall generally conform to General Technical Requirements.

QUALITY ASSURANCE

Manufacturers of 230 kV & 110kV GIS shall certify on their compliance to ISO 9001:2008 by an organization authorized for certification.

DETAILED RATINGS

Switchgear and substation equipment shall be suitable for continuous operation on a 3-phase, 50 Hz system of 230 kV & 110kV nominal voltages as per Key Single Line Diagram, Technical Requirements and under the specified climatic conditions. The 230 kV & 110kV system shall be effectively earthed.

TYPE OF SWITCHGEAR

The switchgear shall be of the SF6 gas insulated metal-enclosed type capable of continuous operation under the climatic conditions existing at the Site. Double busbar switchgear shall be provided. Busbar selector isolators as specified in the Schedules are required to facilitate the changeover of individual circuits from one busbar to the other with the circuit on load and a bus coupler closed. Test report on capability of on load bus transfer shall be submitted for the Employer's Representative's approval.

The arrangement of the switchgear shall be such that all units face in the same direction and particular emphasis is placed on the provision of adequate clearance between chambers and between adjacent bays to facilitate maintenance.

The design of the switchgear shall be such as to enable extensions to be added at either end with the minimum of disturbance to the installed equipment and with one busbar in service. Suitable arrangement shall be provided with the switchgear for H.V. test of future extension part to keep the outage of the existing switchgear to a minimum.

The design shall include all facilities necessary to enable the performance of the specified site checks and tests during pre-commissioning & commissioning tests and after any repair & maintenance. The Contractor shall state the test facilities provided and indicate any attachments or special equipment provided for this purpose.

DESIGN PRINCIPLES AND GENERAL REQUIREMENTS

General

The design and performance of the switchgear shall comply with this Specification and the latest revision of the relevant International electro technical Commission (IEC), if no other standards are specified. Deviations from these specifications and standards shall be stated in the appropriate Schedule.

The Contractor shall submit drawings indicating possible switch room layouts for 230 kV and 110 kV equipment for Employer's Representative's approval.

The switchgear shall be supplied complete with all auxiliary equipment necessary for safe operation, routine and periodic maintenance and repairs with sufficient space between modules.

The normal operations will be effected from the System Control Centre. The bidder shall take into consideration the unmanned operation of the substation in his design.

Control facilities shall be simple and clearly designated with the respective function and instructions on operation and maintenance and it shall be unambiguous.

The following provisions shall be made for control and indications :

Local control cubicle to equipment - control of circuit breakers, disconnectors and earthing switches where power operated, complete with electrical indications, mimic diagram, gauges and alarm annunciator.

Remote panel in the control room on the site - control of circuit breakers, disconnectors and line side earthing switches where power operated with position indication in each instance.

Supervisory control from a system control room centre-provision of control of circuit breakers and disconnectors switches where power operated, with position indication in each instance.

All necessary local/remote and remote/supervisory control relays, interposing relays and selector switches are to be provided as part of this Contract.

Circuit identifying labels shall be fitted at the front and rear of each individual circuit assembly and on the local control cubicle.

In case of labels not visible when standing on the floor, additional name plate shall be fixed at a suitable location.

A single line diagram shall be marked along each bay showing the location of all items of switchgear.

In the event of leakage from any compartment, equipment shall withstand rated voltage with SF6 at atmospheric pressure.

The insulation levels shall be able to withstand basic test voltages in accordance with the relevant standards for Synchronizing Operation for Breakers.

Busbar connections and enclosures shall be designed to absorb the effects of thermal expansion

without application of stress to the supporting structure.

Equipment foundation requirement details complete with floor and structure fixings consistent with the switchgear design offered are to be provided at an early stage in order for these to be incorporated in the civil works design.

Availability for Maintenance, Repair, Extensions, Testing

Maintenance, Repair or Extension (MRE) and HV Testing on one busbar with directly connected apparatuses shall be possible with the other busbar in normal operation.

MRE Testing on one switchgear bay shall be possible with all other switchgear bays in normal operation on one busbar.

MRE Testing on/off bus coupler bay shall be possible with one busbar at the time in normal operation and all switchgear bays in normal operation.

Maintenance access to each module shall be possible without necessitating the outage of adjacent modules.

Gas Compartments

The switchgear units and busbar systems shall be divided into several gas-filled compartments, sealed from each other by gas-tight partitions.

The various gas zones shall be further sub-divided when necessary to restrict any internal arcing damage, particularly within sections of busbars and to enable gas handling procedures to be completed with the minimum of delay. The partitions should confine any internal faults to a respective section of the switchgear.

The number of gas compartments shall be such as to limit the amount of switchgear which has to be isolated and taken out of service as a result of gas leakages, planned maintenance or internal faults.

Proposals for the partitioning of gas zones shall be clearly indicated on the drawings submitted with the bid. Partitioning on the GIS shall be clearly marked with yellow paint on the GIS. Gas volumes and duration of gas handling procedures shall also be indicated in the technical schedules. Each gas zone shall have its own gas monitoring, filling, degassing, regassing & gas sampling facility.

Total time for gas evacuation and filling of the largest chamber shall not exceed 10 hours.

Suitable arrangements shall be provided for the thermal expansion and contraction of the busbars and busbar chambers without detriment to the current carrying capacity or gas volume.

Devices shall be provided for each section of switchgear as appropriate to allow for pressure relief. All relief devices shall be located such that operation of the devices shall not endanger

personnel working on the equipment or in the vicinity of the equipment.

These devices shall be arranged to give individual compartment alarms in the local control units and initiation of remote alarms. Each gas-filled chamber shall be fitted with static filters to absorb any moisture which may be present. In addition, filters for removal of SF₆ decomposition products shall be provided in Circuit Breaker compartments.

For circuits equipped with double cable isolation, provision shall be made to remove the gas from either cable chamber whilst maintaining the other cable in service. i.e., Gas monitoring of the chamber in service shall be maintained at all times.

In chambers equipped for 230kV & 110 kV cable sealing ends a disconnecting link must be provided to allow easy isolation between the cable sealing end and the main connections. It must be possible to remove this link without removal/refitting of the main connections alternatively the barrier should be designed for HVAC test of Power Cable.

In order to compensate for any small variations in floor level each compartment shall be fitted with means of adjustment (jacking screws or similar). Such adjustments shall be fully described in the maintenance manuals provided by the manufacturer. In case such arrangements do not exist, it shall be the responsibility of the manufacturer to ensure acceptable floor level tolerance.

Enclosures shall be clearly marked to identify gas compartment zones, disconnectors, circuit-breakers, earthing switches, current transformers, voltage transformers, surge arresters and other primary devices contained therein. The method proposed shall be subject to the approval of the Employer's Representative.

Gas Barrier and Supporting Insulators

Gas barriers shall be gas tight and of sufficient strength and factor of safety to withstand short circuit forces and the maximum pressure differential that can occur under internal fault conditions. The gas barrier withstand pressure shall be more than that of bursting disc. It should be possible to vacuum, any chamber with adjacent chambers having full pressure.

Enclosures

The enclosures for the SF₆ gas insulated switchgear shall be of Aluminium Alloy.

It shall be capable of withstanding maximum differential pressure between adjacent gas zone over a considerable period. Evidence shall be provided to verify that enclosures have been designed and tested in accordance with established pressure vessel codes.

Each enclosure shall be tested and stamped by the inspecting authority issuing the test certificate.

Circuit-breakers, isolators, earth switches, VTs, CTs, surge arresters, cable termination chambers, all and any other chambers and components shall have pressure tests on enclosures as per IEC 62271-203 clause 7.101. The withstand pressure of the enclosures shall be well over the bursting disc operation pressure and shall be embossed on all the enclosures at a conspicuous

location.

Voltages induced in the enclosures shall not be allowed to exceed reasonable safe limits. All chambers throughout the equipment shall be earthed at an approved number of points. All necessary earthing bars and associated fixings shall be provided. Approved GIS earthing drawings are to be supplied from the manufacturer of the GIS.

Each enclosure shall be provided with lifting points to facilitate maintenance or repair works.

SF6 Gas

(a) SF6 Gas Requirements

All SF6 gas supplied for use in the switchgear shall comply with the requirements of IEC 60376.

Test Reports shall be submitted for review.

(b) SF6 Immersed Insulation

Busbars and items of switchgear shall be supported in the enclosures by insulators of materials compatible with SF6 gas and the products of gas decomposition.

Gas barrier insulators and bushings, including gas-oil and gas-air bushings shall comply with the specified conditions for sealing of enclosures. The Employer's Representative shall be advised of design pressures used and may require test evidence to substantiate performance under extremes of differential pressure and temperature.

SF6 immersed insulation shall otherwise comply with the relevant clauses for insulators and bushings.

Gas Monitors

Gas density monitors complete with alarm and lockout contacts or manometers with pressure switch for alarm and lockout shall be provided. The gas monitor shall be located such that readings can be taken easily standing on the floor. Means shall be provided to enable gas systems to be safely replenished whilst the equipment is in service.

For circuit breaker compartments, a lockout feature shall be provided to prevent operation whenever SF6 gas pressure is less than that permitted by the design for satisfactory operation. Contacts shall be included to initiate alarms to warn of this condition.

Two sets of voltage free electrical changeover contacts shall be provided for every alarm for remote SCADA and repeat alarm facilities in addition to alarm fascias incorporated in the local control panel/marshalling kiosk associated with each primary circuit. Contact multiplying relays may be used.

Position Indicators

Position indicators shall be provided for all circuit-breakers, disconnectors and earthing switches to show whether the main contacts of these switches are in the fully open or closed positions. Position indicator should be directly coupled with shaft drive for all three phases.

Indicators shall be of a reliable mechanical design and be positively driven in both directions by the final drive stage of the contact operating mechanism. Reference marks should be punched or engraved on the main frame for this purpose. Each indicator shall be clearly visible to operating staff at operating control points and access routes provided under this contract.

Temperature Rise

The temperature rise limits shall be in accordance with IEC62271-203. The switchgear shall be capable of carrying the specified rated current at rated frequency continuously in accordance with normal service conditions as defined in IEC 62271-1 as well as site ambient conditions.

The design of sliding type current carrying connectors and joints shall be such that they meet the aforementioned conditions over the full permitted range of movement. Where such joints may be made or adjusted on Site, full details of alignment procedure, together with any necessary alignment tools or gauges shall be described in the maintenance manual and included in the supply of special tools.

Arrangement

The switchgear shall be installed in a building with a cable basement, both being maintained at a slight positive pressure of filtered air such that any SF₆ gas released in the building will be discharged externally via pipes from the lowest point.

The Contractor shall supply the necessary permanent type of ladders and galleries for access to all levels of equipment during normal operation or maintenance.

The Contractor shall include in his supply power operated lifting appliances with all accessories as appropriate to the size and weight of component parts of the switchgear which require to be lifted in the course of maintenance or repair. The layout arrangement shall allow for full mobility of the gas handling plant ladders, cat way walks etc. along the switch room.

The offer shall include (a) mobile platform suitable to reach any equipment, (b) Handles of manual operation of D/S, E/S and (c) any special tool required for the operation of the switchgear. 2 nos. of 63A sockets shall be provided in the GIS room at suitable location for the gas handling plant and HV test set.

Mechanical Construction

Components that may require to be renewed and standard assemblies that may be transferred from one circuit to another shall be interchangeable and where required this shall be demonstrated by the contractor. Flanges shall comply with an appropriate metric standard as regards both dimensions and drilling, where appropriate.

Screwed couplings and fittings shall have pipe threads to ISO Recommendations.

Testing Facilities

Testing flanges/adaptor and associated bushings for 3 phases shall be provided where relevant on each circuit for HV withstand testing of main cables and switchgear. Each testing flange shall be positioned in a separate gas zone compartment which shall be independent of adjacent disconnector and earthing switch gas sections.

HV Cable Testing Facility

A set of single and three-phase cable test bushings and the facility for connection to the switchgear shall be provided which will permit the full AC testing of all cable connected circuits. It shall be possible to connect the test bushings without dismantling other equipment and permit testing three single-core cables at the same time or separately by connecting the test bushing to the AC high voltage test kit fitted at a suitably safe place inside the switchgear room. Adequate precautions shall be taken to ensure that any section of busbars insulated by SF₆ gas is not subjected to any cable testing voltage unless able to withstand such voltages. Hence the bidder shall indicate if there is any deviation.

Removal/Insertion of Links for HV Cable Tests and Primary Injection

The Contractor shall be responsible for the degassing, removal of the cable chamber links at the remote ends, and regassing to facilitate HV Cable Tests and Primary Injection. Once the tests are complete the degassing, insertion of the links and regassing shall be completed thus allowing normal operation of the switchgear. This shall include replacement of gaskets as necessary.

Sealing of Enclosures

To prevent ingress of moisture or leakage of gas during the service life of the equipment, the sealing materials used at all joints and interfaces shall satisfy the following requirements:

Not affected by SF₆ gas

Non-hygroscopic, containing no silicon

Non-aging and non-shrinking

Retain resilience for long periods under stress

Stable under all temperature conditions

Seals including those at compartment partitions shall continue to function correctly throughout the temperature and pressure ranges in service and the pressure differentials, including vacuum and test pressures, during erection, maintenance and subsequent revisions.

Expansion bellows and diaphragms, pressure relief devices and inspection windows shall be designed to be free of leakage under the same conditions as stated for seals.

Where the use of cast Aluminium is envisaged the Manufacturer shall submit to Employer's Representative evidence of tests carried out for porosity and extended pressure testing to show the quality of the castings used.

Gas Losses

The Manufacturer should be prepared to guarantee the equipment for a gas loss of not more than 0.5% per annum in any single gas compartment, and not more than 0.5% for the total installation.

Earthing System

All metal parts other than those forming part of any electrical circuit shall be earthed to the earthing system. Any necessary terminals on part of the equipment required for this purpose shall be provided by Contractor. The jointing parts of the earthing conductors/strips are to be properly tinned.

230kV & 110 kV cable sheath shall be connected to the earthing grid through the link box.

Gas Handling Equipment

Gas handling plant shall be provided at each installation to permit emergency topping up of gas in the switchgear in the event of leakage and for use during any maintenance works.

The mobile gas handling unit, the size of which shall allow full mobility within the switch room, shall be included for the complete sampling, testing, filtering, drying, extraction and refilling of SF6 gas. This unit shall be self-contained and comprise of a wheeled trolley housing all necessary compressors, vacuum pumps, filter, etc. gauges, piping and controls etc., together with a gas storage tank with usable capacity. The unit shall be capable of evacuating air from the switchgear compartments and replenishing them with gas at the end of a maintenance period. Facilities shall also allow for circulation of the gas from a compartment through filters in order to extract moisture pressure.

Additional mobile or static storage (at least one full cylinder of SF6 gas together with one empty cylinder) shall be provided for use in combination with the gas trolley and to extend storage facilities.

All necessary pipe-work, flexible hoses, couplings, valves, pressure and vacuum gauges shall be included to enable interconnection between the switchgear compartments, gas trolley and storage tanks and the cylinders provided by major producers of SF6 gas.

To enable safe maintenance to be carried out on any portion of the switchgear when all electrical supplies to the local control unit are switched off two portable gas alarm units shall be provided. The alarm units shall be self-contained and capable of giving clear audible warning should the gas pressure in any adjoining gas-filled chamber become unsafe. The cost of these equipment shall be included in the GIS price.

Technical Data:

Vacuum Pump

Nominal suction capacity	:	10m ³ /h
Achievable final vacuum	:	< 1 mbar Compressor
Theor. intake volume	:	5, 7 m ³ /h
Suction pressure	:	p = 0,8 to 3 bar (for a short time up to 0, 5 bar)
Max. counter-pressure	:	p = 50 bar
Storage performance	:	90 kg
SF ₆ Filling performance	:	140 kb SF ₆ /h.

An approved portable SF₆ gas leakage detector, oxygen analyzer, moisture meter and manual operating handles/tools (for circuit breakers, disconnectors, earth switches) shall be provided for each substation.

APPARATUS

Circuit Breakers

Operating Duty and Performance

General

The requirements of IEC 62271-100 in respect of type tests, routine tests, service, operation and the making and breaking of fault currents shall apply to the specified circuit breakers.

Circuit breakers shall be complete with spring or hydraulic operated mechanisms. Where circuit breakers require other services these shall be included in the supply and erection of the common services installation at each substation, and shall include alternative back up facilities.

Offers of circuit breakers shall include proof that a satisfactory period of commercial service experience of not less than three years in climatic conditions similar to Chennai has been obtained with the type and rating put forward; failure to provide this proof may result in rejection of the bid.

Rate of Rise of Re striking voltage

Attention is drawn to the transient recovery voltage (TRV) requirements of the IEC Standards. Where not specifically stated in the test certificates submitted with the Bid, the Bidder shall certify that the TRV to which the Circuit breaker was subjected during the short circuit tests was the most severe condition that could be imposed by the available test plant for a first phase-to-clear factor of 1.3.

Any device incorporated in a circuit breaker to limit or control the rate-of-rise of re striking voltage across the circuit breaker contacts shall likewise be to Employer's Representative's approval and full descriptions of any such device shall be given.

Evidence shall be submitted with the bid to verify that all circuit breakers when interrupting faults on the secondary side of a transformer the transient recovery voltage conditions, that could arise will not exceed the tested interrupting capabilities of the circuit breaker proposed.

Interrupting Duty

In addition to the requirements of IEC 62271-100 for interrupting terminal faults all circuit breakers shall be capable of coping with the interrupting duties produced by the switching of low inductive currents associated with reactors and transformer magnetizing currents and by the switching of capacitive currents associated with overhead lines, cables and capacitors banks as may be applicable. Circuit breakers for these duties shall be of the re strike-free type only.

All circuit breakers shall also be capable of interrupting currents associated with short-line faults and the out-of-phase switching conditions that may occur in service.

The total interrupting time shall be 40ms or less for 245kV CB, 60ms or less for 145kV CB from energization of trip circuit of the circuit breaker to the extinction of the arc. The total closing time shall be less than 65msec from energization of closing circuit of the circuit breaker to closing of the breaker contacts. The operating duty cycle shall be 0 - 0.3 sec - CO - 3 min - CO, with no de-rating for the first re-closure between operations over the voltage range from nominal to rated maximum voltage and from zero to the maximum rated interrupting current without the necessity of intermediate maintenance. The circuit breakers shall be capable of withstanding the transient recovery voltage as per IEC-62271 (values to be determined by the Contractor).

The circuit breaker shall be designed for M2 class as per IEC 62271 under all duty conditions.

Fault Clearance Time

The overall fault clearance time including relay operating time shall be in accordance with the requirements specified.

General Arrangement

Facilities for measurement of circuit breaker contact resistance and timing tests without removal of covers or SF6 gas filling shall be provided. Full details of the testing procedures shall be submitted with the Bid.

Means shall be provided to allow access for the inspection and maintenance of fixed and moving contacts and other enclosed components.

Circuit breakers use the SF6 gas conforming to IEC or other approved standard as the insulating medium as well as for arc quenching.

Circuit breakers shall operate on the principle of self generating gas pressure within the interrupter for arc extinction. e.g., puffer type. A lockout feature shall be incorporated to prevent operation of the circuit breaker whenever the gas pressure falls to a value below which it would be incapable of performing in accordance with rated duty. A pressure switch (temperature compensator type) operated SF₆ low in CB alarm shall be incorporated at LCC, Remote Control centre as urgent feeder alarm at SCC to give indication of falling gas pressure prior to lockout of the circuit breaker.

Suitable facilities shall be included for gas sampling and for draining and replenishing the gas volume for maintenance. Absorption of moisture and the decomposition products of arcing or discharge in the gas shall be achieved by integral filters.

Sufficient nos. of N/O and N/C auxiliary electrical contacts shall be provided for using interlocking circuits and for states indication at the remote and supervisory control centers and any other requirement. At least 10% spare N/O and N/C contacts shall be wired up to LCC for future use.

Operating Mechanisms

The circuit breaker operating mechanism shall be power operated and of the type specified. Operation will normally be from a remote or supervisory position but facilities shall be provided for operation locally by electrical release and by direct manual release from stored energy devices when the circuit breaker is isolated for maintenance. It shall be possible to padlock each local control function in the open position. Operation counters shall be fitted to all circuit breaker mechanisms.

The mechanism and its control scheme shall be such that, in the event of an electrical tripping pulse being applied to the circuit breaker during the closing stroke, or of the mechanism failing to latch in the closed position, the circuit breaker shall open fully and in such a manner as to be capable of interrupting its rated breaking current.

The mechanism and its control scheme shall be such that the mechanism shall not make repeated attempts to close the circuit breaker when the control switch is held in the CLOSE position in the event of failure to latch on the first closing attempt or in the event of a trip signal being given to the circuit breaker i.e., anti-pumping facility to be provided.

The electrical closing and tripping devices, including direct acting solenoid coils and solenoid operated valves, shall be capable of operation over the ambient temperature range when the voltage at their terminals is any value within the voltage range stipulated in IEC62271-100 and in addition over the range of all operating conditions of the batteries and chargers supplied under this Contract.

The circuit breaker shall preferably be driven by a single mechanism coupled to the three phases.

The circuit breakers shall be provided with the facility for measuring the electrical timing of the contacts.

All circuit breaker operating mechanisms shall be fitted with independent duplicate shunt trip coils suitable for either independent or simultaneous operation.

On feeder circuits Trip Coil 1 (TC1) shall be operated by all circuit protection and intertrips except Main 2 protection. Trip Coil 2 (TC2) shall be operated by Main 2 protection and the local, remote and supervisory control switches.

On Bus Coupler and -Bus Section-circuits TC1 shall -be -operative- by bus zone protection and TC2 by overcurrent protection and controls.

On Transformer and Generator circuits TC1 shall be operated by all protection and intertrips except REF and TC2 by REF and controls.

Power closing mechanisms shall be recharged automatically for further operations as soon as the circuit breaker has completed the closing operation and the design of the closing mechanisms shall be such that the circuit breaker cannot be operated inadvertently due to external shock forces resulting from short- circuits, circuit breaker operation, or any other cause.

Operating mechanisms shall be capable of storing energy for at least two complete closing and tripping operations or one O-C-O operation, local to the equipment and without recharging. Mechanisms shall preferably utilize dc supplies for recharging duties.

Means shall be provided for the CB manual (non-electrical) tripping of the circuit breaker, preferably by a shrouded push button and facilities shall be provided for locking off this means of tripping. It shall not be possible to lock mechanically the trip mechanism so as to render the electrical tripping inoperative.

Facilities shall be provided to permit manual slow closing and slow opening of the circuit breaker for maintenance purposes. It shall not be possible to "slow close" or "slow open" a circuit breaker when connected in the normal service condition.

Spring Charged Mechanisms

Circuit-breakers fitted with power charged spring operated closing mechanism shall also meet the following requirements.

When fully charged the spring mechanism shall have sufficient stored energy to permit the operating sequence O-C-0/2 C-0 to be performed following the loss of supply to the charging motor.

The mechanism shall be charged automatically, for further operations, as soon as the circuit breaker has completed a closing operation. The time required to power charge the spring shall not exceed 30(as per IEC Standard) seconds.

The spring shall be fully charged before it can be released to close the circuit breaker. It shall

not be possible for the breaker to close whilst the spring is being charged.

Manual Spring charging facility shall be provided.

A mechanical indicating device shall be provided to indicate the state of the spring. The indication shall be visible with the doors of the mechanism cabinet closed. An auxiliary switch shall give the remote indication of "spring discharged".

An indicating device shall be provided at the local control panel and the main control room and also over the supervisory system to indicate a spring failing to be charged by a pre-set time after circuit breaker closing.

Circuit Disconnectors and Earthing Switches

General

Circuit Disconnectors and Earthing Switches shall be supplied as shown on the contract drawings and as indicated in the Schedules. Each disconnector and E/S shall be labeled with SCADA numbers as per SLD by providing permanent engraved stickers.

Transformer circuit modules shall be equipped with not less than two maintenance earthing switches, one on either side of the transformer circuit breaker.

Each busbar shall also contain high speed make-proof earthing switch as per the single line diagram.

In case of designs incorporating double isolation and interposing earthed metallic screen shall provide similar facilities which enable safe access for testing, inspection, maintenance and extension whilst other parts are in service.

Isolating and earthing switches shall be arranged to permit safe maintenance of any section of the equipment when the remainder is alive. Isolating switches shall be arranged for operation while the equipment is alive, but will not be required to break current other than the charging currents of open busbars and connections (including circuit-breaker bushings) or load currents shared by parallel circuits under the conditions of this Specification.

Isolators shall be housed in compartments partitioned from the circuit breakers and the busbars or feeders with which they are associated.

Isolators with double isolations, may be housed into two adjacent compartments. It shall be possible with such partitioning and with the isolator compartments maintained at full gas pressure, to carry out high voltage insulation withstand tests on outgoing circuit cabling or on sections of busbar, without taking adjacent equipment or sections of busbar out of service.

Load making and breaking switches with fault making capability shall be provided which shall

be suitable for switching on load without detriment to the equipment and under normal duties up to the circuit rating specified.

Switch mechanisms shall be so designed that the isolator cannot be opened by forces due to currents passing through it and shall be self-locking in both the "open" and "closed" positions. The mechanism shall open and close all three phases simultaneously.

Power operated drives shall be provided which shall be suitable for local, remote and supervisory control (supervisory control of earth switches is not required) and should be fitted with a removable emergency manual operation facility. It should be possible to lock-off the manual and local facility and padlock the mechanism in the open and closed positions with the motor automatically disengaged (isolator and earth switch).

Local mechanical position indicators shall be provided on all switches and shall be visible from ground level. Transparent window shall have to be provided as required to see the Disconnector and Earth switch contact status (Close or Open).

For safe earthing of the busbars and feeders, high speed fault making spring driven earth switches shall be provided. The mechanisms shall be electrically operated with provision for local manual operation. The contacts of these earth switches shall have the same fault making capability as that of the circuit-breaker.

Each section of busbar which can be electrically isolated from other sections of busbar by means of isolators or circuit-breakers shall incorporate high speed earthing switches as specified above.

Slow speed maintenance earthing switches shall be manually and electrically operated from the local position only. Positive mechanical and electrical interlocks shall be provided to prevent unintentional use of this earthing equipment.

Selected earthing switches shall be arranged such that, with a minimum use of tools and special fittings, they may be used to facilitate such tests as CT primary injection, contact timing and voltage drop measurement without the necessity to open gas-filled compartments. Detailed means of performing these tests, shall be provided.

Each Isolator/Earth Switch shall have its own separate power and control supply and supplied from the station battery.

Sufficient nos. of N/O and N/C auxiliary electrical contacts shall be provided for using in interlocking circuits and for status indications at the remote and supervisory control centres and any other requirement. At least 10% spare N/O and N/C contacts shall be wired upto LCC for future use by Employer's Representative.

The Disconnector Switch (DS) shall be designed for M1 class as per IEC 62271 under all duty conditions. The Earthing Switch (ES) shall be designed for M0 class (Mechanical endurance) and E1 class (Electrical endurance).

Disconnectors

Disconnectors shall be of the metal enclosed design and shall generally comply with the requirements of IEC 62271-102, 62271-104 and 62271-203.

Disconnectors shall be arranged to permit safe maintenance of any section of the equipment when the remainder is alive.

Disconnectors shall be provided with motor driven mechanisms and shall open and close all three phases simultaneously. It shall not be possible for the disconnectors to open or close inadvertently due to forces which may occur in service or under short-circuits.

The mechanisms shall be capable of being locked and secured by padlock in the open or closed position.

In the event of driving motor failure, means for hand operation shall be provided which are operable from ground level or walkways provided.

While doing a hand operation of disconnector, driving motor supply shall be cut off by appropriate means.

All disconnectors shall be fully interlocked with associated circuit breakers, disconnectors and earthing switches to ensure safe operation of the equipment under all service conditions.

The disconnector shall be interlocked with CB is arranged in such a way that CB shall not be allowed to close unless the concerned disconnector is fully closed, i.e. Late make type auxiliary contact shall be used for this purpose.

Electrical interlocking is required for maintenance and operation.

The insulation level for the isolating distance between disconnector contacts shall be at least 15% higher than that for the remainder of the equipment.

Disconnectors shall be capable of switching load currents when shunted by a parallel path (on-load bus transfer) and capacitance charging currents associated with open busbar, bushings and capacitor voltage transformers. Test certificates on the capabilities of on load bus transfer of disconnectors are to be provided.

If the disconnectors are expected to generate fast rising transients during interruption of capacitive currents, adequate protection shall be provided for transient voltage control.

Maintenance Earthing Switches

Earthing switches shall generally comply with the requirements of IEC 62271- 100 and 62271-203.

Earthing switches integrally mounted with disconnectors or separately mounted shall be provided for earthing already isolated sections of gas insulated switchgear in order to provide safety maintenance. Motor operated mechanisms shall be provided but it shall be possible to

operate the switch manually in emergency conditions.

The earthing switch, when in the closed position shall have a short-time current withstand as specified for the feeder. No burning or welding of contacts shall occur.

Provisions for testing purposes shall be incorporated in the design of earthing switch to facilitate primary current injection tests and other low voltage checks. Fully insulated designs of earthing shall incorporate removable earth links suitable for the short-time current rating specified. It shall be possible to apply maintenance earths on either side of the test zone for safety reasons.

All earthing switches shall be mechanically interlocked with associated circuit breakers and disconnectors so that it shall not be possible to close an earthing switch onto a live circuit or to make the circuit alive when the earthing switch is closed.

Direct visual indication of the earthing switch position should be provided, with clear markings to show that the device is fully open or closed.

High Speed Earthing Switches

These earthing switches shall be capable of making onto a live circuit and suitable for high speed power operation. It shall be impossible to slow close these earthing switches.

They shall be located at all feeder terminal points and busbars or other location where there is no certainty that the point to be earthed is not energized.

High speed earthing switches shall be capable of interrupting induced currents as may be necessary when opening the earthing switches used for grounding one out of two or more long parallel circuits.

The operating mechanism of High Speed Earthing Switches shall be motor wound spring operated type with one of the following features:

The closing spring shall remain in discharged position when the switch contacts are in open position. The closing spring shall be charged only when the closing command is given either electrically or manually and the contacts shall close automatically after the spring is fully charged.

If earthing switch is provided with the design in which closing spring is charged and latched in the open & close position of the switch, then mechanical locking arrangement shall be provided to avoid un-intentional closing of the switch either electrically or manually.

In both the designs, facility for padlocking the mechanism in the open position of the switch shall be provided.

The design of the Earthing Switch shall be approved by the Employer's Representative.

Facilities integral with the earthing switch for primary current injection or low voltage checks

shall be insulated from earth and incorporate a disconnectable earth strap.

These earthing switches shall otherwise be in accordance with the requirements for maintenance earthing switches.

Current Transformers

Current transformers shall be supplied suitable for the duty specified and comply with the requirements of IEC 60044-1 and BS 3938 as appropriate.

Current transformers, where specified, shall be SF6 gas insulated, shall be compatible with the switchgear and shall preferably not contain any hygroscopic insulating material which could affect the SF6 gas in either the current transformer or in the associated switchgear chamber.

Current transformers shall comply with the requirements of the common sections of this Specification. Where separate terminal boxes are used for current transformer secondary wiring, the identifying labels shall be fitted to the terminal boxes in a conspicuous position but not on removable covers.

Current transformers including primary conductors shall have a short time current rating and duration not less than that of the associated switchgear. All current transformers shall have sufficient overload capacity to permit continuous operation with currents up to 150% of the rated current of the associated equipment.

Secondary windings of each current transformer shall be earthed through a withdrawable link at one point only; in the relay panel for protection circuits and in the control panel for instrumentation.

Current transformers for tariff metering shall not be used for any other purpose. Current transformers for statistical metering may also be used for other instruments and protection.

Where double ratio secondary windings are specified a label shall be provided at the secondary terminals of the current transformer indicating clearly the connection required for either ratio. These connections and the ratio in use shall be shown on the appropriate schematic and connection diagrams.

CT sizing calculations shall be submitted to the Employer's Representative for approval.

Where double ratios are specified and current transformers with multiple windings are tendered, it shall be possible to select either ratio for each winding without alteration to the number of primary turns.

The characteristics of current transformers used for protection circuits shall include the following requirements.

For overcurrent protection, they shall not saturate, change ratio or produce harmonic voltages in the secondary winding which will affect the accuracy of the relay with primary currents up to

20 times rates full load current.

For earth fault protection and balanced forms of protection, when connected as in-service, they shall not produce spill currents in excess of half the minimum operating current of the relay but provide stable equipment with primary currents up to 20 times rated full load.

Each protection scheme shall be provided with appropriate current transformers for optimum operation of the scheme. Provision should be made to carry primary injection test of bushing CTs for 100% rating.

Terminal boards shall have shorting/disconnecting links to allow testing with the circuit in service and on load. It shall be possible to carry out primary injection testing of the CTs with 100% rating when the switchgear is fully assembled, or retesting of the CTs during the service life of the switchgear without interruption of supply to adjacent circuits or any part of busbar. The testing facilities provide in the design for site testing shall be stated by the Bidder.

The contractor should clearly mention the continuous rating of earth switches and their associated cables for the purpose of primary injection tests. The secondary windings of each set of current transformers shall be capable of being open circuited for one minute with the primary winding carrying the rated current. The secondary wiring of all CT's shall be brought to a common terminal block located within the local control cubicle.

The polarity of the primary and secondary windings of each transformer shall be clearly indicated at the respective terminals and in addition labels shall be fitted in a readily accessible position to indicate the ratio, class and duty of each transformer winding.

Neutral CT for REF protection and any other CTs which require to be matched with switchgear CTs will be manufactured by switchgear manufacturers and hand over to transformer manufacturer for installation. Suitable mounting arrangement is to be made by the transformer manufacturer.

Voltage Transformers

Indoor voltage transformers, where specified, shall be SF6 gas insulated, shall be compatible with the switchgear and shall preferably not contain any hygroscopic insulating material which could affect the SF6 gas in either the voltage transformer or in the associated switchgear chamber.

Voltage transformers shall comply with the common sections of this Specification, comply with the requirements of IEC 60044-2.

The rated secondary voltage per phase shall be 110/3volts in the case of star connected windings and the rated voltage factor shall be 1.2 continuous; 1.5 for 30 seconds.

Facilities for isolating the primary connections without having to lift the VT from the switchgear shall be provided. This primary isolation shall be without degassing.

It shall not be possible for voltage transformer secondary windings to be connected directly in parallel, except through interposing voltage transformers associated with a synchronizing scheme. To prevent any possibility of back energizing a VT secondary winding via synchronizing circuits, circuit breaker auxiliary contacts which are of the late make-early break type shall be employed.

Voltage transformers shall be capable of carrying continuously, without thermal damage 150% of their rated output.

Voltage transformers on feeder circuits shall be located on the feeder side of the circuit breaker outside the protected zone covered by the busbar protection. They shall however be included in the protected zone afforded by the feeder protection.

Primary connections shall have the same short time current rating as the associated switchgear.

Each secondary winding of the voltage transformers shall be protected by suitable approved fuses and links which shall be located as close as possible to the voltage transformer, preferably within the terminal box. All secondary winding connections, including both ends of the secondary winding shall be brought out to the fuses and links. The fuses and links shall be connected to approved terminal blocks for termination of multicore cables. A metallic label shall be provided and fixed at the voltage transformer clearly indicating the connections required for each winding.

Separate sets of MCBs shall be provided at the VT for:

- (a) Each protection scheme
- (b) Instruments, disturbance recorder, fault locator etc.
- (c) Synchronizing

The circuits for each main protection scheme shall be segregated in separate multi-core cables from the VT to the protection panels. An alarm (VT. failure) shall be provided for each set of MCBs.

The neutral point of each voltage transformer secondary circuit shall be earthed at one point only via a separate removable link of approved design. The earth link shall be situated in an accessible position and suitably labeled.

A magnetization curve shall be provided for each voltage transformer for approval by Employer's Representative.

The location of the voltage transformers to be installed on the primary switchgear shall be approved by the Employer's Representative.

Fixed ladders and/or catwalk structures with handrails are to be provided for the VTs for inspection/testing/replacement of fuse, etc.

Mechanical shock indicators shall be fitted to VTs prior to dispatch from the factory, to indicate

how the VT was handled during transit and to determine if detailed inspection is required at Site.

Electromagnetic voltage transformers shall be capable of discharging the capacitance of line, cables and switchgear which may remain connected to them during switching operations. The Bidder shall declare any limitations of the equipment for this duty.

The contractor shall ensure that no disruptive over voltages will be generated due to ferro-resonance phenomena and if necessary by suitably connecting resistors across the secondary of VT after approval of Employer's Representative. All necessary site tests are to be performed on VTs before commissioning. Details of the test procedures and test formats are to be provided.

Feeder and Transformer Connections

General

SF6 immersed cable sealing end chambers or SF6 gas insulated bus ducts shall be provided as specified for outgoing circuits.

If the Contractor opted to connect the transformer using SF6 gas insulated bus ducts and air insulated bushing, the supply and installation of such gas insulated bus ducts and Air Insulated Bushing shall be included under this contract by the Contractor.

When the circuits are connected via cables directly to the SF6 switchgear terminals the cable and sealing ends shall be as per IEC Standards.

Connections shall be suitable for the specified continuous and short circuit current ratings. Where necessary, expansion joints shall be provided to accommodate differential movements between the switchgear phase terminals and conductors.

The manufacturer of the switchgear is required to coordinate design of SF6 filled enclosures with that of cable sealing ends and transformers supplied by other manufacturers such that the integrity of gas and/or oil pressure compartments is maintained.

Facilities shall be provided for high voltage a.c. testing and conducting cable fault location measurements of cabled circuits.

To reduce the effect of solar gain all SF6 or other types of insulated bus ducts exposed to direct sunlight shall be covered with metallic sun shielding (If the installation is outdoor partly).

Cable Sealing Ends

Cable sealing ends shall be suitable for terminating the cables specified directly into the GIS switchgear. The dimensions and terminal arrangements, together with details of filling medium of the sealing end shall be submitted for approval by the Employer's Representative before manufacturing.

All sealing ends shall be suitable for filling and shall be designed with joint faces which will

ensure leak-free operation and exclude the entry of oil or gas.

Where required to reduce local heating when single-core cables are adopted, non-magnetic gland plates shall be provided or alternatively, non-magnetic inserts.

Design of cable termination equipment must ensure that the following conditions are maintained throughout the life of the equipment.

The insulating material, either gas or oil, from inside the cable does not escape and penetrate the switchgear enclosure.

The SF6 gas does not enter the cable from the enclosure.

The cable sealing end does not introduce moisture into the gas in the sealing end enclosure.

The sealing end is capable of withstanding the cable test voltages and differential pressures without damage including overpressure of +30% of normal operating pressure.

Insulating and Earthing

Sealing ends shall be provided with all fittings including flexible connections where necessary. Stress cones or other approved means for grading the voltage stress shall be provided for insulating the cable within the sealing end. (The insulated flange and external casing shall be provided by the cable manufacturer). Glands shall be insulated from the chamber.

The insulation between cable and chamber shall be capable of withstanding a dry high voltage test of 3kV a.c. for one minute.

Removable links shall be provided close to the GIS to enable sheath tests to be carried out and to prevent arcing to adjacent metal framework during isolator operation.

Material

Porcelain or molded insulators used in the manufacture of cable sealing ends shall be sound, free from defects and thoroughly vitrified so that the glaze or surface treatment is not depended upon for insulation.

The insulators and fittings shall be unaffected by the filling media or rapid temperature changes likely to arise when operating in the Site conditions and shall be designed so as to facilitate cleaning.

Porcelain shall not engage directly with hard metal and, where necessary, an approved resilient material shall be interposed between the porcelain and the end fittings. All porcelain clamping surfaces in contact with gaskets shall be accurately ground and free from glaze.

All fixing material used shall not enter into chemical action with the metal parts or cause fracture by expansion during service. Where cement is used as a fixing medium, the thickness of cement shall be as small and even as possible and proper care shall be taken to centre and locate the individual parts correctly during cementing.

Each porcelain or molded insulator shall have marked upon it the manufacturer's identification mark and such other mark' as may be approved to assist in the representative selection of insulators for the type tests. The mark shall be clearly legible and also visible after assembly of end fittings and shall be imprinted before firing.

When an insulator bearing a certain identification mark has been rejected, no further insulators bearing this mark shall be submitted and the Contractor shall satisfy Employer's Representative that adequate steps will be taken to mark or segregate the insulators which have been rejected in such a way that there shall be no possibility of such insulators being re-submitted subsequently for test or being supplied.

Surge Arresters(Metal Oxide without gaps for A.C. systems)

Indoor GIS surge arresters and outdoor GIS surge arresters shall be of the type metal oxide arresters without gaps complete with surge counters and shall fulfill requirements as per IEC 60099-4, IEC 60099-5 and Employer's Representative's approval.

Control Equipment

Local Control Cubicle

Functions

Each circuit breaker bay shall be provided with a local control cubicle containing local control switches and a mimic diagram for the operation and semaphore for status indication of the circuit breaker and all associated isolators and earth switches together with selector switches to prevent local and remote and supervisory controls being in operation simultaneously.

Closing of the circuit breaker from the local control unit shall only be available when the breaker is isolated for maintenance purposes. Local control cubicle shall be suitable for installation in a separate place or mounted with the GIS bay. Status indications in the LCC shall be semaphore type or LED type.

Circuit breaker control position selector, operating control switch and electrical emergency trip push button shall be installed in the Local Control Cubicle. Circuit breaker control from this position will be used under maintenance and emergency conditions only. The emergency trip push buttons shall be properly shrouded.

If a disconnector or earth switch is not the fully open or closed position a "Control Circuit Faulty" alarm shall be initiated, and electrical operation shall be blocked.

Local manual release facilities shall be provided for closing and tripping the Circuit breaker.

The operation of both releases shall be subject to lockout if insufficient stored energy is available. Local manual releases shall be provided with locking off facilities.

Sufficient electrical terminals shall be provided for the termination and interconnection of all cabling associated with remote and supervisory control, alarms, indications, protection and local ring main supplies.

Where control cabling between the local control cubicle and the switchgear are connected by plug and socket boxes, the plugs and sockets shall not be inter-changeable.

Hydraulic and SF6 auxiliary equipment necessary for the correct functioning of the circuit breakers, disconnectors and earth switches shall be located in a separate cubicle compartment.

Design

Operating mechanisms, auxiliary switches and associated relays, control switches, control cable terminations, and other ancillary equipment shall be accommodated in sheet steel vermin proof cubicles. Local control cubicles shall be provided to be free standing or mounted on the GIS with front access and shall be equipped with anti condensation heaters. A suitable humidity stat and thermostat shall be included in the heater circuit. The electrical apparatus so protected shall be designed so that the maximum permitted rise in temperature is not exceeded if the heaters are energized while the apparatus is in operation.

Cubicles shall be of rigid construction, preferably folded but alternatively formed on a framework of standard rolled steel sections and shall include any supporting steelwork necessary for mounting on the circuit breaker or on concrete foundations. Access to all compartments shall be provided by either removable panels or doors. All fastenings shall be integral with the panel or door and provision made for locking. Doors and panels shall be fitted with weatherproof sealing material suitable for the climatic conditions specified. Cubicles shall be well ventilated through vermin-proof louvers having anti insect screen.

The interior of each cubicle shall be finished with a semi gloss white surface. An interior lamp suitable for the local LVAC supply, controlled by a door operating switch, shall be fitted at the top of each section.

The arrangement of equipment within cubicles shall be such that access for maintenance or removal of any item shall be possible with the minimum disturbance of associated apparatus.

All the control switches shall be internal i.e., installed behind a lockable glass door.

Anti -condensation Heaters

Anti-condensation heaters of an approved type shall be provided inside each cubicle. They shall be shrouded and located so as not to cause injury to personnel or damage to equipment. The heaters shall have individual humidity stat and thermostatic control and shall be arranged to cut off when the cubicle internal temperature exceeds between 30-35°C and humidity less than 30%. A master heater circuit switch shall be provided on the switchboard or panel with an indicating

lamp to show whether the supply is on or off. The location of the heater circuit switch and indicating lamp shall be either on a common panel or in such a location that it does not require moving when extensions are provided. The heaters shall operate from the specified single phase a.c. supply. Isolation facilities for a.c. supply shall be provided in each panel.

Auxiliary Switches and Contactors

Auxiliary switches positively driven in both directions shall be provided on all Circuit breakers and isolators for local and remote indication, control and interlocking and repeat relays where necessary. Busbar protection has direct driven auxiliary contacts for CT circuits. With each Circuit breaker, isolating device, and earthing device, there shall be supplied all necessary auxiliary switches, contactors and mechanisms for indication, protection, metering, control, interlocking, supervisory and other services. All such auxiliary switches shall be enclosed in dust free housing. Not less than eight (4 NO + 4 NC) spare auxiliary switch ways shall be provided with each Circuit breaker and not less than six (3 NO + 3 NC) on all other devices. All auxiliary switches shall be wired up to a terminal board in the local control cubicle of the switchgear whether they are in use or not in the first instance and shall be arranged in the same sequence on appropriate busbar coupling and sectioning equipment that sections or sets of busbars cannot be paralleled by means of the busbar isolating devices unless a parallel circuit is already closed through the Circuit breakers of all the equipment.

Switches shall be provided to interrupt the supply of current to the tripping mechanisms of the circuit-breakers directly the operation of the latter has been completed. All such switches and mechanisms shall be mounted in approved accessible positions clear of the operating mechanism and shall be adequately protected. The contacts of all auxiliary switches shall be strong and shall have a positive wiping action when closing.

Direct acting auxiliary switch make before break contacts shall be used in conjunction with busbar protection schemes.

Auxiliary contactors shall be provided only where the circuit requirement cannot be met by the auxiliary switch arrangements and multiple contactors and relays will not be accepted in lieu of auxiliary switches except as specifically approved by the Employer's Representative.

Interlocking

An interlocking scheme shall be provided which takes into account the following basic requirements.

To safeguard maintenance personnel who may be working on one section of the equipment with other sections live.

To prevent incorrect switching sequences which could lead to a hazardous situation to plant, equipment and personnel.

The interlocking scheme shall be electrical for all operational interlocks but shall be effective

when the equipment is being controlled locally, under emergency hand or from a supervisory position.

All electrical interlocks shall so function as to interruption the operating supply and a system of interlocks shall be provided which cover the emergency hand operation of apparatus which is normally power operated. Failure of supply or connections to any electrical interlock shall not produce or permit faulty operation. Visible indication shall be provided to show whether the mechanism is locked or free. Means, normally padlocked, shall be provided whereby the bolt can be operated in the emergency of a failure of interlock supplies.

Where key interlocking is employed, tripping of the Circuit breaker shall not occur if any attempt is made to remove the trapped key from the mechanism. Any local emergency tripping device shall be kept separate and distinct from the key interlocking.

Circuit breakers closing shall be possible irrespective of the busbar and circuit isolator position.

Disconnecting switches shall be so interlocked that they cannot be operated unless the associated Circuit breaker is open except that where double busbar arrangements are specified, on-load transfer of feeder circuits from one busbar to another shall be made possible by interlocks which ensure that the associated bus coupler and its isolators are closed.

Earthing switches shall be interlocked such that they cannot be operated unless the associated isolator is open.

All isolating devices shall be interlocked with associated circuit-breakers and isolators in the same station so that it shall not be possible to make or break current on an isolating device unless a parallel circuit in that station is already closed.

In double busbar stations where provision for on-load changeover of busbars is specified, the busbar isolating devices shall be so interlocked with the appropriate busbar coupling and sectioning equipment. In all other circumstances, the busbar isolating devices of equipment other than busbar sectioning and coupling equipment shall be so interlocked that their respective Circuit breakers can only be coupled to one set of busbars at a time. It shall not be possible to parallel sections of busbars except through the Circuit breakers of the busbar coupling and sectioning equipment.

For each primary circuit, an interlock bypass switch shall be provided, mounted on the local control cubicle, for use during commissioning of the Switchgear. The switch shall be key operated (common key for each circuit) spring return to normal and provided with sufficient direct drive contacts to enable operation' of the- circuit breaker, isolators and earth switches independent of the electrical interlocking circuitry. By-passing of interlocks shall only be possible in the local (Maintenance) position.

Interlocking philosophy shall be provided by the switchgear manufacturer and shall be submitted for Employer's Representative's approval.

Locking Facilities

Locks and locking facilities shall be provided on each item of substation equipment as detailed below and shall be additional to the mechanical interlocking devices specified in the above clause.

Where a mechanism is to be locked in a specific position, provision shall be made at that part of the mechanism where the operating power is applied and not to remote or ancillary linkages.

The following locking facilities shall be provided with common key operated locks.

- a.) Circuit breaker mechanisms in the open position and any associated manual operating device in the neutral position.
- b.) Isolating switches in both open and closed positions.
- c.) Operating cubicle access doors.

TESTS

Inspection and testing of GIS during manufacture (FAT) and after installation on site (SAT) shall be in accordance with the Specification and IEC Standards.

**SCHEDULE OF TECHNICAL REQUIREMENTS OF 230 kV and 110 kV
INDOOR TYPE GAS INSULATED SWITCHGEAR (GIS)**

SL. No.	Description	Unit	230 kV	110 kV
1. Site Condition				
Max. Altitude above sea level	m		not more than 150	not more than 150
Max. Ambient temperature outdoor °C			+45	+45
Min. Ambient temperature outdoor °C			+4	+4
Max. Ambient relative humidity %	%		100	100
Max. Seismic acceleration at floor level				
- horizontal	g		0.1	0.1
- vertical	g		0.1	0.1
2. Type Designation				
Enclosure				
- busbar			three phase	three phase
- bay			single phase	three phase
Enclosure Material			Al	Al
Standards			IEC	IEC
3. Electrical Data				
Rated Voltage	kV		245	145
Rated Frequency	Hz		50	50
Insulation Level				
- lightning impulse withstand	kV		1050	650
- 50 Hz withstand 1 minute	kV		460	275
Rated continuous current at 40°C				
Ambient temperature				
- main bus bar and bus coupler	A		3000	3000

SL. No.	Description	Unit	230 kV	110 kV
- transformer bay	A	1600	2000 (for Auto Tr.)	1250 (for 110kV Tr.)
- line bay	A	1600	1250	
Rated short time withstand				
- current	kA	50	40	
- duration	sec	3	3	
Rated peak withstand current	kA	125	100	

4. Secondary Circuit

Auxiliary voltage			
- for control and signal	V dc	110	110
- for remote control	V dc	110	110
- for heating	V ac	415/230	415/230
- tolerances	%	-15/+15	-15/+15

5. Circuit Breaker

Enclosure		single phase	three phase
Enclosure material		Al	Al
Rated short time breaking current	kA	50	40
Rated peak withstand current	kA	125	100
Percentage D.C component	%	40	40
First-pole-to-clear-factor		1.3	1.3
Rated breaking current			
- Cable charging	A	250	160
Switching overvoltage	p.u.	2.5	2.5
Operating mechanism		single/three phase	three phase
Operating mechanism (for closing/opening)		spring	spring

SL. No.	Description	Unit	230 kV	110 kV
	Number of making coil per Operating mechanism	pcs	1	1
	Number of tripping coil per Operating mechanism	pcs	2	2
	Rated motor voltage	V dc	110	110
	Rated operating sequence - t - t'		O-t-CO-t'-CO sec 0.3 min 3	O-t-CO-t'-CO 0.3 3

6. Disconnector & Earthing Switch

Enclosure mechanism (for closing/opening)		three/single phase manual & motorised	three phase Operating manual & motorised
Rated motor voltage	V dc	110	110

7. Surge Arrester

Rated voltage	kV	186	120
Nominal discharge current	kA	10	10
Discharge class	heavy duty class 3 heavy duty class 3		

8. CT ratio, class and output

(a) Line bay	A	*	*
(b) 230/110/33 kV	A	*	*
Transformer bay			
(c) 110/11/11 kV	A	*	*
Transformer bay			
(a) Bus coupler bay	A	*	*

*Note : * Contractor to design and submit to Employer's Representative for approval.*

9. VT ratio, class and output

Ratio	kV	230/ $\sqrt{3}$ /0.11/ $\sqrt{3}$ /0.11/ $\sqrt{3}$	110/ $\sqrt{3}$ /0.11/ $\sqrt{3}$ /0.11/ $\sqrt{3}$
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Total burden	VA	15(measuring)	15(measuring)
Accuracy class		30(Protection) 3P & 0.2	30(Protection) 3P & 0.2

Degree of Protection**for indoor GIS****IP54****for outdoor GIS****IP55W****TYPE TEST REQUIREMENT:**

Type test certificates of Gas Insulated Switchgear (GIS) shall be issued by a *Short-Circuit Testing Liaison* Member testing organisation / laboratory in the manner as mentioned in the STL Guides.

(i) GIS Switchgear

- (a) One Complete Switchgear (for 110 kV and 230 kV GIS)

Sl. No.	IEC 62271-203 Clause	Test Name
i.	6.2	Dielectric tests: - Lightning impulse voltage tests - Power-frequency voltage tests
ii.	6.4	Measurement of the resistance of circuits
iii.	6.5	Temperature-rise tests
iv.	6.6	Short-time and peak withstand current tests
v.	6.104	Pressure test on partitions
vi.	6.105	Test under conditions of arcing due to an internal fault
vii.	6.106	Insulator tests

(b) Circuit Breaker

Sl. No.	IEC 62271-100 Clause	Test Name
i.	6.2	Dielectric tests: - Lightning impulse voltage tests - Power-frequency voltage tests
ii.	6.4	Measurement of the resistance of circuits
iii.	6.5	Temperature-rise tests
iv.	6.6	Short-time and peak withstand current tests
v.	6.101	Mechanical and environmental tests

Sl. No.	IEC 62271- 100 Clause	Test Name
vi.	6.103	Test circuits for short circuit making and breaking tests
vii	6.108	Single-phase and double-earth fault tests
viii.	6.109	Short-line fault tests
ix.	6.110	Out-of-phase making and breaking tests

(c) Disconnector & Earthing Switch

Sl. No.	IEC 62271- 102 Clause	Test Name
i.	6.2	Dielectric tests: - Lightning impulse voltage tests - Power-frequency voltage tests
ii.	6.4	Measurement of the resistance of circuits
iii.	6.5	Temperature-rise tests
iv.	6.6	Short-time and peak withstand current tests
v.	6.101	Tests to prove the short-circuit making performance of earthing switches
vi.	6.102	Operating and mechanical endurance tests
vii.	6.106	Bus-transfer current switching tests
viii.	6.107	Induced current switching tests

(d) Current Transformer

- (ii) Short-time current tests
- (iii) Temperature-rise test
- (iv) Impulse tests on primary winding

(e) Voltage Transformer

- (i) Temperature-rise test
- (ii) Lightning Impulse test

(f) Gas leakage rate (Per year)

8.6.2 POWER TRANSFORMERS

The transformers shall be oil immersed and suitable for outdoor installation and shall comply with IEC 60076, Parts 1 to 8 & 10 inclusive.

Electrical clearances shall not be less than as stated in the Project Requirements in Volume 1, whichever is the greater.

Cooling

The types of cooling shall be as stated in the electrical requirements and the letters relating to the method of cooling used in this Specification and Schedules shall be in accordance with IEC 60076.

Where a combination of three / two methods of cooling is applied to one transformer, as for ONAN/ONAF units for 230/110/33kV transformer and ONAN/ONAF units for 110/11/11 kV transformer, the transformer shall be capable of operating under the ONAN condition as stated in the Schedule of Requirements, after which the cooling equipment is to come into operation and the Transformer will operate as an ONAF unit.

Failure of one fan shall not reduce the continuous maximum rating of the transformer.

Parallel Operation

Transformers supplied against each item shall be designed to operate satisfactory, one with the other, when operating on the same tap position.

Handling on Site

For installation purposes and to permit the moving of transformer, the transformers are to be equipped with castors (rail wheels). A permanent rail transfer track system shall be provided, integrated with the transformer foundations. The castors should be able to swivel in both the longitudinal and transverse directions.

A system of wedges shall be included to stop any unwanted movement of the transformer during its operating life. The distance between rails must be compatible with the transformer dimensions and also the rail gauge prevailing at existing substation sites.

Continuous Maximum Rating

Transformers shall have the rating stated in the Schedule of Requirements and shall comply with the requirements as regards temperature rise and overloads on all tapings, irrespective of the direction of power flow and with the voltage of the lower voltage winding at the normal voltage stated in the Schedule of Requirements. To allow for high atmospheric temperatures, the allowable temperature rises shall be reduced in accordance with IEC 60076-2.

The overload capability shall be in accordance with IEC 60076-7.

Electrical Connections

Transformer windings shall be connected in accordance with the Vector group symbol specified in the Schedule of Requirements and as per IEC 60076. The neutral point of star connected winding shall be brought out for grounding.

All electrical connections within windings shall be brazed but, subject to approval, mechanically crimped joints may be used for round stranded conductors on tapping, bushing or earthing connections and on bundle conductors where design has been proved by type test and application is subject to rigorous quality control.

Ability to Withstand Short Circuit

All transformers shall be capable of withstanding, on any tappings and without damage, the thermal and dynamic effects of external short circuits under the conditions stated in IEC 60076 Part 5. For this purpose, the design short circuit level for each system voltage is stated in the Schedule of Requirements.

Calculations and Tests

Evidence shall be submitted with the Bid as to the extent to which the manufacturer has proved, or is able to prove, either by calculation or test, the ability of the specified Transformers to withstand short circuit.

The Bidder shall provide with his Bid a brief description of those transformers, or parts thereof, which have been subjected to short circuit test or for which short circuit calculations are available. It is preferred that this information relates to designs comparable with the transformers tendered but, in the event, this is not so, the Employer's Representative reserves the right to require calculations to prove that the design of transformers tendered will satisfactorily comply with this Clause.

Losses and Evaluation of Losses

Guaranteed values for component losses of the total loss which shall be as low as is consistent with transport restrictions, reliability and economic use of materials, shall be as stated in the Schedule of Particulars and Guarantees.

Bids will be assessed on the basis of the least 'Present Worth' of capital cost plus guaranteed losses, being the sum of the installed Bid Price of the transformers plus a sum which shall be:-

For each unit of the three-phase 230/110/33kV, 150 MVA (ONAN/ONAF) power transformer,
Evaluated price of transformer loss = N.a + L.b + M.c

Where N = No load loss (core-loss) at rated voltage in kW

- L = Load loss (copper-loss) at 75 deg. C, 50 Hz maximum continuous rating in kW
- M = Total load of transformer cooling fans at transformer maximum continuous rating in kW (when all the cooling fans are in operation)
- a = Cost/kW of no load loss (core-loss) valued at USD
- b = Cost/kW of load loss (copper-loss) valued at USD
- c = Cost/kW of auxiliary power valued at USD

For each unit of the three-phase 110/11/11 kV, 50 MVA (ONAN/ONAF) power transformer,

Evaluated price of transformer loss = N.a + L.b + M.c

- Where N = No load loss (core-loss) at rated voltage in kW
- L = Load loss (copper-loss) at 75°C, 50 Hz maximum continuous rating in kW
- M = Total load of transformer cooling fans at transformer maximum continuous rating in kW (when all the cooling fans are in operation)
- a = Cost/kW of no load loss (core-loss) valued at USD
- b = Cost/kW of load loss (copper-loss) valued at USD
- c = Cost/kW of auxiliary power valued at USD

The acceptance of transformers yielding component losses higher than the guaranteed values shall be governed by either of the following:-

Component losses in excess of guaranteed values but within the tolerance permitted under IEC

60076 Part 1.

Transformers shall be acceptable subject to full compliance with all technical particulars, including temperature rises at CMR and subject to the Bidder accepting deduction from the Contract Price of charges for each kW or part thereof of component losses in excess of the guaranteed values, at the above evaluation rates.

Component losses in excess of guaranteed values and exceeding the tolerance permitted under IEC 60076 Part 1.

The acceptance of transformers shall be entirely at the discretion of the Employer and subject to the Bidder accepting the deduction from the Contract Price of charges for each kW or part thereof of component losses in excess of the guaranteed values, at the above loss evaluation rates.

In the event of transformers yielding component and total losses which are either equal to or below the guaranteed values, the Bidder will not be entitled to any premium in respect of reduction in losses below the guaranteed values.

Impedance

The value of impedance measured on various tapping's shall be as stated in the Schedule and minimum and maximum values where stated in the Schedule of Requirements shall be guaranteed by the Contractor.

Noise

The transformer noise levels shall be measured as a type test and in accordance with IEC 60076-10. The acceptance level of the transformers shall be as stated in the Schedule of Requirements.

Harmonic Suppression

Transformers shall be designed with particular attention to the suppression of harmonic voltages, especially the third, fifth and seventh harmonics, and to minimize the detrimental effects resulting there from.

MAGNETIC CIRCUIT AND WINDINGS

Magnetic Circuit

The core winding structure and major insulation shall be such as to permit an unobstructed flow of cooling oil over the core and through the core cooling ducts to ensure efficient cooling of the core and where required of flux shunts and tie rods/bars.

The magnetic circuit shall be insulated from core bolts and supporting framework and be capable of withstanding a test voltage to core bolts and to the frame of 2.5 kV r.m.s for one minute. Two separate insulated removable bolted earthing links shall be provided for earthing of the core and

of the core-supporting framework to the exterior of the tank. These links shall be located in a covered box at the top of the transformer and arranged so they are accessible for testing purpose without opening up the transformer. Alternatively, connection to both the core and the frame may be made via two externally bolted links within an access box fitted with an oil tight cover near the base of the tank.

The core shall be earthed via copper straps inserted in each group of core packets separated by oil ducts or other insulating materials: and at a minimum of four (4) points distributed evenly across the width of the core.

Flux Density

Cores shall be constructed from cold rolled grain oriented steel sheets. Design shall be such that there will be no adverse effects due to core or stray flux heating with the quality of steel employed, and that when operating under the most onerous conditions envisaged in IEC 60076 and IEC 60354, flux density in any part of the magnetic circuit does not exceed 1.9 Tesla.

Windings

Construction of Windings

Transformer star connected windings shall have graded insulation as defined in IEC 60076. For 33 kV and below they shall have uniform insulation as defined in IEC 60076. All neutral points shall be insulated to withstand the applied test voltage specified in the Schedule of Requirements.

The windings shall be located in a manner which will ensure that they remain electromagnetically balanced and that their magnetic centers remain coincident under all conditions of operation.

The windings shall also be thoroughly dried and shrunk by the application of axial pressure for such length of time as will ensure that further shrinkage will not occur in service.

The windings and leads of all transformers shall be braced to withstand the shocks which may occur through rough handling and vibration during transport, switching and other transient service conditions including external short circuit.

If the winding is built up of sections or of disc coils separated by spacers, the clamping arrangements shall ensure that equal pressures are applied to all columns of spacers.

Tertiary Windings

The tertiary winding of 230/110/33kV power transformer shall be adequately rated for the specified load and its average and hot spot winding gradients at the specified load shall not exceed the specified temperature rise for winding average and winding hot spot when added to the mean oil and top oil temperature rises measured during the temperature rise test on the HV and LV temperature rise tests.

The tertiary winding shall further have adequately conductor cross sectional area and mechanical strength to withstand a through fault on the tertiary terminals and the fault current present in that winding during line to ground fault on the HV and LV phase terminals and without exceeding the maximum permitted current density and temperature rise limits calculated in accordance with IEC 60076-5 Clause 4.1.4.

Internal Earthing

All metal parts of the transformer, with the exception of the individual core laminations, core bolts and associated individual clamping plates, shall be maintained at some fixed potential.

Earthing of Core Clamping Structure

The top main core clamping structure shall be connected to the tank body by a copper strap. The bottom main core clamping structure shall be earthed by one or more of the following methods:

- 1.) by connection through vertical tie rods to the top structure;
- 2.) by direct metal-to-metal contact with the tank base maintained by the weight of the core and windings;
- 3.) by connection to the top structure on the same side of the core as the main earth connection to the tank.

Earthing of Magnetic Circuits

The magnetic circuit shall be earthed to the clamping structure at one point only through a removable link placed in an accessible position just beneath an inspection opening in the tank cover and which, by disconnection, will enable the insulation between the core and clamping plates, etc., to be tested at voltages up to 2.5 kV. The link shall have no detachable components and the connection to the link shall be on the same side of the core as the main earth connection. These requirements are compulsory.

All insulating barriers within magnetic circuits shall be bridged by means of Aluminium or tinned copper strips, so inserted as to maintain electrical continuity.

Earthing of Coil Clamping Rings

Where coil clamping rings are of metal at earth potential, each ring shall be connected to the adjacent core clamping structure on the same side of the Transformer as the main earth connection.

Size of Earthing Connections

Main earthing connections shall have a cross-sectional area of not less than 80 sq.mm but connections inserted between laminations may have cross-sectional areas reduced to 20 mm² when in close thermal contact with the core.

TANKS AND ANCILLARY EQUIPMENT

Transformer Tanks

Each transformer shall be enclosed in a suitably stiffened welded steel tank such that the transformer can be lifted and transported without permanent deformation or oil leakage. The construction shall employ weldable structural steel of an approved grade to BS EN 10029. The final coat colour of transformers shall be to Munsell 5Y-7/1. The On-load tap changer tank shall be separated from the main tank of the transformer.

Lifting lugs shall be provided, suitable for the weight of the transformer, including core and windings, fittings, and with the tank filled with oil. Each tank shall be provided with at least four jacking lugs, and where required, with lugs suitably positioned for transport on a beam transporter. Haulage lugs should also be provided to enable a cable to be used safely for haulage in any direction.

The transformer tank shall be capable of withstanding a full vacuum when empty of oil, without any significant permanent deformation or damage.

All joints, other than those which may have to be broken, shall be welded.

The tank and cover shall be designed in such a manner as to leave no external pockets in which water can lodge no internal pockets in which oil can remain when draining the tank or in which air can be trapped when filling the tank, and to provide easy access to all external surfaces for painting.

Where cooling tubes are used, each tube shall be of heavy gauge steel welded into the tank sides, top and bottom.

Each tank cover shall be of adequate strength, must not distort when lifted and shall be provided with suitable flanges having sufficient and properly spaced bolts. Inspection openings shall be provided to give access to the internal connections of bushings, winding connections and earthing links. Each opening shall be correctly located and must be of ample size for the purpose for which it is intended. All inspection covers shall be provided with lifting handles.

Pockets shall be provided for a stem type thermometer and for the bulbs of temperature indicators where specified. These pockets shall be located in the position of maximum oil temperature and it must be possible to remove any bulb without lowering the oil level in the tank. Captive screwed caps shall be provided to prevent the ingress of water to the thermometer pockets when they are not in use.

A ladder shall be provided on one side of the tank as a means for inspection and access to the top of the transformer. The lower section of the ladder shall be equipped with a barrier complete with provision for locking with a padlock.

Conservator Tanks, Breathers and Air Dryers

Each transformer shall be provided with an overhead conservator tank formed of substantial steel plates and arranged above the highest point of the oil circulating system. Connections into the main tank shall be at the highest point to prevent the trapping of air or gas under the main tank cover.

The capacity of conservator tank shall be adequate for the expansion and contraction of oil in the whole system under the specified operating conditions. Conservator tanks shall also be provided with a cleaning door, filling cap, drain valve with captive cap and an oil level indicator with minimum and maximum levels indicated. The normal level at an oil temperature of 25 deg. C shall be indicated and the minimum and maximum levels shall also be correlated with oil temperature markings. The temperature markings shall preferably be integral with the level indicating device.

The pipe-work between the conservator and the transformer tank shall comply with the requirements of this specification and a valve shall be provided at the conservator to cut off the oil supply to the tank.

The conservator shall be fitted with an air cell which shall be connected to a silica gel breather of a type which permits the silica gel content to be removed for drying. Due to the climatic conditions at site, this breather shall be larger than would be fitted for use in a temperate climate. All breathers shall be mounted at a height of approximately 1400 mm above ground level.

A completely separate conservator shall be provided for the OLTC. This conservator shall be fitted with: an oil level gauge, a desiccant breather, isolating valves shall be provided for connection from OLTC conservator connection pipe to OLTC and to connection breather, an oil sump drain valve for sump, a filling cap and a removable end plate for inspection and repainting.

Valves

Each transformer shall be fitted with the following valves as a minimum requirement:

Main Tank

- A.) One 50mm bore filter valve located near to the top of the tank.
- B.) One 50 mm bore filter valve located near to the bottom of the tank and diagonally opposite to the filter valve required against (A). Where design permits, this valve may be combined with item (C).
- C.) One 50mm drain valve with such arrangements as may be necessary inside the tank to ensure that the tank can be completely drained of oil as far as practicable. This valve shall also be provided with an approved oil sampling device.
- D.) One valve between the main tank and gas actuated relay, complete with bypass facility to facilitate removal of relay and maintain oil flow.

Conservator

A.) One valve between the conservator and gas actuated relay for the main tank and, where appropriate, for the tap change diverter switch tank complete with bypass pipe-work for Buchholz relay to facilitate maintenance of the relay.

B.) One drain valve for oil conservator tank so arranged that the tank can be completely drained of all oil.

Tap Changer

A.) 50mm filter and 50mm drain valve where selector switches are contained in a separate tank.

Diverter Switch Tank

A.) One drain valve to be fitted to each tank.

Radiators and Cooler Banks

A.) Valves at each point of connection to the tank

B.) The two valves arrangement across the gas actuated relay are to be connected with an oil pipe-work bypass facility to facilitate removal of the relay, due to failure etc., and still maintain the oil flow system between the conservator and main tank.

Blank flanges, plates or captive screw caps shall be fitted to all valves and pipe ends not normally connected in service.

The omission of any, or the provision of alternative arrangements to the above requirements, will not be accepted unless approved in writing by the Employer before manufacture.

Joints and Gaskets

All joint faces shall be arranged to prevent the ingress of water or leakage of oil with a minimum of gasket surface exposed to the action of oil or air.

Oil resisting synthetic rubber gaskets are not permissible except where the synthetic rubber is used as a bonding medium for cork, or similar material, or where metal inserts are provided to limit compression.

Gaskets shall be as thin as possible consistent with the provision of a good seal and full details of all gasket sealing arrangements shall be shown on the Plant drawings.

Pressure Relief Device

An approved pressure relief device of sufficient size for the rapid release of over pressure that may be generated in the tank, and designed to operate at a static pressure lower than the hydraulic test pressure, shall be provided. It shall be of the spring operated valve type and shall be provided

with one set of normally open signaling contacts which will be used for trip alarm purposes.

The relief device is to be mounted on the tank cover and is to be provided with a skirt to project at least 25mm into the tank to prevent gas accumulation. Discharge of oil shall be directed away from the transformer top cover and clear of any operating position.

Earthing Terminals

Two substantial steel flag type terminals having two 14mm diameter holes on 55mm centers shall be located one on either side and near to the bottom of the transformer to facilitate connection to the local earthing system.

Rating, Diagram and Valve Plates

The following plates, or an approved combined plate, shall be fixed to each transformer tank at an average height of 1500mm above the ground level:

- 1.) A rating plate bearing the data specified in IEC 76 Part 1. This plate shall also include the short-circuit current rating and time-factor for each winding.
- 2.) A diagram plate showing in an approved manner the internal connections and the voltage vector relationship of the several windings, in accordance with IEC 76 Part 1 with the transformer voltage ratio for each tap and, in addition, a plan view of the transformer giving the correct physical relationship of the terminals.
- 3.) A plate showing the location and function of all valves and air release cocks or plugs. This plate shall also if necessary warn operators to refer to the Maintenance Instructions before applying vacuum.

Plates are to be of stainless steel or other approved material capable of withstanding the rigours of continuous outdoor service at site.

Nuts & Bolts of Transformer Tanks

All nuts & bolts of transformer shall be stainless steel.

COOLING PLANT

Radiators and coolers shall be hot-dip galvanized, designed so that all painted surfaces can be thoroughly cleaned and easily painted in situ with brush or spray gun. The design shall also avoid pockets in which water can collect and shall be capable of withstanding the pressure tests specified in for the transformer main tank.

The clearance between any oil or other pipe-work and live parts shall be not less than the minimum clearances stated in the Schedule of Requirements.

Radiators Connected Directly to Tank

Where built-on radiators are used, each radiator shall be connected to the main tank through flanged valves. Plugs shall be fitted at the top of each radiator for air release and at the bottom for draining.

A valve shall be provided on the tank at each point of connection to the tank.

Cooler Banks

Each cooler bank shall be provided with:

- A. A valve at each point of connection to the tank.
 - B. A valve at each point of connection of radiators.
 - C. Loose blanking plates for blanking off the main oil connections.
 - D. A 50mm filter valve at the top of each cooler bank.
- E. A 50mm drain valve at the lowest point of each interconnecting oil pipe.
- F. A thermometer pocket, fitted with captive screw cap, in the inlet and in the outlet oil pipes.
- G. Air release and drain plugs on each radiator.

The omission of any or the provision of alternative, arrangements to the above requirements will not be accepted unless approved in writing by the Employer's Representative before manufacture.

Forced Cooling

The type of forced cooling shall be as stated in the Schedule of Requirements.

Forced cooling equipment for transformers of similar rating and design shall be completely interchangeable, one with the other, without modification on Site.

Oil Pipes and Flanges

All oil piping necessary for the connecting of each transformer to its conservator, cooler banks etc. shall be supplied and erected under this Contract.

The oil piping shall be of approved material with machined flanged joints. Copper pipe-work is to comply with BS 61.

Dimensions of steel pipes shall be in accordance with BS 3600 and the drilling of all pipe flanges shall comply with BS 4504.

An approved expansion piece shall be provided in each oil pipe connection between the transformer and each oil cooler bank.

All necessary pipe supports, foundation bolts and other attachments are to be provided.

It shall be possible to drain any section of pipe-work independently of the rest and drain valves or plugs shall be provided as necessary to meet this requirement.

Air Blowers

Air blowers for forced air cooling shall be of approved make and design and be suitable for continuous operation out-of-doors. They shall also be capable of withstanding the stresses imposed when brought up to speed by the direct application of full line voltage to the motor.

To reduce noise to the practical minimum, motors shall be mounted independently from the coolers or, alternatively, an approved form of anti-vibration mounting shall be provided.

It shall be possible to remove the blower, complete with motor, without disturbing or dismantling the cooler structure framework.

Blades shall be of material subject to approval.

Blower casings shall be made of galvanized steel of thickness not less than 2.6mm (14 S.W.G.) and shall be suitably stiffened by angles or tees.

Galvanized wire guards with mesh not exceeding 12.5mm shall be provided to prevent accidental contact with the blades. Guards shall also be provided over all moving parts. Guards shall be designed such that blades and other moving parts can not be touched by test fingers to IEC 60529.

Cooler Control

Where forced cooling using multiple small single-phase motors is employed, the motors in each cooling bank shall be grouped so as to form a balanced three-phase load.

Each motor or group of motors shall be provided with a three-pole electrically operated contactor and with control gear of approved design for starting and stopping manually.

Where forced cooling is used on transformers, provision shall be included under this Contract for automatic starting and stopping from contacts on the winding temperature indicating devices as specified. The control equipment shall be provided with a short time delay device to prevent the starting of more than one motor, or group of motors in the case of multiple cooling, at a time.

Where motors are operated in groups, the group protection shall be arranged so that it will operate satisfactorily in the event of a fault occurring in a single motor.

The control arrangements are to be designed to prevent the starting of motors totaling more than 15kW simultaneously, either manually or automatically. Phase failure relays are to be provided in the main cooler supply circuit.

All contacts and other parts which may require periodic renewal, adjustment or inspection shall

be readily accessible.

All wiring for the control gear accommodated in the marshalling kiosk, together with all necessary cable boxes and terminations and all wiring between the marshalling kiosk and the motors, shall be included in the Contract.

An alarm of indicating “Transformer Cooling Fault” is to be provided and initiated in the event of any ventilation/cooling motor trip, or failure of either main or control supplies.

VOLTAGE CONTROL

Transformers shall be provided with tap changers for varying the effective transformation ratio. Control schemes of on load tap change shall utilize 110V ac centre tap earthed voltage derived from the 415V, 3 phase, 4 wire system. Phase failure relays shall be provided to ensure a secure supply.

Number and range of taps shall be as called for in the Schedule A of Requirements.

All terminals shall be clearly and permanently marked with numbers corresponding to the cables connected thereto.

Tap positions shall be numbered consecutively, ranging from one upwards. The tap positions shall be numbered so that by raising the tap position the LV voltage is increased.

On-Load Tap Changers

On-load tap changers shall be MR Germany, ABB Sweden, or equivalent make and shall comply with IEC 60214 and shall be suitable for power flow in both directions. Only designs which have been type tested in accordance with these standards will be accepted.

Current making and breaking switches associated with the tap selectors or otherwise where combined with tap selectors shall be contained in a tank in which the head of oil is maintained by means completely independent of that on the transformer itself. Details of maintaining oil separation, oil levels, detection of oil surges and provision of alarm or trip contacts will be dependent on the design of tap-changer and be to the approval of the Employer's Representative.

Mechanisms

The tap change mechanism shall be designed such that when a tap change has been initiated, it will be completed independently of the operation of the control relays and switches. If a failure of the auxiliary supply during tap change or any other contingency would result in that movement not being completed an approved means shall be provided to safeguard the transformer and its auxiliary equipment.

Limit switches shall be provided to prevent over-running of the tap changing mechanism. These shall be directly connected in the operating motor circuit. In addition, mechanical stops shall be fitted to prevent over-running of the mechanism under any conditions. For on-load tap change

equipment these stops shall withstand the full torque of the driving mechanism without damage to the tap change equipment.

Thermal devices or other approved means shall be provided to protect the motor and control circuit.

A permanently legible lubrication chart shall be provided and fitted inside the tap change mechanism chamber.

Local and Remote Control

Equipment for local, manual and electrical operation shall be provided in a cubicle. A thermostat controlled anti-condensation heater is to be provided in the cubicle. Electrical remote control equipment shall also be supplied.

The following operating conditions are to apply to the on-load tap changer controls:

- 1.) It must not be possible to operate the electric drive when the manual operating gear is in use.
- 2.) It must not be possible for two electric control points to be in operation at the same time.
- 3.) Operation from the local or remote control switch shall cause one tap movement only, unless the control switch is returned to the off position between successive operations.
- 4.) It must not be possible for any transformer operating in parallel with one or more transformers in a group to be out of step with the other transformers in the group. Any deviation in the position of tap changers has to stop further function of the AVR. (Out of step protection)

All electrical control switches and local manual operating gear shall be clearly labeled in an approved manner to indicate the direction of tap changing, i.e. raise and lower tap number.

Emergency stop push-button at local and remote control positions.

Indications

Apparatus of an approved type shall be provided on each transformer:

To give indication mechanically at the transformer and electrically at the remote control point of the number of the tapping in use.

To give electrical indication, separate from that specified above, of tap position at the remote supervisory point.

To give indication at the remote control point and at the supervisory control point that a tap change is in progress; this indication to continue until the tap change is completed.

To give indication at the remote control point and at the supervisory control point when the transformers operating in parallel are operating out of step.

To indicate at the tap change mechanism the number of operations completed by the equipment.

Automatic Voltage Control

Automatic Control shall be suitable for control of transformers in parallel.

In addition to the methods of control the following methods shall also be provided.

1.) Automatic Independent - It shall be possible to select automatic independent control for each transformer irrespective of the method of control selected for any other of the associated transformers.

2.) Automatic parallel - It shall be possible to select any transformer for master or follower control.

3.) It must not be possible to operate any tap changer by supervisory, remote or local electrical hand control while the equipment is switched for automatic operation.

Voltage Regulating Relays

Automatic voltage control shall be initiated by a voltage regulating relay of an approved type and suitable for flush mounting. The relay shall operate from the nominal reference voltage stated in the Schedule of Requirements derived from a circuit mounted LV voltage transformer having Class 1.0 or 0.5 accuracy to IEC 60186 and the relay voltage reference balance point shall be adjustable.

The relay bandwidth shall preferably be adjustable to any value between 1.5 times and 2.5 times the transformer tap step percentage, the nominal setting being twice the transformer tap step percentage.

The relay shall be insensitive to frequency variation between the limits of 47Hz and 51Hz. The relay shall be complete with a time delay element adjustable between 10 and 120 seconds. The relay shall also incorporate an under voltage blocking facility which renders the control inoperative if the reference voltage falls below 80 percent of the nominal value with automatic restoration of control when the reference voltage rises to 85 percent of nominal value.

On each transformer the voltage transformer supply to the voltage regulating relay shall be monitored for partial or complete failure. The specified indicating lamp and alarm will be inoperative when the circuit- breaker controlling the lower voltage side of the transformer is open and also that when the tap changer is on control other than automatic control.

Parallel operation and Master/follower facilities shall have to be provided in the AVR relay. The AVR relay shall be fully integrated into the substation automation system and all AVR related operations shall be securely performed from the Substation Automation System. The Substation Automation supplier shall be responsible for integrating the AVR relay.

Remote Control Panels

The remote control panels specified in the Schedule of Requirements shall be floor mounted sheet steel cubicles of approved type, layout and colour to Munsell 5Y-7/1 and shall be provided for each transformer. Each shall form a complete enclosure with lockable rear doors and shall be fitted with interior lamp, door switch, heaters, cable gland plates for bottom entry of cables and all other equipment to provide the features specified, the standard requirements (which may be varied to suit manufacturer's design) being as follows:

Instruments:

Voltmeter (voltage at the low voltage terminals of the transformer).

Tap position indicator with integral or separate scale to indicate the no-load LV voltage in kV appropriate to each winding tap.

Relays:

Automatic voltage control.

Controls:

Automatic/Non-automatic voltage control selector switch, Remote/Supervisory tap change control selector switch, Pistol grip selector switch with centre zero, Independent/Master/Follower selector switch, AVR voltage reference adjuster.

Indications and Alarms:

Tap change in progress - white lamp

Tap change out of step - amber lamp

Tap change incomplete - amber

Tap change control on "local"

Tap change control on auto/manual

Group 1 Air forced cooling equipment running - white

Group 1 Air forced cooling overcurrent alarm - amber

Group 2 Air forced cooling equipment running - white

Group 2 Air forced cooling overcurrent alarm - amber

Forced cooling failure-amber lamp

VT Fail alarm - amber

Supply voltage to OLTC failure - amber lamp

Remote control schemes shall be entirely suitable for operation with the distance between the transformer and remote control panels.

Off-Load Tap Changers

The off-circuit tapping's for Auxiliary transformer shall be provided on the higher voltage windings for variation of no-load primary voltage as specified in the Schedule of Requirements.

Off-load tap-changing shall be carried out by means of an external hand-operated tapping switch mounted on the side of the tank. All phases of the tapping switch must be operated by one hand wheel.

The tapping switch shall have a spring-loaded captive bolt or other approved means on the moving part which positively locates the switch correctly at each tapping position. This bolt must be lockable at each tapping position and shall be provided with a suitable padlock and keys. Moving the switch from one tapping position to another shall require that the bolt be withdrawn by hand from its locating socket on the transformer tank against the spring pressure.

Tap-position numbers corresponding to the tapping switch bolt-locating sockets shall be cast or engraved in a metal indication plate fixed to the tank and a keyed metal pointer on the tapping switch operating handle shall show clearly at which tapping number the transformer is operating.

All tap-position indicators shall be marked with one integer for each tap position, beginning at number 1. Adjacent taps shall be numbered consecutively in such a manner that when moving a tap to a new tapping position which has a higher number, the no-load output voltage of the untapped winding increases.

SUPERVISORY CONTROL

Requirements

Transformer tap change control will be effected from the substation control room with facilities for remote control from the National Load Dispatch Centre. All necessary connections, indications, auxiliary switches, relays and changeover switches to meet supervisory control requirements shall be provided and connected under this Contract to terminal blocks in the remote control panels. The supply and installation of the multicore control cables between the remote control panels and the Plant/Telecontrol Interface Cubicle shall be provided under the Contract.

The following supervisory facilities are required:

Controls:

Supervisory selection of auto/non auto voltage control.

Tap change raise/lower by direct operation of tap changer.

Tap change blocking on/off.

Remote/Supervisory selection "Override".

Parallel/Independent control.

Indications and Alarms:

Tap position indication

Tap change out of step alarm

Buchholz and winding temperature non-trip alarm

Tap change control on Local/Supervisory

Parallel/Independent, master/follower

Tap change blocking on/off

Tap change control on Automatic/Manual

All contacts for supervisory alarms and indications shall be potential free.

HV & LV TERMINALS AND CONNECTIONS

Primary and Secondary Terminals

Auto Power Transformers are to be provided with Cable Termination Modules (instead of porcelain insulators) which act as a link between the Power Transformer and the High voltage cables complying with IEC 62271-209. The cable termination module shall have the inspection hole with connecting flange for the high voltage cable testing set. During high voltage cable testing, the primary conductor between the cable sealing end and the switchgear can be removed.

Neutral for the power transformer shall be terminated to the Earth thru the porcelain bushing.

Tertiary and Neutral Terminations

Terminations of delta connected tertiary windings and neutral ends of windings shall be as follows:

Delta Connected Tertiary Windings

Delta connected tertiary windings for local AC distribution shall be terminated with cable termination modules and will act as a link between the Power Transformer and the High Voltage cables complying with IEC 62271-209.

Where current transformers are specified in the Schedule of Requirements or on the Drawings, these shall be included in this Contract.

Neutral Ends of Windings

Neutral ends of the three phase windings shall be connected at a point accessible from a hand hole at the transformer tank top cover. Where current transformers are specified at the neutral ends before the neutral connection of the windings, to be used in conjunction with a protection, they shall be installed such that access is possible through the same hand hole and maintenance of these CT, if need be, can be carried out without lowering the transformer oil below the core and winding.

The star connection shall then be brought out via one outdoor bushing insulator capable of withstanding an AC power frequency test.

Mounting of Bushings

Transformer cable termination modules shall be mounted on the tank in a manner such that the external connections can be taken away clear of all obstacles. Neutral bushings shall be mounted in a position from which a connection can be taken to a neutral current transformer mounted on a bracket secured to the transformer tank.

The clearances from phase to earth must not be less than those stated in the Schedule A of Requirements.

A flexible pull-through lead suitably sweated to the end of the winding copper shall be provided for the bushings and is to be continuous to the connector which is housed in the helmet of the bushings.

When bushings with an under-oil end of a re-entrant type are used the associated flexible pull-through lead is to be fitted with a suitably designed gas bubble deflector.

The bushing flanges must not be of re-entrant shape which may trap air.

Clamps and fittings made of steel or malleable iron shall be galvanized and all bolt threads are to be greased before erection.

Bushing Current Transformer (BCT)

BCT particulars are stated in the Schedule A of Requirements.

AUXILIARY POWER AND CONTROL CABLES

Scope of Supply

This Contract includes the supply, installation and termination of the necessary auxiliary power and control cables within items of the substation supplied under the Contract.

The Contractor shall produce, during the currency of the Contract and in any case before shipment of the material commences, detailed cable core schedules for each transformer.

Auxiliary power and control cables shall have copper conductors, PVC insulated, armoured and PVC sheathed overall. The cable design shall generally be in accordance with BS 6346:1989.

All cables installed under the Contract shall utilize compression glands of type E1 to BS.6121 or otherwise designed to secure armour wires and bond them to earthed metal and to provide seals between sheath and gland and between inner sheath and threaded fixing component.

The Contractor shall supply and fit the compression gland and make off individual cores on to the terminal boards, including the supply and fitting of numbered markers on each core.

TEMPERATURE AND ALARM DEVICES

Temperature Indicating Devices and Alarms

The transformers shall be provided with approved devices of Kilhstrom or equivalent for indicating the top oil temperature and hottest spot winding temperatures. The devices shall have a dial type indicator and, in addition, a pointer to register the highest temperature reached. Each winding temperature device shall have three separate contacts fitted, one of which shall be used to control the cooling plant motors, one to give an alarm and one to trip the associated circuit-breakers.

To simulate indication of the hottest spot temperature of the winding the device shall comprise a current transformer associated with one phase only and a heating device designed to operate continuously at 130 percent of transformer CMR current and for 30 minutes at 150 percent of CMR current, associated with a sensing bulb installed in an oil tight pocket in the transformer top oil.

The winding temperature indicators (WTI) shall be housed in the marshalling cubicle. The tripping contacts of the winding temperature indicators shall be adjustable to close between 80 deg C and 150 deg C and to re-open when the temperature has fallen by not more than 10 deg C.

The alarm contacts and the contacts used to control the cooling plant motors on the above devices shall be adjustable to close between 50 deg C and 100 deg C and to re- open when the temperature has fallen by a desired amount between 10 deg C and 15 deg C.

All contacts shall be adjustable to a scale and must be accessible on removal of the relay cover. Alarm and trip circuit contacts shall be suitable for making or breaking 150 VA between the limits of 30 volts and 250 volts AC or DC and of making 500 VA between the limits of 110 and 250V DC. Cooler motor control contacts shall be suitable for operating the cooler contactors direct or, if necessary, through an interposing relay.

The temperature indicators in the marshalling kiosk shall be so designed that it is possible to move the pointers by hand for the purpose of checking the operation of the contacts and associated equipment.

The working parts of the instrument shall be made visible by the provision of cut- away dials

and glass-fronted covers and all setting and error adjustment devices shall be easily accessible.

Connections shall be brought from the device to terminal boards placed inside the marshalling cubicle.

Terminals, links and a 63mm moving iron ammeter shall be provided in the marshalling kiosk for each WTI for:

Checking the output of the current transformer.

1.) Testing the current transformer and thermal image characteristics.
2.) Disconnecting the bulb heaters from the current transformer secondary circuit

to enable the instrument to be used as an oil temperature indicator. Links shall be provided.

Gas and Oil-Actuated Relays

Each transformer shall be fitted with gas and oil-actuated relay equipment having alarm contacts which close on collection of gas or low oil level, and tripping contacts which close following oil surge conditions.

Each gas and oil-actuated relay shall be provided with a test cock to take a flexible pipe connection for checking the operation of the relay.

Each relay shall be fitted with a calibrated glass window for indication of gas volume.

To allow gas to be collected at ground level, a small bore pipe shall be connected to the gas release cock of the gas and oil-actuated relay and brought down to a point approximately 1400mm above ground level, where it shall be terminated by a cock which shall have provision for locking to prevent unauthorized operation.

The design of the relay mounting arrangements, the associated pipe-work and the cooling plant shall be such that maloperation of the relay will not take place under normal service conditions, including starting or stopping of oil circulating pumps, whether by manual or automatic control under all operating temperatures.

The pipe-work shall be so arranged that all gas arising from the transformer will pass into the gas and oil-actuated relay. The oil circuit through the relay must not form a delivery path in parallel with any circulating oil pipe, nor is it to be teed into or connected through the pressure relief vent. Sharp bends in the pipe-work shall be avoided.

For two conservators piped separately to the transformer, one Gas and Oil actuated relay shall be installed in the main tank and an Oil-flow relay shall be installed in the OLTC conservator.

SHIPMENT AND DRYING OUT

Shipment

Each transformer, when prepared for shipment, shall be fitted with a shock indicator or recorder which shall remain in situ until the transformer is delivered to site. In the event that the transformer is found to have been subjected to excessive shock in transit, such examination as is necessary shall be made in the presence of the Employer's Representative.

Where practicable, transformers shall be shipped with oil filling to cover core and windings but, when shipped under pressure of gas, shall be fitted for the duration of delivery to site and for such time thereafter as is necessary, with a gauge and gas cylinder adequate to maintain internal pressure above atmospheric.

Drying Out

All transformers shall be dried out by an approved method at the manufacturer's works and so arranged that they might be put into service without further drying out on Site.

Clear instructions shall be included in the Maintenance Instructions regarding any special precautionary measures (e.g. strutting of tap changer barriers or tank cover) which must be taken before the specified vacuum treatment can be carried out. Any special equipment necessary to enable the transformer to withstand the treatment shall be provided with each transformer.

TRANSFORMER OIL AND TREATMENT

Transformer Oil

The Contractor shall supply the first filling of all insulating oil required for the operation of the Plant and, after treatment, a test shall be made in the Employer's Representative's presence to prove that the breakdown voltage is at least 60kV at 2.5mm electrode gap. The transformer oil shall be new, inhibited, naphthenic based mineral oil, free from additives. It shall be acid-refined and pre-treated and shall have properties complying with IEC 60296-class II.

Oil Purifier Equipment

The oil purifier equipment is to be mounted on a steerable trailer equipped with pneumatic types, over-run and parking brakes and weatherproof canopy. The equipment shall be capable of purification of oil to IEC 60296 and IEC 60422, shall be of the replaceable paper filter type and shall have the following facilities:

- 1.) Oil treatment rate not less than 6000 litres per hour.
- 2.) Water extraction capability down to 5 ppm.
- 3.) Reduction of dissolved gas content to 1% by volume or less.
- 4.) Filtration level less than 1 micron.
- 5.) Oil transfer, vacuum pumps and heaters suitable for 415V, 3 phase 50Hz, 4 wire, supply.
- 6.) Vacuum capability approximately 1 Torr.

- 7.) Facility to apply vacuum to transformer tank during oil filling.
- 8.) Two 15m lengths of wire reinforced hose coloured differently for clean and dirty oil.
- 9.) Facility for "closed loop" operation.
- 10.) One 20m length of power supply cable with plug and socket at the filter end only.

Oil Storage

Contractor shall supply the first filling of transformer oil. It is envisaged that the oil will be supplied to site in 200kg drums and filtered by use of the plant described in the preceding paragraph into a storage tank prior to transfer again via filter plant into the transformer.

Storage tanks shall be painted internally and externally and shall be equipped with:

- 1.) 50mm top inlet and bottom outlets with blank flanges
- 2.) 50mm drain valve
- 3.) Oil level indicator
- 4.) Hand hole
- 5.) Silica gel breather
- 6.) Collapsible Oil Containers

This section covers the design, manufacture and supply of 9000 litre and 18000 litre capacity two collapsible oil container suitable for on-site storing, transferring and transporting transformer oil associated with the transformers being supplied under the Contract.

Each container shall be made up of one or several layers (and securely bonded together) of tough polymer and textile material which can be folded with ease for transportation purposes. The outer surface of the container shall be coated with a tough abrasion resistant compound and on the inner face with a polymer compatible with the transformer oil.

The containers shall be provided with the following fittings:

- 1.) Controllable inlet and outlet valves constructed from brass or Aluminium alloy and a gun metal outlet plug.
- 2.) Air vent plug(s) for air release during oil filling and located at the centre and top of each container.
- 3.) Two sets of special tools, gauges and spanners necessary to operate and maintain the valves, plugs etc.

The guarantee period is 36 months from the date certified in the Final Acceptance Certificate.

The following details are to be submitted with the proposal to supply the oil container.

- 1.) Descriptive literature and technical specification of the container design.
- 2.) Manufacturer's production capability and supply record for at least 5 years service experience.
- 3.) Test certification record.
- 4.) Type reference number, capacity, weight and dimensions (laid flat unfilled and maximum filled height).

SCHEDULE OF TECHNICAL REQUIREMENTS OF 230/110/33 kV POWER TRANSFORMER

Sl. No.	Description		
	RATING AND PERFORMANCE		
1	Maximum continuous rating (MCR)	MVA	150
2	Number of Phases		3
3	Number of windings		Auto plus stabilising
4	Normal ratio of transformation at no load and at principle tap - HV/LV/TV	kV	230/110/33
5.1	Corresponding highest system voltages	kV	245/145/36
5.2	Corresponding lowest system frequency	Hz	48

Sl. No.	Description		
6	Minimum withstand voltages: - Full wave impulse withstand of windings of line terminal bushings - Induced over voltage - Power frequency withstand of neutral	kVp kVp kV rms kV rms	By Manufacturer
7	Type of cooling		ONAN/ONAF
8	Minimum continuous rating	MVA	150
9	Rating of tertiary windings	KVA	315
10	Service conditions: - External cooling medium - Altitude not exceeding - Air temperature not exceeding Average air temperature in any one year not exceeding: - In any one day - Average in one year	- m <input type="checkbox"/> C <input type="checkbox"/> C <input type="checkbox"/> C	Air 150 45 35 25
11.1	Maximum temperature : - Top oil rise normal - Average ONAN winding rise - Average ONAF winding rise	<input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/>	50 55 55
11.2	Maximum hot spot temperature at maximum continuous rating at yearly average ambient temperature	<input type="checkbox"/>	98
11.3	Winding hot spot temperature on emergency overload not exceeding	<input type="checkbox"/>	140
12	Phase connections: - HV winding		Star Delta

Sl. No.	Description		
	- LV winding - TV winding		Delta
	- Vector group - HV/LV/TV		YNa0d1
13	Short circuit withstand fault level at terminals of: - 230 kV busbars - 110 kV busbars - 33 kV busbars	kA kA kA	50 40 31.5
14	Impedance voltage at 75°C and at normal tap and MCR between windings (% on HV Base): - HV & LV % on HV base	%	By Manufacturer
15	Delta connected tertiary winding - Nominal voltage - External load	kV kVA	33 315kVA
16.1	Total range of variation of on load transformation ratio (on HV side) as sl. no. 4: -Ratio - Size of steps	% %	±10 1.25
16.2	Type of control		On load local, remote and supervisory electrical and hand operation
17	Line drop compensation		Yes
18	Whether automatic control required and referenced voltage		Yes, 110V, 50Hz
19	Whether separate remote control panel required		Yes
20	DC supply: - Nominal	V	110

Sl. No.	Description		
	- Maximum float voltage	V	125
21	Whether provision for supervisory control required, including AVR setting		Yes
22	Whether marshalling kiosk required		Tank side Cubicle
23	Number of transformers for which automatic control is to be suitable		2 (and provision for future 3 rd)
24	<p>TERMINATIONS</p> <p>Bushing insulators or cable boxes on line and neutral terminals:</p> <ul style="list-style-type: none"> i) HV line ii) Neutral iii) LV line iv) Tertiary winding 		Cable Termination Modules
25	<p>BCT PARTICULARS</p> <ul style="list-style-type: none"> i) HV (230kV) Side: Core 1 Core 2 ii) LV (110 kV) Side: iii) Core 1, Core 2 & Core 3 iv) Tertiary Side : Core 1, Core 2 & Core 3 v) Neutral Bushing (core 1): 		<p>matched with WTI</p> <p>Ratio & burden matched with WTI and OLTC</p> <p>Ratio & burden matched with WTI</p>

Sl. No.	Description		
26	Pollution category of bushing insulators		25 mm/kV of system rated (highest) voltage
27	COOLING i) Number of cooler banks required per transformer		To suit transformer design 50
	ii) Rating of each cooler bank as percentage of total loss at CMR iii) Standby cooling requirement	%	One fan in each group
28	GENERAL		
29	Type of oil preservation system		Air Cell
	Maximum acceptable noise level		78 dBA

**SCHEDULE OF TECHNICAL
REQUIREMENTS OF 110/11/11 kV POWER
TRANSFORMER (50 MVA)**

RATING AND PERFORMANCE			
1	Maximum continuous rating (MCR)	MVA	50
2	Number of Phases		3
3	Number of windings		2
4	Normal ratio of transformation at no load and at principle tap - HV/LV/TV	kV	110/11/11
5.1	Corresponding highest system voltages	kV	145/36
5.2	Corresponding lowest system frequency	Hz	48
6	Minimum withstand voltages: - Full wave impulse withstand of windings of line terminal bushings - Induced over voltage - Power frequency withstand of neutral	kVp kVp kVrms kV rms	By Manufacturer
7	Type of cooling		ONAN/ONAF
8	Minimum continuous rating	MVA	50
9	Rating of tertiary windings	KVA	315
10	Service conditions: - External cooling medium - Altitude not exceeding - Air temperature not exceeding Average air temperature in any one year not exceeding: - In any one day - Average in one year	- m °C °C °C	Air 150 45 45 35
11.1	Maximum temperature :		

	RATING AND PERFORMANCE		
	<ul style="list-style-type: none"> - Top oil rise normal - Average ONAN winding rise - Average ONAF winding rise 	$^{\circ}\text{C}$ $^{\circ}\text{C}$ $^{\circ}\text{C}$	50 55 55
11.2	Maximum hot spot temperature at maximum continuous rating at yearly average ambient temperature	$^{\circ}\text{C}$	98
11.3	Winding hot spot temperature on emergency overload not exceeding	$^{\circ}\text{C}$	140
12	Phase connections:		
	<ul style="list-style-type: none"> - HV winding - LV winding - TV winding - Vector group - HV/LV/TV 		Star Delta Delta YNd5
13	Short circuit withstand fault level (one sec.) at terminals of: <ul style="list-style-type: none"> - 110 kV busbars 11 kV busbars		40 kA 50 kA
14	Impedance voltage at 75°C and MCR (50 MVA) between windings (% on HV Base) at Nominal tap at maximum tap at minimum tap		By Manufacturer
15	Not used		
16.1	Total range of variation of on load transformation ratio (on HV side) as sl. no. 4: <ul style="list-style-type: none"> - Ratio 		± 10

RATING AND PERFORMANCE			
	Size of steps		1.25
16.2	Type of control		On load local, remote and supervisory electrical and hand operation
17	Line drop compensation		Yes
18	Whether automatic control required and referenced voltage		Yes, 110V, 50Hz
19	Whether separate remote control panel required		Yes
20	DC supply: Nominal Maximum float voltage		110 125
21	Whether provision for supervisory control required, including AVR setting		Yes
22	Whether marshalling kiosk required		Tank side Cubicle
23	Number of transformers for which automatic control is to be suitable		4
24	TERMINATIONS Bushing insulators or cable boxes on line and neutral terminals: i) HV line ii) Neutral LV line		Cable Termination Modules

RATING AND PERFORMANCE			
25	BCT PARTICULARS i) HV (110kV) Side Core 1 Core 2		Ratio, burden and accuracy class shall be matched with WTI meter
	ii) LV (11 kV) Side Core 1 Core 2 Core 3		for WTI meter for Tap changer
	iii) Neutral Bushing (core 1 & 2):		
26	Pollution category of bushing insulators		25 mm/kV of system rated (highest) voltage
27	COOLING i) Number of cooler banks required per transformer ii) Rating of each cooler bank as percentage of total loss at CMR Standby cooling requirement	%	i)To suit transformer design ii)100% iii)One fan in each group
27	GENERAL Type of oil preservation system Maximum acceptable noise level		Air Cell 78 dBA

8.6.3 Earthing /Auxiliary Transformers

Earthing transformers shall comply with IEC 60076-6 and shall be of the oil immersed ONAN type suitable for outdoor installation. They are to have a main interconnected star winding brought out via oil/air terminal bushings, which will be directly connected to the lower voltage terminals of the associated system transformer.

The neutral point of the interconnected star winding shall be brought out of the tank through a bushing insulator. This point maybe isolated or connected to earth directly or through a

resistance in order to provide an earthing point for the neutral of the system.

The earthing transformers shall have a secondary winding to supply the substation auxiliary load. The voltage ratio shall be 33/0.415kV. The star-connected secondary windings shall be arranged to give a three-phase, four wire supply with the star point solidly earthed. The secondary winding shall have a continuous rating as stated in the Schedule of Requirements and shall conform to IEC 60076.

Electrical and Short Circuit Characteristics

Earthing transformers will normally have their neutral points connected to earth via a resistance which limits earth fault current to the full load current at the associated power transformer. However, provision is made for solidly earthing the neutral points and, under this condition, the earthing transformers shall be capable of withstanding, both thermally and mechanically without damage, for a period of 5 seconds the application of normal three phase line voltage to the

terminals of the interconnected star winding with one line terminal earthed. The current density of the winding under this condition shall not exceed 50A/mm².

In addition, the interconnected star winding of each earthing transformer, when at its maximum temperature due to continuous full load on the auxiliary winding, shall be designed to carry for 10 seconds without injurious heating an earth fault current in the neutral connection as specified. The current density under such conditions shall not exceed 23A/mm².

Tanks and Fittings

Earthing transformers shall be provided with the following fittings:

- 1.) Conservator vessel with removable end cover and prismatic oil gauge.
- 2.) Buchholz relay.
- 3.) One thermometer pocket with captive screw cap.
- 4.) Silica gel breather of the oil seal type.
- 5.) Pressure relief device.
- 6.) Filter valve and combined filter and drain valves.
- 7.) Oil sampling device.
- 8.) Rating plate.
- 9.) Tank earth terminals.
- 10.) Lifting lugs.

Secondary Windings

The three-phase, four-wire secondary windings shall be terminated at a three-pole MCCB unit with bolted neutral link and gland entry for a four-core solid dielectric cable. This shall be accommodated in a lockable, fully weatherproof compartment together with a neutral earthing link. The purpose of the neutral earthing link is to connect the 415V system neutral to earth. It shall be connected between the transformer winding end and a suitably located earthing terminal to which the system earth can be connected.

The windings shall be fitted with off-load tap changer to vary the voltage ± 5 percent of the nominal open circuit value in 2.5 percent steps.

Terminal Connections

The 33 kV / 11kV side of the earthing transformers shall be fitted with cable termination modules. The earth point connection to the neutral earthing resistor shall be via a 33 kV / 11 kV conductor.

Inspection and Testing

Inspection and testing of transformers during manufacture and after installation on site shall be in accordance with this Specification.

SCHEDULE OF TECHNICAL REQUIREMENTS OF 33/0.415 kV EARTHING (STATION SERVICE) TRANSFORMER

EARTHING TRANSFORMER			
1	Nominal rating	kVA	315
2	Number of phase		3
3	Frequency	Hz	50
4	No-load voltage ratio	kV	33/0.415
5	Corresponding highest system voltage	kV	36/1.1
6	Type of cooling		ONAN
7	Coolant		Mineral Oil
8	Type		Core, Conservator Type
9	Installation		Outdoor, High Salinity, Tropical , high rainfall and humidity
10	Earthing		Neutral solidly earthed in interconnected star winding

			Neutral earthed in LT 3 phase, 4 wire system
11	Windings		Double wound of high conductivity copper
12	Test voltage		Impulse test voltage (1.2/50 μ s) kV 170/10 (HT/LT) Power frequency withstand voltage kV 70/2.5 (HT/LT) for 1 min
13	Vector group		ZNyn11
14	Neutral to be brought out		HT: Yes, LT: Yes
15	Neutral insulation		Full insulation and 100% loading capacity
16	HV/LV Terminals		Cable Termination Modules
17	Impedance voltage	%	5
18	Tapping range		Off load tap changer $\pm 5\%$ in the step of 2.5
19	Tap changer control		Manual
20	BCT Particulars: HV side Neutral(core-1) LV side (core-1)		100/1A 600/1A

SCHEDULE OF TECHNICAL REQUIREMENTS OF 11/0.415 kV EARTHING (STATION SERVICE) TRANSFORMER

	EARTHING TRANSFORMER		
1	Nominal rating	kVA	315
2	Number of phase		3
3	Frequency	Hz	50
4	No-load voltage ratio	kV	11/0.415
5	Corresponding highest system voltage	kV	12/1.1
6	Type of cooling		ONAN
7	Coolant		Mineral Oil

8	Type		Core, Conservator Type
9	Installation		Outdoor, High Salinity, Tropical, high rainfall and humidity
10	Earthing		Neutral solidly earthed in interconnected star winding Neutral earthed in LT 3 phase, 4 wire system
11	Windings		Double wound of high conductivity copper
12	Test voltage		Impulse test voltage (1.2/50 μ s) kV 75/10 (HT/LT) Power frequency withstand voltage kV 28/2.5 (HT/LT) for 1 min
13	Vector group		ZNyn11
14	Neutral to be brought out		HT: Yes, LT: Yes
15	Neutral insulation		Full insulation and 100% loading capacity
16	HV/LV Terminals		Cable Termination Modules
17	Impedance voltage	%	5
18	Tapping range		Off load tap changer $\pm 5\%$ in the step of 2.5
19	Tap changer control		Manual
20	BCT Particulars: HV side Neutral(core-1) LV side (core-1)		100/1A 600/1A

8.6.4 Protection, Control and Metering

The protection and control facilities shall be suitable for the power system arrangement as shown in the Drawings of this Technical Specifications.

From operational experience, including system stability, protection coordination, integration with existing protection and control equipment, capitalizing of staff experience and familiarization with equipment, protection settings calculation mechanism and methodology of operation, standardization of operation performance, facilities and spare requirements, the protection relays, control& automation systems including complete panel are being rationalized to specific types.

The system operator is making every effort to avoid serious system mal-operation and as such the types of relaying to be supplied for system expansion including this project shall comprise equipment from the following manufacturers countries of origin:

- 1.) Alstom (France/UK)
- 2.) ABB (Switzerland/Sweden)
- 3.) Siemens (Germany)
- 4.) Schneider Electric (France/UK)

Acceptance of any other relays with similar characteristics will have to undergo substantial field trials of at least one year to the satisfaction of the Employer's Representative to ensure satisfactory operation.

The protection shall be sufficiently sensitive to cater for the minimum fault level condition. The protection shall also be suitable for a system fault level equal to the switchgear rating as specified in this specification. All current transformer design shall be based on these fault levels.

All relays shall operate correctly within system frequency limits of 47Hz to 51Hz.

FAULT CLEARANCE TIMES

230 kV, 110 kV, 33 kV and 11kV systems overall fault clearance times (i.e. from fault initiation to arc extinction) shall not exceed the following:

Type of Fault Maximum Fault Clearance Time

Nominal system voltage between phases	kV	230	110	11
Substation and Transformer fault	msec	100	120	160
Line fault				
(a) Up to 72% of the line length (i.e.. 90% of a distance relay Zone 1 reach setting of 80% of the line impedance)	msec	100	120	160
(b) 72% to 100% of the line length where, plusmsec		130	150	190
protection signalling time				

These requirements must be fulfilled under all system conditions including maximum dc current offset and any time delay. Clearance within these times shall be achieved for all types of faults except high resistance earth faults detected by DEF protection or under circuit breaker failure conditions.

ARRANGEMENT OF FACILITIES

Control and relay equipment shall be mounted on panels and cubicles as specified and shall be installed in permanent buildings on the substation sites. The order of the panels shall follow the sequence shown on the drawings.

Control panels shall incorporate all necessary control and indication facilities for the operation of the plant and equipment at the associated substation. In addition, the plant may be remotely controlled and supervised from the National Load Dispatch Centre (NLDC).

The Gateway system for communication to the NLDC shall be supplied under this contract including all necessary items like auxiliary switches, relays and changeover switches, etc. Where specified for the mounting of, and connection to, interposing relays and transducers, links shall be provided to enable transducers to be isolated for test purpose and shortening facilities shall be provided where transducers are used in the secondary of the current transformers. All circuits provided under this contract whether or not they are subject to the system control requirements at the present time, shall be designed and constructed so that the standard facilities specified can be readily provided as required in the future.

The employer will be responsible for carrying out system protection calculation and determine relay setting value for the new substation including remote end substation. The contractor shall review the protection setting calculation given by the employer and shall be responsible for implementation of protection setting that will be provided by employer including configuration, testing, commissioning etc. The Employer's Representative shall witness the protection setting & testing of the same. In case, the proposed Protective relay is not suitable for the proposed application the Contractor shall change to a suitable relay as recommended by the manufacturer without any cost implications to the Employer.

MULTICORE CABLE DIAGRAMS

This Contract includes the preparation of cabling schematic diagrams, showing the approved routing of cores in the various cables, and detailed cable schedules and connection diagrams for all the cables associated with each item of equipment.

TEST AND EARTHING FACILITIES

Each control or relay panels shall be provided with a copper earth bar of not less than 150 sq. mm cross-section and arranged so that the bars of adjacent panels can be joined together to form a common bus.

The common earthing busbar of control and relay panels shall be connected to the main station earthing system via a copper earthing connection of not less than 150 sq. mm.

Software for testing the protection & control devices shall be included in the scope of supply. In addition, for secondary injection testing of the protection & control devices, provision shall be made in the panel for current & voltage injection using standard test set and disconnecting type

terminal blocks with facility for short circuiting of current transformer secondary circuit etc. by means of movement of links from their normal operating position, or any other testing arrangement approved by the Employer.

PROTECTION DEVICES

Simplified arrangements of the main connections and protection for the various items of plant are shown in the Key Single Line Diagram Drawing of this Technical Specifications.

Protection equipment shall be designed and applied to provide maximum discrimination between faulty and healthy circuits. All equipment are to remain inoperative during transient phenomena which may arise during switching or other disturbances to the system.

Current transformers, where possible, are to be located so as to include the associated circuit breaker within the protected zone and shall be located generally as indicated on the schematic drawings included in this Specification.

Transformer Buchholz, winding temperature and tap changer protective devices are to be supplied under this contract, and all necessary interposing relays, tripping relays and cabling associated with these devices shall be supplied and mounted under this Contract.

RELAYS

Relays shall conform to IEC 61850 standards, be of approved types complying with IEC 60255 or BS 142 and 5992, parts 1, 2 and 3 as appropriate, fully tropicalized, and shall have approved characteristics. Relays designed identical to relays with a minimum of five years proven field experience will only be accepted. Supply record of proposed relays shall be furnished for the last five years. The Employer will reject any design he considers unsatisfactory or having insufficient field experience. All the Protective relays shall be numerical type. Numerical relays shall be configured in such a way that at least two (2) nos relays shall be provided for each feeder.

The protection relays, shall be located in conventional panels and shall be flush mounted in dust and moisture proof cases and of the draw out type with rear connections. The panel front side shall be covered by a transparent glass door.

Relays shall be of approved construction and shall be arranged so that adjustments, testing and replacement can be effected with the minimum of time and labour. Relays of the hand reset type shall be capable of being reset without opening the case.

Electrically reset tripping relays shall be provided where necessitated by the system of control, such as for those circuits subject to remote supervisory control.

Relay contacts shall be suitable for making and breaking the maximum currents which, they may be required to control in normal service but where contacts of the protective relays are

unable to deal directly with the tripping currents, approved auxiliary contacts, relays or auxiliary switches shall be provided. In such cases the number of auxiliary contacts or tripping relays operating in tandem shall be kept to the minimum in order to achieve fast fault clearance times. Separate contacts shall be provided for alarm and tripping functions. Relay contacts shall make firmly without bounce and the whole of the relay mechanisms shall be as far as possible unaffected by vibration or external magnetic fields.

Relays, where appropriate, shall be provided with LCD, LED or flag indicators, phase coloured where applicable. LCD, LED or Flag indicators shall be of the hand reset pattern and shall be capable of being reset without opening the case. Where two or more phase elements are included in one case, separate indicators shall be provided for each element.

All Relay settings shall be visible and readable without having to remove the relay front cover. It shall not be possible to amend relay settings with the front cover in place; other than over a serial link, if provided.

If a connector for local use is provided, this shall be accessible only after removing the front cover. Where a port is provided for permanent connection to a modem or other peripheral equipment, remote access shall be password protected.

Relays which rely for their operation on an external DC supply shall utilize for this purpose the trip supply of the associated circuit-breaker trip coil. This supply shall be monitored and an alarm provided in the event of failure.

Any auxiliary supplies needed shall be drawn from the main station batteries and not from separate internal batteries in the protection equipment.

Relays, whether mounted in panels or not, shall be provided with clearly inscribed labels describing their function and designation in addition to the general purpose labels.

Attention is practically drawn to the tropical climate and relay designs should be entirely suitable for duty under full tropical conditions.

To minimize the effect of electrolysis, relay coils operating on DC shall be so connected that the coils are not continuously energized from the positive pole of the battery.

Relay shall be suitable for operation on 110 V nominal, 121 V float DC systems without the use of voltage dropping resistors or diodes.

Numerical protection shall be designed in such a way that in case of a failure of DC auxiliary infeed, the full information need to be maintained at least 24 hrs. After a recovery of DC auxiliary infeed the last information and alarms will be displayed and the alarm "failure of DC auxiliary infeed" released. The relay reset shall not erase the relay memory.

The Numerical protection functions shall be in the form of software such that additional or different functions, application specific logic, etc. can be readily implemented without changes to the existing hardware. It shall be possible to program/ parameterize by a portable computer

(PC) all the numerical protective relays and the entire relay operating and configuring software and the portable computers and other accessory equipment needed to communicate with the relays shall be provided.

All numerical relays shall be adequately protected against damage from incoming surge and shall meet relevant IEC, BS and ANSI SWC test standards. Relays shall utilize a DC-DC converter type regulated power supply to provide transient surge isolation between the station battery and protection equipment. Each DC supply shall be designed to protect it from high voltage and surge and provide electrically isolated contacts for annunciation.

In addition to all equipment and components, the Contractor shall supply documents and calculations to prove the correct functioning of the equipment and he shall ensure and demonstrate that the setting range of relays and the operating limits of all equipment are suitable for the intended applications.

Electromagnetic Compatibility

In certain cases, e.g., distance protection, current differential etc., electronic relays, or devices utilizing microprocessors are specified and electromagnetic devices will not be accepted.

Where such devices are required, they and the ancillary circuits connected to them, such as power supplies, current and voltage transformer secondary's, status, tripping or alarm circuits shall be designed to ensure that they are compatible for use in the hostile electrical environment found in an EHV substation.

Adequate steps, by means of suitable design, shall be taken to prevent Electromagnetic Interference (EMI) generated by sources such as circuit breakers, disconnectors, lightning, radio or radar emissions, switching contactors in dc circuits, etc. or Electrostatic Discharges (ESD) from affecting relay performance or causing damage to components.

All relays offered must therefore have been type tested to meet the current requirements of IEC 60255 with respect to High Frequency disturbance, Fast Transients, Electrostatic Discharge, Radio Frequency Interference testing, etc.

OVER HEADLINE PROTECTION

230 kV Overhead Line Protection

230kV Overhead Line shall be protected by Distance relay both for main 1and main 2 and Directional Earth Fault relay as a backup under this Contract.

Only the backup protection can be incorporated in the bay control unit and not the main 1 and main 2 protection. Main protections shall be provided separately.

Both main protections and directional earth fault protection operating in conjunction with tele-protection channels over optical fibre or power line carrier circuits to form a permissive under reach scheme of distance protection.

Each set of protection will be energised from separate current transformers and shall have facilities for independently tripping duplicated circuit-breaker tripping coils and initiating auto-reclosing, breaker failure protection, inter-tripping, alarms, fault location equipment, disturbance recorders etc. The Contractor shall ensure that the relay contacts used for initiation of auto reclosing shall have the same dwell time as the main tripping contacts to avoid any problems arising from contact racing with the auto reclose relay.

Two sets of protection shall consist of different types of relays either from the same manufacturer or from different manufacturers. Separate elements shall be provided for phase and earth fault measurement. Separate elements shall also be provided for each zone. Phase and earth fault compensation features shall be incorporated to ensure accurate distance measurement for all types of fault and to allow for variation in the path of earth faults on the system.

Distance as Main-1 & Main-2 Protection and Directional Earth Fault Protection as Backup

The main protection (First and Second main) shall be of numerical type and shall be provided by distance relays for use with a signalling channel.

The relay scheme offered shall be suitable for use in the permissive under-reaching, permissive overreaching, blocking and unblocking modes. All these options shall be contained and selectable in the standard relay scheme. The relay should be applicable to all neutral ground possibilities and should be suitable for the protection of long or short overhead lines or cables, double circuit lines, heavily loaded lines, lines with weak in feeds etc.

The permissive over reach scheme shall operate in a permissive under reach/overreach transfer tripping mode with under reaching zone I elements and overreaching zone 2 elements and suitable logic to achieve fast tripping at the sending end in the event of a weak infeed at the receiving end. The weak infeed logic shall comprise a zone 3 element set to look in the reverse direction, which 'echos' back the received signal to the sending end if the reversed zone 3 comparator does not operate.

To provide high speed tripping when a line terminal is open a 'signal echo feature' shall be provided, which is initiated when either the feeder disconnector is open, or when the associated circuit breakers are open.

The Zone 1 elements will normally be set to approximately 80 per cent of the line impedance. They shall trip the local line circuit-breaker.

The Zone 2 elements will be set to over-reach the remote substation and in the case of permissive over-reaching mode operate in conjunction with teleprotection signalling channels to form a permissive over-reaching scheme. They shall also act as a back-up time delayed zone which trips the local circuit-breaker. In the case of permissive under-reaching mode protection the overreaching Zone 2 unit will be used as the permissive element to permit instantaneous tripping of the local circuit.

The Zone 3 elements shall provide a further time delayed back-up zone.

Distance protection back-up zones shall also trip the remote end circuit breaker(s) via a direct intertripping channel.

Partially cross polarised mho or polygonal impedance characteristics relays are preferred for Zones 1 and 2 for 3-phase and 2-phase faults but other characteristics will be considered. Quadrilateral characteristics with adaptive reactance measurement to avoid overreach or under reach for resistive faults with pre fault load are preferred for earth faults. The relays shall operate for faults in the direction of the protected line only. Under no circumstances shall they operate for reverse faults even when the voltage supplied to the relay falls to zero on all three phases nor shall they operate due to the transient response of the capacitive voltage transformers following reverse close-up faults. Details of methods used for polarising the relays to deal with faults close to the relaying point shall be provided. Zone 3 shall be capable of being set as either directional or non-directional and shall be capable of being independently off set in both directions.

The reach of each zone and reverse element shall be individually adjustable by means of a multi-tap voltage transformer or other approved method. The characteristic angle shall be adjustable between approximately 40 and 80 degrees.

Where used in a permissive overreach transfer tripping scheme with weak infeed tripping the zone 3 unit may be set looking in the reverse direction. The reverse looking impedance/directional elements shall detect all reverse faults capable of being detected by the Zone 2 relay at the remote substation. Bidders shall explain how this is achieved.

Single pole tripping and auto-reclosing are being employed and the auto-reclosing scheme requirements are given in Section 5.11. The distance protection shall be suitable for such a scheme and the Contractor shall substantiate by calculation or other means that phase selective tripping will be achieved under the system conditions anticipated in the daily operation.

The Contractor may request whatever information he requires for carrying out the necessary calculations.

Auto reclosing shall be capable of being blocked for

any three phase fault

any Zone 2 or Zone 3 time delayed trip

carrier channel out of service

DEF aided trip

DEF back up time delayed trip

Switch on to fault.

The necessary circuitry shall be incorporated to inhibit the Zone 1 and Zone 2 phase fault elements when necessary during single phase to earth faults and during the single phase auto

reclose dead time. These features shall be selectable by links or switches. Provision shall also be made to ensure that the earth fault elements reset during the single phase dead time.

The protection sensitivity shall be shown to be adequate for the minimum fault level conditions. These will be advised to the Contractor at a later stage.

Where fault resistance may be significant, the Contractor shall illustrate that the distance protection can cover such values taking fault current distribution and load conditions into account.

The operating time of each distance protection zone shall be substantially independent of fault current magnitude. The operating times shall be stated in the Schedule of Particulars and, in addition, curves shall be provided showing the effect of line and source impedance, fault position and operating current.

Under no circumstances shall any line protection operate because of normal system switching including de-energisation of the line.

A feature shall be incorporated to ensure instantaneous tripping in the event that the circuit-breaker is closed onto a fault on a previously de-energised line.

Distance protection back-up Zone 2 and Zone 3 time delay setting ranges shall be 0.2 to 1.0 seconds and 0.5 to 3.0 seconds respectively.

A carrier receive signal extension timer with a delay on reset of 100 msecs shall be provided to ensure that relays at both ends of a parallel feeder circuit have sufficient time to trip for faults occurring in the end zones of the protected line.

A monitoring system shall be provided to supervise the voltage transformer supply to each set of distance protection. In the event of loss of one, two or three phases, the monitoring system shall inhibit relay operation and initiate an alarm. The VT supervision unit associated with the distance relay shall also inhibit the DEF protection in the event of VT fuse failure.

All relays shall incorporate indicators to show the relay tripped, zone indication and the phase or phases faulted. Indication must not be lost in the event of a supply failure.

Directional earth fault protection operating in a permissive overreach scheme shall be provided to cater for high resistance faults which cannot be detected by the distance protection. The same teleprotection signalling channel shall be used for the directional earth fault scheme and the distance protection scheme. An echo feature shall be included with the DEF Scheme and shall be subject to approval by the Employer's Representative.

The directional relays shall be dual polarised i.e., polarised with zero sequence voltage and current. The relay sensitivity shall be adjustable between approximately 5 and 10% of rated current. A relay characteristic angle of 60 degrees is preferred but alternative angles will be considered. It is appreciated that because the 230kV system zero sequence source is an auto transformer with a delta tertiary winding, that current polarising of a dual polarised relay is

unreliable without careful analysis. The contractor shall be responsible for determining whether such a current signal can be taken from the auto transformer neutral and safely used for polarising the relay within three months of being advised of all transformer impedance parameters.

The directional earth fault protection shall initiate three pole tripping. It must therefore include a short time delay to permit single pole tripping by the distance protection. Initiation of three pole reclosing following operation of a DEF aided trip shall be selectable by means of a switch.

Directional earth fault relays shall incorporate a back-up stage in addition to the aided tripping unit. The time delay range shall be 0.2 to 5.0 seconds or inverse time delayed with a characteristic to IEC 60255.

Neither the distance protection scheme nor the directional earth fault scheme shall mal-operate due to fault current reversal during sequential clearance of a fault on the parallel circuit.

The effect of zero sequence mutual coupling between the double circuit lines on the protection shall be described, together with any measures considered necessary to overcome this effect.

The distance protection time delayed back-up Zones 2 and 3 and the directional earth fault back-up stage shall intertrip the remote station circuit-breakers over direct intertripping channels.

Auto reclosing shall not be initiated on receipt of direct intertripping signal. Direct intertripping shall also be initiated in the event of a 3 phase fault in any zone, or following a switch on to fault trip.

Distance relays shall be supplemented by power swing blocking relays. Power swing blocking relays shall be compatible with their appropriate distance relays, and for distance relays having offset mho zone 3 characteristics or starters shall comprise an offset mho characteristic which encompasses and is concentric with the distance relay impedance starter or zone 3 characteristic. Similarly, where it is possible to shape the zone 3 or starter characteristic the power swing blocking relay characteristic shall also be capable of similar shaping. Where zone 3 is set reverse looking the power swing blocking characteristic shall be set such that it encompasses the forward looking zone 2 characteristic.

Facilities shall be provided to block zones 1, 2 and 3 of the distance relay from the power swing blocking logic as required.

Blocking logic shall be derived by determining the time taken for the apparent impedance of the power swing locus to pass from the characteristic of the power swing relay to the appropriate distance relay characteristic. Blocking shall not take place until the apparent impedance has passed through the two power swing characteristics and the set time delay has expired. The associated time delay relay shall have a setting range of 50-250 ms.

Relays shall be of numerical or static design. Electromechanical relays will not be accepted. The Numerical relays shall be design with 16 bit Analogue to Digital converters, powerful Digital

signal processors, CPU etc. The relay should have continuous self supervision and diagnosis. A local display unit shall be provided on the front of the relay for measure and display, Distance to fault indication, diagnostics, etc. and also for acknowledging and resetting of latched outputs. The required software for setting and configuring the relay shall be provided with the relay and this Man Machine Communication (MMC) shall be user friendly and should not require any special programming knowledge. It should be possible to do the settings off line and load the settings on to the relay with a standard portable PC with a fibre optic connection. A separate communication port shall be provided so that the distance relays can in future communicate with the Station monitoring system as well as easily be integrated into Station Control Systems. A PC with a Man Machine Communication (MMC) software for setting of the relay shall be included in the scope of supply.

Reset times shall be low to ensure the associated distance relay reverts to its normal role as soon as possible following a power swing.

Power swing blocking shall be inhibited during the single pole dead time of an auto reclose cycle so that if a power swing develops during this period the distance protection can give an immediate three phase trip. The bidder shall advise whether it is possible to extend the inhibition of the power swing blocking to cover a period immediately following auto reclosing so that if a power swing develops on reclosing onto a permanent fault a 3 phase trip would be permitted. The bidder shall also advise whether power swing blocking can be inhibited if an earth fault occurs during a power swing.

If the associated VT supplies are lost due to VT fuse failure the power swing blocking relay shall not operate.

Where protection is supplied from multi-ratio current transformers, the lowest ratio will be used for the initial system configuration, when fault levels are low. The working ratio will be increased when the system expands and the fault levels and load transfers increase.

Differential as Main-1 & Main-2 protection and Directional Earth Fault Protection as Backup

The protection shall be of numerical type line differential relay and shall be suitable for short underground or over head line protection (single or double circuit) in solidly or low impedance grounded systems.

The relay shall incorporate a facility to compensate for different CT ratios at each line terminal.

A tripping signal for a fault shall be given within 30 ms of fault occurrence (including main tripping relay).

The differential protection shall measure the currents of three phases independently and the tripping shall take place should the comparison of the values in both the terminal stations result in a differential current above a set level. The relay shall incorporate methods for ensuring protection stability for external faults with allowance for CT transformation errors. The minimum CT requirements for the protection must be clearly stated. The protection shall offer

phase-selective tripping, if required.

For digital communication between relays at each line terminal, the protection shall be suitable for direct interfacing to the available communication link according to the particular application. This may be a pair dedicated optical fibres, or a digital interface card of a multiplexed communications link. Where the multiplexer forms part of an overall communications system, the relays shall incorporate the necessary algorithms to ensure stability with load current during communications path route-switching.

Upon detection of a communications channel failure and following a time delay of less than 10 seconds, an alarm shall be given. In the event of signalling channel failure the protection must not trip due to load or emergency load currents.

The protection system shall incorporate at least one zone of directional under impedance protection, to provide time-delayed remote back-up tripping in the even of a fault in an adjacent remote circuit not being cleared by its main protection. This protection function shall be blocked in the event of VT signal failure.

The protection system shall offer standby directional protection elements that can automatically or manually (as selected) be brought into service in the event of data communications link failure between the relay terminals. The alternative protection shall, preferably be one zone of high-speed under reaching distance protection and one zone of time-delayed overreaching distance protection.

In addition to the tripping contacts the protection shall provide all necessary contacts for initiating phase-selective auto re-closing, breaker failure protection, disturbance recorder, signaling and alarms.

For overhead lines, the relay shall be compatible with the external single and three phase auto reclose system which is to be common for the Main-1 and Main-2 protection.

The protection system shall include a secure integral inter-tripping facility, which can be used as a secondary inter-tripping path by external breaker fail protection.

The relay shall be equipped with self-supervision of both its software and hardware (including VT signal supervision). Detection of a failure shall result in the affected part(s) of the protection system being blocked, so that no incorrect tripping will occur.

In the event of a relay failure an alarm contact must operate and the nature of the failure should be indicated where possible.

The trip output contacts of the relay must either be suitable for switching the breaker trip coil currents directly, or an interposing trip relay with heavy duty contacts must be provided. In the event of breaker failure, where the circuit breaker auxiliary contact may not interrupt the trip coil current, the trip contacts within the differential relay should not be damaged if the relay resets following breaker fail protection clearance.

Coupling Bay Protection

The Coupler bay shall be provided with over current instantaneous trip relay protection and over current time delay relay protection and instantaneous trip relay protection.

In case of main & transfer bus arrangement all trip-signal of line and transformer feeder protection shall be transferred to the coupling breaker in case the feeder breaker is bypassed and the feeder is protected by the coupling-bay circuit breaker. This shall be provided by auxiliary relay, not by auxiliary contacts of the circuit breaker by-pass isolator.

BUSBAR PROTECTION

The busbar protection (double scheme) shall be low impedance type numerical relay. The protection shall be extensible to cover the final substation arrangements and Bidders shall state what extra material is required.

The busbar protection shall have the following features:

Two independent measurement & tripping criteria. One based on stabilized current differential algorithm and the other on directional current comparison and shall be capable of detecting three phase, phase-phase and phase to earth faults, under all system generation plant conditions. They shall meet the fault clearance time of 100ms under all conditions.

Two independent hand or electrically reset busbar protection trip relays shall be associated with each circuit-breaker. These trip relays may also be employed for circuit breaker failure. Operation of either of these relays shall block closing of the associated circuit breaker.

Each trip relay shall trip the circuit-breaker via both trip coils. Both relays on the 230kV or 110 kV transformer circuits shall trip the associated circuit-breakers.

The operating time of the measuring relays shall not exceed 30 msecs at five times the relay current setting.

The busbar protection will be supplied from multi-ratio current transformers. The working ratio will be selected on the basis of maximum load transfer in the same manner as the line current transformer ratios.

The overall fault setting shall be between 10% and 30% of the minimum fault current available for any type of fault, unless otherwise specified. The minimum fault current for busbar faults will be advised at a later stage.

The rated stability limit of the protection shall not be less than the switchgear short circuit rating.

Automatic and continuous supervision of current transformer circuits shall be provided to give an alarm when the out-of-balance current reaches an undesirable value. Operation of current transformer supervision equipment should take the defective protection zone out-of-service.

The Contract shall include for all necessary current transformers, relay panels, marshalling boxes, isolating and shorting links, etc. A lockable Busbar protection ON/OFF switch shall be provided.

Current transformer secondary bus wiring should be suitably dimensioned to reduce current transformer burdens to a minimum.

Suitable voltage limiting devices shall be provided as necessary, including across the unused part of the CT secondary when tapings are employed.

Full details of the scheme offered, together with performance figures for stability and sensitivity, shall be provided.

The numerical busbar protection shall be multi processor in structure, with extensive self supervision,

16 bit analogue to digital converters, together with appropriate algorithms to provide phase segregated measuring principles and multi criteria evaluations before initialisation of trip commands. The busbar protection shall be of decentralised type and the bay units shall be fixed as close to the CT's as possible reducing the copper wiring to a bare minimum and thereby also reducing the CT burden and CT dimension.

If the intercommunication between the bay unit and central unit by fibre optic cables, the required fibre optic cable and all necessary items shall be supplied, connected and commissioned by the contractor.

Conditions of Acceptance of Busbar Protection Systems shall be Submitted on the Basis of Calculated Performance.

The Employer's Representative is prepared to accept Calculated Performance data for differential busbar protection systems in lieu of heavy current tests, subject to the following:

The rated stability limit shall be no less than the three phase symmetrical breaking capacity of the associated switchgear.

The overall fault setting for any type of fault shall be between 10% and 30% of the minimum fault current available. The minimum fault current available for a busbar fault will be advised later.

Current transformer knee point voltages shall not be less than twice the relay circuit setting voltage.

The maximum peak voltage across current transformer secondary wiring shall not exceed 3kV under maximum internal fault conditions.

Associated current transformers shall be 5P20, low reactance type. Split core type current transformers will not be accepted.

The contractor shall submit for the Employer's Representatives approval a design report detailing the protected equipment, design parameters of associated current transformers, details of connections and burdens between current transformers and relays, details of the relay circuits and performance calculations.

CIRCUIT BREAKER FAILURE PROTECTION

Breaker failure protection shall be fitted to all 230kV & 110kV GIS circuit breakers. The breaker failure protection on a circuit-breaker shall be initiated by all the other protection devices which normally initiate tripping of that breaker including the receipt of a direct intertripping signal from a remote line end. In the event of the circuit-breaker failing to open within a pre-selected time, the breaker failure protection shall initiate tripping of all adjacent circuit-breakers. It shall also incorporate provision for initiating tripping of any remote infeeds, via direct intertripping channels over optical fibre communication link or power line carrier circuits.

The position of each circuit-breaker shall be monitored by a current check relays fed from the protection current transformers as shown on the drawings. The relay outputs shall be connected in series in a "two out of two" arrangement. The relays shall have an operating time of approximately 10msec. and a consistent reset time of less than 15msec. The relays shall be capable of remaining in the operated position continuously and of carrying twice the circuit rated current continuously.

The scheme provided shall be suitable for use in a single pole and three pole tripping and auto reclosing schemes as appropriate.

The operating time from initiation to back tripping output shall be selected by means of duplicated timers with a setting range of 50-500 msecs. The two timers per circuit breaker in the case of the 230 kV scheme shall be connected in series in a two-out-two basis and shall energise both trip coils of all adjacent circuit breakers via two back tripping circuits from separate d.c. supplies.

The timers shall be of a modern design to minimise over travel. With the approval of the Employer's Representative the busbar protection trip circuits may be employed for circuit breaker fail back tripping.

In the event that a circuit breaker is unable to trip due to low gas pressure, low hydraulic oil pressure etc. the associated alarm shall be arranged to by-pass the breaker fail time delay. The breaker fail relay/scheme shall be designed to accept this input.

Operation of the breaker fail protection shall block manual and automatic reclosure of the associated circuit breaker. Breaker failure protections inbuilt in distance / transformer relays will not be accepted.

AUTO RECLOSE SCHEME

Three pole and/or single pole, single shot repetitive auto-reclosing equipment, shall be provided

for the 230kV overhead line circuit-breakers.

Reclosure shall be initiated following tripping by either main protection operating in Zone 1 or in conjunction with a teleprotection receive signal. Selection facilities shall also be provided to enable or block three pole delayed auto-reclosing following operation of the directional earth fault protection aided trip output. Reclosure shall not be initiated in the event of a three phase fault, nor any type of fault in the second or third back-up zones, nor when a direct intertripping signal is received, nor when the circuit-breaker is closed onto a fault on a previously de-energised line, nor when the DEF back-up protection operates nor if the carrier channel is out of service.

The following modes of operation shall be selectable by means of a switch or switches or programmable.

Single pole, high speed, auto-reclose: Auto-reclosure shall only be initiated in the event of a single phase to earth fault. All other types of faults shall result in three phase tripping without auto-reclosing.

Three pole delayed reclosing: Delaying reclosing shall only be initiated in the event of a single phase or two phase fault. Three phase faults shall result in tripping without auto-reclosing.

Single pole, high speed and/or three phase delayed, auto-reclosing as appropriate.

Single pole, high speed auto-reclosing shall be initiated only in the event of a single phase-earth fault and delayed reclosing initiated in the event of a two phase fault. Three phase tripping without re-closing shall take place for three phase faults.

No auto reclosing: Three phase tripping without auto-reclose shall take place for any type of fault.

If a second earth fault occurs during the single pole auto-reclose dead time, and the selector switch is in the single and/or three pole reclosing mode three phase tripping with subsequent delayed three pole auto-reclose shall take place. If the auto-reclose selector switch is in the single pole reclose mode, three phase tripping with lockout should follow. Any auxiliary relays required to meet this logic shall be deemed to be included.

The high speed and delayed reclosing dead times have to be coordinated with the equipment being provided at the remote substation. Tentative ranges are, as follows:

High speed single pole reclose dead time : 0.3 to 3 seconds.

Delayed three pole reclose dead time : 3 to 30 seconds.

Bidders shall state available ranges.

The reclaim time i.e. the time period following the automatic reclosing of the circuit-breaker, during which any further fault results in three phase tripping and lockout, shall be chosen to

match the duty cycle of the circuit-breakers, assuming the shortest available dead time is chosen. The reclaim time shall not, however, be less than five seconds, and the reclaim timer range shall extend to 180 seconds. (The reclaim time commences at the instant the reclose command is given to the circuit-breaker and, therefore, includes the circuit-breaker closing time).

The closing command shall be limited to two seconds, after which time the reclosing equipment shall be automatically reset without resetting the reclaim timer. The reclosing equipment shall also reset if dead line check or synchronism check conditions are not satisfied within a predetermined time of the check relays being energised.

A counter shall be provided to record the number of reclosures and lockout after a pre-selected number of reclosures has been reached.

The rated duty cycle of the circuit breaker as defined in IEC 60056 (and subsequent amendments) states that following an initial trip and auto reclosure a further reclosure is not permitted for a further 3 mins.

Reclosing schemes shall include voltage monitoring and check synchronising relays as appropriate.

Dead line check relays shall monitor the condition of the line and busbar and permit three pole reclosing only when the line is de-energised and the busbar is energised. The line is considered to be de-energised when the voltage is less than twenty percent of rated voltage, and the busbar is considered to be energised when the voltage is greater than eighty percent of rated voltage.

(A signal shall be provided from the dead line check relays for interlocking of the line earth switches to prevent the switches being closed onto a live line).

When a voltage is present on both sides of a circuit breaker, the synchronism check relay shall monitor the magnitudes of the two voltages across the open circuit-breaker, and the phase angle and slip frequency between these voltages. Closing shall only be permitted when these are within prescribed limits.

Check synchronising relays shall comply with the requirements of this specification. The same relays may be used as for manual closing.

OVERCURRENT AND EARTH FAULT PROTECTION

The overcurrent and earth fault relays shall be fully Numerical and have multi characteristics (inverse, very inverse, extremely inverse) to IEC 60255.

Over current relays shall have a current setting range from at least 50% - 200% in 25% setting steps. Earth fault relays shall have a current setting range from at least 20% - 80% in 10% setting steps.

Time multiplier settings shall be continuously adjustable from 0 to 1 or, as an alternative in steps of 0.025 from 0.05 to 1.0.

In the case of transformer circuits relays shall be provided with high set instantaneous units which can be set to 1.25 times the fault current in the HV winding for a fault on the LV terminals computed using the transformer minimum impedance and assuming negligible source impedance. The instantaneous unit shall have a low transient overreach (less than 5% for system X/R ratio of 10) and an operating time of less than 40 msec at two times the current setting.

In the case of underground line circuits relays should have a reset ratio greater than 95% to enable settings to be made which are close to the circuit emergency rating. The relay contacts must close at a current equivalent to 110% of the setting and relay overshoot must not exceed 50 msecs.

Over current and earth fault relays shall trip via the CB duplicate trip coils and initiate duplicated direct intertripping to the remote line end CB.

Relays shall be thermally rated such that the operating time of the relay at the highest practical current levels on any combination of current and time multiplier settings shall not exceed the thermal withstand time of the relay. The contractor shall provide copies of type test reports to show that this requirement has been met.

Directional back up over current and earth fault relays shall be provided for underground Cable feeders and the directional elements shall be voltage polarised.

Directional units for directional over current protection shall be quadrature connected with a relay characteristic angle setting of 30° or 45° current leading voltage.

Directional units for directional earth fault back up protection shall employ residual voltage quantities and the relay characteristic angle be variable 0°, 45° and 60°, current lag.

The nominal operating boundary shall be $\pm 90^\circ$ from the relay characteristic angle and the operating time of the directional unit shall not exceed 20 ms at the relay characteristic angle.

The relay shall be capable of operating correctly when both the operating current and polarising voltage quantities are 1% of rated values at an angle equal to the relay characteristic angle.

The residual polarising voltage for earth faults may reach 190.5 volts and therefore it should withstand this value continuously. The continuous withstand current should be no less than twice rated current.

TRANSFORMER PROTECTION

Biased Differential Protection

The transformer differential protection shall be fully numerical design with 16 bit Analogue to Digital converters, powerful Digital signal processors, CPU etc. The relay should have continuous self supervision and diagnosis. A local display unit shall be provided on the front of the relay for measure and display, Trip indications, diagnostics, etc. and also for acknowledging and resetting of latched outputs. The required software for setting and configuring the relay shall

be provided with the relay and this Human Machine Interface (HMI) shall be user friendly and should not require any special programming knowledge. It should be possible to do the settings off line and load the settings on to the relay with a standard portable PC with a fibre optic connection.

Overall differential protection shall be of the biased differential type and capable of detecting phase and earth faults.

Separate facilities shall be provided to enable bias and operating settings to be adjusted. The minimum operating setting shall not be greater than 20 per cent of the rated full load current of the transformer.

The protection shall be designed to ensure stability on any transformer tap position under maximum through fault conditions with maximum d.c. offset. An infinite source is to be assumed and the through fault current calculated using the transformer impedance only.

Correction for matching transformer vector groups and main CT ratio's for Transformer Differential protection shall be performed within the relay without the use of external interposing-transformer.

The relays shall have magnetising inrush current restraint of the second harmonic or other approved means. All necessary interposing current transformers shall be provided under the contract.

Where specified in the drawings two separate biased transformer differential protection relays shall be provided for each transformer.

Restricted or Balanced Earth Fault Protection

Where specified, or shown on drawings, transformer windings and connections shall be protected by restricted earth fault protection. Delta connected windings shall be protected by balanced earth fault protection. Relays shall be of identical numerical design as the main protection and of the low impedance type with necessary protection against over voltages. For reliability reasons the Restricted earth fault relay shall be separate from the main-1 transformer differential relay, but in case of two biased differential relay the Restricted earth fault relay can be incorporated in main-2 differential relay.

Relays shall have maximum sensitivity and minimum operating times consistent with stability for faults outside the protected zone and on magnetising inrush surges.

The rated stability limit shall not be less than the maximum current available for an external fault. This shall be taken as 16 times the rated current of the protected winding of the power transformer, or any other value agreed by the Employer's Representative.

For the purpose of calculations, it shall be assumed that any neutral earthing impedance is short circuited.

The Employer's Representative is prepared to accept calculated performance for instantaneous high impedance restricted earth fault protection in lieu of heavy current tests, subject to the conditions of this specification except:

The rated stability limit shall be as specified above.

The fault setting shall be as specified below.

When the transformer winding is connected to a solidly earthed power system, the fault setting shall be between 10% and 60% of the rated current of the winding. When the transformer winding has more than one rating, the setting shall be based on the lower rating.

When the protected transformer is not connected to a solidly earthed power system the fault setting shall be between 10% and 25% of the minimum current available for an earth fault at the transformer terminals.

230/110kV Transformer Back-up Overcurrent Protection

Three pole inverse time back up over current and earth fault protection shall be provided as shown on the drawings. This shall comply generally with the specification but in addition the over current elements shall also be a two stage device. Stage 1 shall be arranged to trip the 110kV circuit breaker and stage 2, the 230kV circuit breaker. Stage 1 will comprise the inverse time unit and stage 2 will comprise an additional definite time unit with a setting range of 50 msec - 5 secs.

Gas Pressure (Buchholz) Protection

Power transformers and earthing transformers shall be fitted with Buchholz devices under this contract. The Buchholz device will be of the two element type giving operation under gassing and under surge conditions.

All necessary flag indication, tripping relays and alarm relays associated with this protection shall be provided, mounted and connected under this Contract.

Oil and/or Winding Temperature

Transformers will be provided with oil and/or winding temperature protection under this contract. These will be of the two stage type with adjustable settings giving alarm and trip facilities.

All necessary flag indication, tripping relays and alarm relays associated with this protection shall be supplied and connected under this Contract.

Low Oil Level and Pressure Relief Devices

Transformers shall be provided with low oil level with contacts for the purpose of providing remote alarm. Transformers shall also be provided with a pressure relief device with contacts

for purposes of remote alarm and trip function.

The alarm relays associated with these devices shall be supplied and connected under this Contract.

Tap Changer Oil Surge

Transformers will be provided with an oil surge or pressure operated device having contacts for purposes of remote alarm and trip.

A relay associated with this device shall be supplied and connected under this Contract.

All necessary flag indication, tripping and alarm relays associated with tap change oil surge shall be provided.

Standby Earth Fault Protection

Standby earth fault protection shall be provided for all earthing transformers/resistors, fed from a current transformer in the transformer/resistor neutral connection.

The operating current shall be adjustable between 10 and 40 per cent of the resistor value. The time delay shall be adjustable between 1 and 10 secs. As an alternative to a definite time relay, a long inverse time relay may be offered.

Tripping Relays

All tripping relays, where specified shall be of the heavy duty type suitable for panel mounting. The trip relays of the offered numerical protections shall be directly capable of tripping the breaker coils. It shall not be required to add additional trip relays

Trip relay contacts shall be suitably rated to satisfactorily perform their required duty and relay operating time shall not exceed 10 ms from initiation of trip relay operating coil to contact close.

Where specified latching type relays shall have hand or electrically reset contacts and hand reset flag indicators. Resetting of the flag indicator and the contacts shall be possible without having to open the relay case.

Tripping relays shall operate when the supply voltage is reduced to not higher than 30% of nominal battery voltage. It shall not operate for wiring leakage currents and discharge of wiring capacitance

230kV and 110 kV circuit breakers are equipped with two trip coils. One tripping relay shall initiate tripping via one trip coil and the other tripping relay via the second trip coil.

DC AUXILIARY VOLTAGE OPERATING RANGE

DC operated relays, coils, elements, etc. will be operated from a 110V rated d.c. battery, which under float charging conditions operates at about 125V d.c. operated relays coils elements etc.

shall be suitable for operation over a voltage range of 66V to 143V. i.e. 110 - 40% + 20%.

TELEPROTECTION SIGNALLING

Details of protection initiation and various permissive and direct intertripping signals shall be submitted by Contractor to the Employer's Representative for approval.

Proposed Fiber Optic Multiplexer equipment system layout Drawing of this Technical Specifications shall also be submitted by Contractor for approval.

TRIPPING RELAYS

All tripping relays, where specified shall be of the high speed, (less than 10ms), high burden, heavy duty (greater than 150W) type suitable for panel mounting.

Relays shall comply with the requirements of this specification.

PROTECTION SETTINGS

Relay settings with calculation for all unit type protective schemes shall be submitted to the Employer's Representative prior to commissioning of any plant for approval. Settings shall also be provided for those relays and other equipment provided under this Section of the Contract which do not require an intimate knowledge of existing relay settings e.g. circuit-breaker fail relays. Detailed calculations shall be provided supporting all recommended settings.

8.6.5 SUBSTATION AUTOMATION SYSTEM

Scope of Supply

This specification covers the design, manufacture, inspection, testing at the manufacturer's works, erection and commissioning of a Substation Automation System, as shown in Drawing of this Technical Specifications& described in the following sections, to control and operate the substation.

This describes the facilities required to provide the control of plant and system within a substation and outlines the facilities to be provided on site, interface requirements and performance criteria.

The Substation Automation System (SA) shall comprise full station and bay protection as well as control, monitoring and communication functions, and provides all functions required for the safe and reliable operation based on IEC 61850 standards supplied in cubicles. It shall enable local station control via PC by means of a human machine interface (HMI) and control software package and perform the necessary system control and data acquisition functions. It shall include communication gateway to NLDC, inter-bay-bus, intelligent electronic devices (IED) for bay control and protection. Contractor shall design the Substation Automation System general system architecture drawing as part of their scope of work.

The communication gateway shall secure control from and information flow to remote network control centers. The inter-bay bus shall provide independent station-to-bay and bay-to-bay data exchange. The bay level intelligent electronic devices (IED) for protection and control shall be directly connected to the instrument transformer and trip/close coils in the switchgear without any interposing equipment and perform control, protection, and monitoring functions subject to a detail proposal approved by the Employer.

The contractor will have option to choose different type of communication network for bay level and process level based on IEC 61850. But network topology and access mode shall be clearly indicated. The availability shall be maintained with suitable topology of ring, star or bus. The physical medium of those shall be glass fibre optics.

The IED's for protection and control functions shall maintain high availability and reliability together with bay independence through extensive self-supervision and state-of-the-art technology. All IED's shall be directly connected to the IEC 61850 bus and shall use only IEC 61850 protocol for communication. No proprietary protocols shall be used.

The system shall be capable of having its computing power increased in the future by the addition of additional computing systems.

The system design life shall be not less than 20 years.

The capacity of the SA system shall be sufficient for the ultimate development of the substation as set out in the project requirements.

The SA supplier shall demonstrate that the system proposed has been designed, installed and commissioned in accordance with IEC 61850 standards and shall provide evidence of satisfactory service experience during the past 5 years.

Compliance with standards

For design and type testing of the protection and control equipment, the following standards shall be applicable:

General List of Specifications

IEC 60255: Electrical Relays

IEC 60038: IEC Standard voltages

IEC 68068: Environmental testing

IEC 60664: Insulation co-ordination for equipment within low-voltage systems

IEC61850: Standard for Substation integrated protection and control data communication

Detailed List of Specifications

IEC 255-6: Measuring relays and protection equipment

IEC 255-7: Test and measurement procedures for electromechanical all-or- nothing relays

IEC 68-2-3: Test Ca: Damp heat steady state

IEC 68-2-30: Test Db and guidance: Damp heat, cyclic

IEC 255-5: Insulation tests for electrical relays

IEC 255-22: Electrical disturbance tests for measuring relays and protection equipment:

IEC 255-22-1: 1 MHz burst disturbance test

IEC 255-22-2: Electrostatic discharge test

IEC 255-22-3: Radiated electromagnetic field disturbance test

IEC 255-22-4: Fast transient disturbance test

IEC 255-11: Interruptions to and alternating component (ripple) in D.C. auxiliary energising quantity to measuring relays

IEC 255-6: Measuring relays and protection equipment

IEC 255-21: Vibration, shock, bump and seismic tests on measuring relays and protection equipment

IEC 255-21-1: Vibration tests(sinusoidal)

IEC 255-21-2: Shock and bump tests

IEC 255-21-3: Seismic tests

IEC 255-0-20: Contact performance of electrical relays

IEC 870-3/class 2: Digital I/O, Analogue I/O dielectric tests

IEC 801-5/class 3: Digital I/O Surge withstand test

IEC 870-3/class2: Radio interference test

IEC 801-4/4: Transient fast burst test

IEC 801-2/4: Static discharge

IEC 801-3/3: Electromagnetic fields

Design and Operating Requirements

General

The SA shall be suitable for operation and monitoring of the complete substation including future extensions. The supplier shall provide a high quality SCD file (System Configuration Description file) complete with ICD files (IEC device capability files) and substation topology which will enable easy extension of the substation in future. The offered products shall be suitable for efficient and reliable operation and maintenance support of the substations.

The SA system shall be state-of-the art design suitable for operation in high voltage substation environment, follow the latest Employer's Representativeing practice, ensure long term compatibility requirements and continuity of equipment supply and the safety of the operating staff.

Protection shall be an integral part of the SA system and protective relays shall be directly connected to the interbay bus in order to provide unrestricted access to all data and information stored in the relays and for changing protection parameters from the remote control location.

Failure behaviour of the hardware and software functions shall be addressed and related diagnostic and rectification working instructions shall be provided. The system performance, if failure of communication to NLDC, main and redundant computer base workstations, central functions, data model, control and protection IED's, station and bay level communication shall also be clearly addressed.

Modes of Operation

The operator stations and specified remote users shall have following operational modes, each password protected.

Monitoring Ability to select graphic displays and lists for viewing only. No capability to acknowledge alarms, complete controls or select items for inclusion in program functions.

Control Selection of graphic display and lists. Able to acknowledge station and SA alarms, complete controls, dressing, etc. associate with normal real time of the control of the substation.

SA ENGINEERing provides all the SA monitoring functions, together with online facilities for program/database/format modifications and checking without the possibility of executing power system controls.

System Manager Provides access to all system functions, including assignment of passwords and system maintenance activities.

In addition, a facility to provide access to the numerical Protection relays including AVR, change/modify relay settings & AVR parameters and fault and disturbance data shall be provided.

A series of passwords shall be personally assigned to operators in each of the above categories.

It shall be possible for substation operators to log on either of the substation workstation and to be allocated the appropriate mode of operation relevant to the password. SA System Engineering work and access to the protection relays and fault and disturbance recording information shall generally be carried out at the Engineering workstation or remote master station.

All the workstation and the system database shall function as a system. It shall not be necessary for example to acknowledge an alarm at more than one workstation.

Similarly, an operator manual entry applied at a workstation shall be immediately displayed at other workstations where this data is presented.

Project Specifications

Specific functions required and boundary conditions of the SA shall be detailed by the Contractor for approval by the ENGINEER.

Vendor's Experience and Local Support

Only experienced and technically capable manufacturers with minimum 15 years experience in design and supply of control and protection systems for electricity transmission and distribution applications will be accepted. Preferred manufacturers will be those who have experience in deliveries of the full scope of substation automation systems and services. This experience has to be substantiated by means of reference installations being in service under similar environmental conditions for at least 10 years. In order to assess the vendor's experience with similar projects, the vendor is required to submit the following with his bid:

Technical design specifications and description of Substation Automation

Catalogues and brochures of equipment and devices offered

Reference list

The vendor shall assure for long-term maintenance and availability of spares. Moreover, a guarantee shall be submitted for the availability of spares during the lifetime of the SA equipment (not less than 10 years).

Quality Assurance and Inspection

Quality Assurance of design and development, production, installation and servicing of material and workmanship shall be governed by ISO 9001. Supporting documents to prove ISO 9001 third party approvals shall be provided with the offer.

The SA system shall be pre-assembled and tested at the vendor's workshop before shipment.

General System Design

The system shall be so designed that personnel without any background in microprocessor based technology can operate the system easily after they have been provided with some basic training.

System control from the substation control room will be with the help of an Industrial Computer (PC) operated by a mouse. The following HMI (Human Machine Interface) functions shall be provided:

Acquisition and plausibility check of switchgear status

Control of switchgear

Remote checking of device parameters and activation of alternative parameter sets in the connected protective relays

Display of actual measured values (U, I, P, Q, f)

Display of events

Display of alarms

Display of trends

Sequence control functions

Dynamic busbar coloring

Disturbance records and fault location

System self-supervision

Hard copy printing

The offered SA shall support remote control and monitoring from NLDC centre via an industrial grade gateway with redundant CPU as well as redundant DC/DC converters. PC based gateways which contains moving parts will not be accepted. The gateway should be designed for a life of at least 20 years. The gateway shall provide for communication to/from remote control centers via IEC60870-5-101 protocol. Even if the Station PC is not available, it shall be possible to control the station from NLDC centre as well as from the backup control panel in the individual bays with all interlocks. Interlocking in case of emergency (i.e. if bay controller fails) should be waived locally by means of a switch with key lock by the Maintenance Engineer for all the switchgear.

Maintenance, modification or extension of components shall not require a shutdown of the whole station automation system. Self-monitoring of single components, modules and communication shall be incorporated to increase the availability of the equipment while minimizing maintenance time to repair.

The Substation Automation System shall be structured in two levels - station level and bay level. The data exchange between the electronic devices on both levels shall take place via an inter-bay bus as per IEC 61850 standards. The entire station shall be controlled and supervised from the station level PC. It shall also be possible to control, monitor and protect each individual bay

from the respective bay level equipment for maintenance purposes or if the communication to a particular bay should fail. Clear control priorities shall prevent initiation of operation of a single switch at the same time from more than one of the various control levels viz., NLDC, station level, bay level or switchgear (apparatus) level. The priority shall always be with the lowest enabled control level. Each bay control and protection unit shall be independent of each other and its functioning shall not be affected by any fault occurring in any of the other bay control and protection units of the station.

The Substation Automation System shall contain the following main functional parts:

Human Machine Interface (HMI) with process database

Gateway function for remote control via an industrial grade hardware

Dial in facility / laptop workstation for protection relay parameterisation, disturbance analysis and SA system fault analysis.

Data exchange between the different system components via high speed bus

Bay level devices for control, monitoring and protection

Bay oriented local control and protection panels with mimic inserts

Facility for emergency operation of all the switchgear, if bay controller fails. (Key / master key system)

The main process information of the station shall be stored in distributed databases. The system shall be based on a de-centralized concept with bay oriented distributed intelligence for safety and availability reasons. Functions shall be decentralized, object oriented and located as close as possible to the process.

The substation monitoring/protection system shall supply data for maintenance, repair and remote parameter setting of protection and control devices in the switchyard.

In the event of a fault in the electrical network, the substation monitoring shall provide a quick means for collecting the relevant and critical data of the fault.

The monitoring system shall be suitable for the supervision and monitoring of all the secondary (IED) and primary devices in a substation including future extensions.

Maintenance, modification or extension of components shall not cause a shut-off of the whole station monitoring system. Self-monitoring of single components, modules and communication shall be incorporated to increase the availability and the reliability of the equipment and minimize maintenance.

It shall be possible to access all protection and control devices for reading the terminal parameters (settings). The setting of parameters or activation of parameter sets shall be restricted

by password to the protection ENGINEER.

One remote computer should be provided with the access to SMS with different access levels. The required SMS software and application specific firmware (for relay parameterisation) shall be provided with associated tools and equipment. The required ENGINEERing tools analysing software also shall be provided/installed both in the station PC and the remote Master Analysis station. A backup copy of all the software shall be provided in CDs.

Flexibility and Scalability

The offered SA system concept shall be flexible and shall permit future extensions to be realized easily as per IEC 61850 standards. Preference will be given to those suppliers who are in a position to provide protection and control devices which can be freely adapted to the application functions required.

System Hardware

Operator Station

The main operator station shall be based on an industrial PC hardware and high- resolution full-graphics screen with manufacturers' standard type tested software operating under Windows environment. An black & white printer and a Hard Copy colour printer shall be connected via LAN to the operator station.

Dual station computers shall control the SA system and drive the work stations and other peripherals. One of the station computers shall operate the system in the “on line” state while the other acts as a “redundant hot standby”. The standby computer shall be continuously updated and shall immediately take over the SA system duties without interruption or transfer mechanism should the on line operator workstation fail. The Industrial computers shall be supplied in cubicles of protection class IP54 or better along with the GPS clock & switches as required.

Disturbance Records shall be analysed using the installed Disturbance Record Analysis programs. The Disturbance Records will be collected, over the interbay bus, from the connected IED's by the system software. All necessary facilities shall be provided to allow the system to perform spontaneous upload of Disturbance data or upload them in a pre-programmed manner. The Event printer shall print events spontaneously as they arrive in the main operator station.

Each uploaded data report file shall be reported on one line that shall contain:

The event date and time

The name of the event object

A descriptive text

The state or value of the object

The information fields above shall be structured in columns for maximum readability.

The hard copy printer shall permit printing of any picture (or part thereof) from the station level PC's using easily accessible commands from the window menus.

The main Station PC's shall be supplied by the station DC battery and a UPS system with a supply duration of not less than 30 minutes shall be provided to supply the monitor and the printers.

At least 32 window annunciator unit shall be directly connected to the main Station PC's to monitor the same and also to annunciate common station abnormal/fault conditions.

Station Inter-bay Bus

The LAN connecting the industrial computer based operator workstations, printers shall be Ethernet 802.3 LAN, Protocol TCP/IP (10 Mbits/ sec or higher) and the physical medium shall be thin Ethernet or fiber optic bus, provided this LAN is kept within the confines of the control room.

The bay control and protection units shall be connected via glass fiber optic cables to a station inter-bay bus using industrial grade Ethernet switches. The station bus according to IEC 61850-8 is today mapped to MSS / Ethernet (with priority tagging and with 100 MS/s). The standard is not making any provision on the Ethernet communication infrastructure. To at least ensure a certain level of quality, performance and availability at least the following described criteria's have to be fulfilled concerning the Ethernet switches and topology.

Industrial grade Ethernet switches that fulfill the hardened requirements concerning temperature, EMC and power supply (110 V DC from the station battery) suitable to be installed in substations shall be provided, i.e., the same data as common for numerical protection. The use of Ethernet Hubs is not permitted as they do not provide collision free transmission. The switches shall support priority tagging and open standards for ring management like fast spanning tree to ensure that e.g., for later system extension utility has not to rely on one switch supplier only. External switches shall be supplied as they have the advantage that there is no interruption or reconfiguration of the Ethernet ring if one or several bay devices are taken out of service. To increase reliability the Ethernet Switches shall have redundant power supply & shall be powered from two different station batteries.

Protection and Control IED's and Local Back-up Control Mimic on 230 kV & 110 kV Level

The bay control IED's, based on microprocessor technology, shall use numerical techniques for the calculation and evaluation of externally input analogue signals. They shall incorporate select-before-operate control principles as safety measures for operation via the HMI. They shall perform all bay related functions, such as protection, commands, bay interlocking, data acquisition, data storage, event and disturbance recording and shall provide inputs for status indication and outputs for commands. They shall be directly connected to the switchgear without any need for separate interposing equipment or transducers.

The numerical bay control IED shall be provided with a minimum of nine (9) configurable (current or voltage) analogue input channels and adequate number of binary input & output channels which are galvanically isolated from the SA system. The channels shall also be individually separated from each other. HV switchgear and instrument transformers shall be directly connected to the bay level IED without any interposing equipment.

The devices shall meet the requirements for withstanding electromagnetic interference according to relevant parts of IEC 255 to conform to the high requirements for operation on the secondary system of HV switchgear.

The 230 kV & 110 kV bay control & protection IED shall have the following features:

A minimum of 9 configurable analogue channels

At least 32 binary inputs, 24 signal relays and 2 command relays

16 nos. LED's on the front of the unit for indication

Synchrocheck function

Power function which can be configured to measure forward or reverse, active or reactive power.

Four (4) independently settable parameter setting groups, settable/selectable locally or remotely via the HMI programme.

4 line Local Display Unit (LDU or front HMI) on the front of the relay which can display both input as well as measured quantities: frequency, phase currents, phase voltages, active power, reactive power, etc.

High speed bus serial communication port as per IEC 61850 standards.

Sequence of Events Recorder with a buffer for 256 events and a resolution of 1 msec. The events that are to be recorded should be freely programmable. These could be alarm/trip signals, external signals connected to optocoupler inputs, internal signals, etc. Once events are defined, they are recorded in chronological order as they occur.

Disturbance Recorder function which can record 9 analogue values, 16 Binary signals and 12 analogue channels for internal measurement values. It shall be possible for the Disturbance Recorder function to be triggered by any internal or external binary signal or internal protective function.

Comprehensive self-supervision

Battery-free memory back-up of Event and Disturbance Records

Logic functions (AND, OR, bistable flip flop, etc.)

Delay/Integrator function

The numerical bay control IED's shall be mounted together with all the relevant bay protective relays in cubicles of Protection Class IP54 or better. Distributed back-up control mimics with associated switches meters and Indicating LED's shall also be provided on these cubicles. These cubicles shall be installed in an air-conditioned room in the substation.

The distributed backup mimic for Local Control shall be installed next to the bay controller IED, which can be used in case of maintenance or emergency or if bay control IED fails. Local bay control via the back-up control mimic on the Control & Protection cubicles shall incorporate the same user safety measures e.g., bay interlocking, synchrocheck, interlock override user guidance, etc. as the station HMI. Local bay control shall be key-locked and the control either from GIS local control panel or station HMI or from remote shall be disabled if the local/remote selector switch on the back-up control mimic is in the 'local' position.

The electronic system has to be provided with functions for self-supervision and testing. Each circuit board shall contain circuits for automatic testing of its own function.

Faults in the bay control IED shall be indicated on a front HMI and a message shall be sent to the station level HMI. The time for fault tracing and replacement of a faulty unit shall be reduced to a minimum. The supervision shall also cover the power supply system, the internal system bus and the ability of the central processing module to communicate with different printed circuit boards.

Failure of any single component within the equipment shall neither cause unwanted operation nor lead to a complete system breakdown. The n-1 criteria must be maintained in worst case scenarios also. Further, a single failure must not have any affect on the primary system, which is monitored and controlled.

Only the backup protection can be incorporated in the bay control unit and not the main protections. Main protection shall be provided separately.

All IED's shall have at least 5 years of successful proven experience in HV applications.

Software Structure

The software package shall be structured according to the SA architecture and strictly divided in various levels. It shall be possible to extend the station with the minimum possible effort. Maintenance, modification or extension of components of any feeder may not force a shut-down of the parts of the system which are not affected by the system adaptation.

Confirmation that the software programs will be supported for a minimum of 20 years is required to be submitted with the bid.

It shall be the responsibility of the contractor to obtain any license required for the operation software. The contractor shall indemnify the client against all claims of infringement of any patent, registered design, copyright, trademark or trade name or other intellectual property right.

Station Level Software

Human Machine Interface (HMI)

The base HMI software package for the operator station shall include the main SA functions and it shall be independent of project specific hardware version and operating system. It shall further include tools for picture editing, ENGINEERing and system configuration. The system shall be easy to use, to maintain, and to adapt according to specific user requirements. The System shall contain a library with standard functions and applications.

Operating System

Windows Workstation operating system shall be used for the operator station as it supports several standard system features, e.g., support for several Windows office applications, multitasking, security levels, data exchange mechanisms (DDE, OLE), open data base communication standards (ODBC) and a standardised, user-friendly look & feel HMI.

Bay Level Software

System Software

The system software shall be structured in various levels. This software shall be placed in a non-volatile memory. Its lowest level shall assure system performance and contain basic functions, which shall not be accessible by the application and maintenance ENGINEER for modifications. The system shall support the generation of typical control macros and a process database for user specific data storage.

Application Software

In order to ensure robust quality and reliable software functions, the main part of the application software shall consist of standard software modules built as functional block elements. The functional blocks shall be documented and thoroughly tested. They shall form part of a library.

The application software within the control/protective devices shall be programmed in a functional block language.

System Testing

The supplier shall submit a test specification for factory acceptance test (FAT) and commissioning tests of the station automation system for approval. For the individual bay level IED's, applicable Type Test certificates shall be submitted.

The manufacturing phase of the SA shall be concluded by a Factory Acceptance Test (FAT). The purpose is to ensure that the Contractor has interpreted the specified requirements correctly. The general philosophy shall be to deliver a system to site only after it has been thoroughly tested and its specified performance has been verified with site conditions simulated to the extent possible in a test lab. If the FAT involves only a certain portion of the system for practical reasons, it has to be assured that this test configuration contains at least one unit of each and every type of equipment incorporated in the delivered system. The bids should prove that they

have the required testing tools to test the IEC 61850 based SA system and such tools shall be used and shown to the ENGINEER at FAT.

If the complete system consists of parts from various suppliers, the FAT shall be limited to sub-system tests. In such cases, the complete system test shall be performed at site together with the Site Acceptance Test (SAT).

The different high voltage apparatuses within the station shall either be operated manually by the operator or automatically by programmed switching sequences.

The control function shall comprise:

Commands from different operator places, e.g. from the associated control centre (NLDC), station HMI, or local control panel according to the operating principle

Select-before execute commands

Operation from only one operator place at a time.

Operation depending on conditions from other functions, such as interlocking, synchrocheck, operator mode, or external status conditions.

The control function shall also include:

Prevention of double operation

Command supervision

Selection of operator place

Block/deblock of operation

Block/deblock of updating of position indications

Manual setting of position indications

Overriding of the interlocking function (Second key switch)

Switchgear run time supervision

Status Supervision

The position of each switchgear, e.g. circuit breaker, isolator, earthing switch, etc., shall be permanently supervised. Every detected change of position shall be immediately visible on the screen in the single-line diagram, recorded in the event list, and a hard copy printout shall be produced. Alarms shall be initiated in cases when spontaneous position changes have taken place.

Each position of an apparatus shall be indicated using two binary auxiliary normally closed (NC)

and normally open (NO) contacts. An alarm shall be initiated if these position indications are inconsistent or indicate an excessive running time of the operating mechanism to change position.

Interlocking

The interlocking function prevents unsafe operation of apparatuses such as isolators and earthing switches within a bay or station wide. The operation of the switchgear shall only be possible when certain conditions are fulfilled. The interlocking function is required to be decentralized so that it does not depend on a central control device. Communication between the various bays for the station interlocking shall be hard wired/take place via interbay bus.

An override function shall be provided, which can be enabled to by-pass the interlocking function via a key/password, in cases of maintenance or emergency situations.

Measurements

Analogue inputs for voltage and current measurements shall be connected directly to the voltage transformers (VT) and the current transformers (CT) without intermediate transducers. The correlated values of active power (W), reactive power (VAr), frequency (Hz), and the rms values for voltage (U) and current (I) shall be calculated.

Event and Alarm Handling

Events and alarms shall be generated either by the switchgear, by the control devices and by the station level unit. They shall be recorded in an event list in the station HMI. Alarms shall be recorded in a separate alarm list and appear on the screen. All or a freely selectable group of events and alarms shall also be printed out on an event printer. The alarms and events shall be time tagged with a time resolution of 1 ms. The time tagging shall be done at the lowest level where the event occurs and the information shall be distributed with the time tagging.

Time Synchronisation

The time within the SA shall be set via a GPS Clock Receiver connected directly to the Bay Level LAN. The time shall then be distributed to the control/protective devices via the high speed optic fiber bus. An accuracy of ± 1 ms within the station is required.

Synchronism and Energising Check

The synchronism and energizing check functions shall be distributed to the control and/or protective devices and shall have the following features:

Adjustable voltage, phase angle, and frequency difference.

Energising for dead line - live bus, or live line - dead bus.

Settings for manual close command shall be adaptable to the specific switchgear.

Voltage Selection

The voltages, which are relevant for the synchrocheck functions, depend on the station topology i.e., on the positions of the circuit breakers and/or the isolators. The correct voltage for synchronising and energising is derived from the auxiliary switches of the circuit breakers, isolator, and earthing switch and shall be selected automatically by the control and protection IED.

HMI Functions

The operator station HMI shall provide basic functions for supervision and control of the substation. The operator shall give commands to the switchgear via the station monitor with the help of mouse clicks on soft-keys.

The HMI shall provide the operator with access to alarms and events displayed on the screen. Besides these lists on the screen, there shall be a print out of hard copies of alarms or events in an event log. The Alarm List shall indicate persisting and fleeting alarms separately.

An acoustic alarm shall indicate abnormalities and all unacknowledged alarms shall be accessible from any screen selected by the operator.

Following standard pictures shall be available from the HMI:

Single line diagram showing the switching status and measured values

Control dialogues

Measurement dialogues

Blocking dialogues

Alarm list, station / bay oriented

Event list, station / bay oriented

System status

Checking of parameter setting

HMI Design Principles

Consistent design principles shall be provided with the HMI concerning labels, colours, dialogues and fonts. Non-valid selections shall be dimmed out.

Object status shall be indicated using different status colours for:

Selected object under command

Selected on the screen

Not updated, obsolete value, not in use or not sampled

Alarm or faulty state

Warning or blocked

Update blocked or manually updated

Control blocked

Normal state

Busbar colouring to show live & dead bus.

Process Status Displays and Command Procedures

The process status of the substation in terms of actual values of currents, voltages, frequency, active and reactive powers as well as the positions of circuit breakers, isolators and transformer tap changers are displayed in the station single line diagram.

In order to ensure a high degree of security against unwanted operation, a special "select – before - execute" command procedure shall be provided. After the "selection" of a switch, the operator shall be able to recognize the selected device on the screen and all other switchgear shall be blocked. After the “execution” of the command, the operated switch symbol shall blink until the switch has reached its final new position.

The system shall permit the operator to execute a command only if the selected object is not blocked and if no interlocking condition is going to be violated. The interlocking conditions shall be checked by the interlocking scheme which is implemented on bay level.

After command execution, the operator shall receive a confirmation that the new switching position is reached or an indication that the switching procedure was unsuccessful with the indication of the reason for non-functioning.

System Supervision Display

The SA system shall feature comprehensive self-supervision such that faults are immediately indicated to the operator before they possibly develop into serious situations. Such faults are recorded as faulty status in a system supervision display. This display shall cover the status of the entire substation including all switchgear, IED's, communication links, and printers at the station level, etc.

Reports

The SA shall generate reports that provide time related information on measured values and calculated values. The data displayed shall comprise:

Trend reports:

Day (mean, peak)

Month (mean, peak)

Semi-annual (mean, peak)

Year (mean, peak)

Historical reports:

Day

Week

Month

Year

It shall be possible to select displayed values from the database on-line in the process display. Scrolling between e.g., days shall be possible. Unsure values shall be indicated. It shall be possible to select the time period for which the specific data are kept in the memory.

This report shall be printed automatically at pre-selected times. It shall also be possible to print this report on request.

Trend Display (Historical Data)

A trend is a time-related follow-up of process data. The analogue channels of all the connected bay level devices on the 230 kV & 110 kV level shall be illustrated as trends. The trends shall be displayed in graphical form as columns or curve diagrams with 10 trends per screen as maximum.

It shall be possible to change the type of value logging (direct, mean, sum, or difference) on-line in the window. It shall also be possible to change the update intervals on-line in the picture as well as the selection of threshold values for alarming purposes.

Event List

The event list shall contain events, which are important for the control and monitoring of the substation. The time has to be displayed for each event.

The operator shall be able to call up the chronological event list on the monitor at any time for the whole substation or sections of it.

A printout of each display shall be possible on the hard copy printer.

The events shall be registered in a chronological event list in which the type of event and its

time of occurrence are specified. It shall be possible to store all events in the computer. The information shall be obtainable also from printed event log.

The chronological event list shall contain:

Position changes of circuit breakers, isolators and earthing devices.

Indication of protective relay operations

Fault signals from the switchgear

Violation of upper and lower limits of analogue measured value.

Loss of communication

Filters for selection of a certain type or group of events shall be available. The filters shall be designed to enable viewing of events grouped per:

Date and time

Bay

Device

Function

Alarm class

Alarm List

Faults and errors occurring in the substation shall be listed in an alarm list and shall be immediately transmitted to the control centre. The alarm list shall substitute a conventional alarm tableau, and shall constitute an evaluation of all station alarms. It shall contain unacknowledged alarms and persisting faults. Date and time of occurrence shall be indicated.

The alarm list consists of a summary display of the present alarm situation. Each alarm shall be reported on one line that contains:

The alarm date and time

The name of the alarming object

A descriptive text

The acknowledgement state

The operator shall be able to acknowledge alarms, which shall be either audible or only displayed on the monitor. Acknowledged alarms shall be marked at the list.

Faults that appear and disappear without being acknowledged shall be specially presented in a separate list for fleeting alarms. For example due to bad contacts or intermittent operation.

Filters for selection of a certain type or group of alarms shall be available as for events.

Object Picture

When selecting an object such as a circuit breaker or isolator in the single line diagram, first the associated bay picture shall be presented. In the selected object picture, all attributes such as

type of blocking,

authority

local / remote control

NLDC/SA control

errors,

etc.,

shall be displayed.

Control Dialogues

The operator shall give commands to the system by means of soft keys located on the single line diagram. It shall also be possible to use the keyboard for soft key activation. Data entry is performed with the keyboard.

User Authority Levels

It shall be possible to restrict the activation of the process pictures of each object (bays, apparatus, etc.) to a certain user authorization group. Each user shall then be given access rights to each group of objects, e.g.:

Display only

Normal operation (e.g. open/close apparatus)

Restricted operation (e.g. by-passed interlock)

System administrator

For maintenance and Engineering purposes of the station HMI, the following authorization levels shall be available:

No Engineering allowed

Engineering/configuration allowed

Entire system management allowed

The access rights shall be defined by passwords assigned during the log-in procedure. Only the system administrator shall be able to add/remove users and change access rights.

System Performance

The refresh/update times on the operator station PC under normal and calm conditions in the substation shall be according to the levels specified below:

Function	Typical Values
Exchange of display (first reaction)	< 1 s
Presentation of a binary change in the process display	< 0.5 s
Presentation of an analogue change in the process display	< 1 s
From order to process output	< 0.5 s
From order to update of display	< 1.5 s

System Reliability

The SA system shall be designed to satisfy very high demands for reliability and availability concerning:

Solid mechanical and electrical design

Security against electrical interference (EMI)

High quality components and boards

Modular, well-tested hardware

Thoroughly developed and tested modular software

Easy-to-understand programming language for application programming

Detailed graphical documentation, according to IEC 1131-3, of the application software

Built-in supervision and diagnostic functions

After sales service

Security

Experience of security requirements

Process know-how

Select before execute at operation

Process status representation as double indications

Distributed solution

Independent units connected to the local area network

Back-up functions

Panel design appropriate to the harsh electrical environment and ambient conditions

Panel grounding to provide immunity against transient ground potential rise

Configuration Tools

The configuration of the station HMI shall be made using the operator station working in Windows NT environment. The various functions shall be customised by easy to use interactive configuration tools. Configuration shall include the visual presentation of the object, adaptations needed in process database and adaptations of the communication configuration data.

A portable Personal Computer (PC) as a service unit shall be foreseen for on-site modifications of the control and protection devices. The service unit shall be used for documentation, test and commissioning.

The PC based service & support system shall be used for the following purposes:

System configuration

System testing

Help functions

Program documentation

Down- and up-loading of programs

System commissioning

Data base management

Changing peripheral parameters

The service & support system shall be able to monitor data in the running substation control system and to present changing variables on the display screen in graphic representation.

Documentation

The following documentation shall be provided for the system during the course of the project and they shall be consistent, CAD supported, and of similar look/feel:

List of Drawings

Control Room Lay-out

Assembly Drawing

Single Line Diagram

Block Diagram

Circuit Diagram

List of Apparatus

List of Labels

Functional Design Specification (FDS)

Test Specification for Factory Acceptance Test (FAT)

Logic Diagram

List of Signals

Operator's Manual

Product Manuals

Calculation for uninterrupted power supply (UPS) dimensioning

High quality SCD file

Indicating Meters in Local Back-up Control Panels

Each circuit shall be equipped with Indicating meter for measurement of three phase currents, voltages, frequency, power factor, active and reactive power. Repeat pulse outputs are to be provided from all energy meters, where specified.

Trip Circuit and Power Supply Supervision

Trip circuit supervision relays shall be provided to monitor each of the trip circuits of circuit-

breakers in the relay panel and each relay shall have sufficient contacts for visual/audible alarm and indication purposes.

The trip circuit supervision scheme shall provide continuous supervision of the trip circuits of the circuit-breaker in either the open or closed position and independent of Local or Remote selection at the local operating position. It shall be suitable for use in single and three pole tripping schemes as appropriate.

Relay elements shall be delayed on drop-off to prevent false alarms during faults on d.c. wiring on adjacent circuits, or due to operation of a trip relay contact.

Series resistances shall be provided in trip circuit supervision circuits to prevent male tripping of a circuit-breaker if a relay element is short circuited.

Relay alarm elements should be equipped with self resetting flag indicators.

Where specified, time delayed power supply supervision relays shall be provided to monitor the duplicated d.c. power supplies for tripping, closing, CB fail, busbar protection etc. within a relay panel. An alarm shall be given if either supply voltage falls below 70% of nominal voltage for a period in excess of 3 secs. The relay shall be equipped with a self resetting flag indicator, and shall be suitable for continuous operation at 125% of nominal d.c. voltage.

BUSBAR VOLTAGE SELECTION

Where required, selected voltage references, one for each busbar, shall be employed for all indications, metering, protection and synchronizing where appropriate. The correct voltage selection for the requirements of each circuit according to the busbar to which it is connected shall be obtained by direct use of auxiliary contacts on busbar selector switches.

Availability Calculations

The contractor shall submit availability calculations for the offered substation automation system.

DIAGRAMS

The Contractor shall submit schematic diagrams for consideration of the ENGINEER within six months of the Contract commencement date. Prior to preparation of schematic diagrams, the Contractor shall provide single line, block and logic diagrams in order to agree the circuit schemes and operating modes.

The Contractor will be provided with a set of drawings for each Substation as soon as possible after award of Contract. As part of the Contract documentation, the Contractor shall provide integrated sets of complete drawings (schematic and wiring diagrams, cable schedules, etc.).

CURRENT TRANSFORMER CALCULATIONS

The Contractor shall submit to the Employer detailed calculations substantiating the parameters of the current transformers he proposes to provide. They shall be presented within six weeks of the Contract commencement date.

SCHEDULE OF TECHNICAL REQUIREMENTS OF SUBSTATION AUTOMATION SYSTEM

1. General Requirement:

Standards to be complied with Substation Automation system	
Test Ca. Damp heat steady state	IEC 60068-2-3
Test Db and guidance; Damp heat cyclic	IEC 60068-2-30
Digital I/O, Analogue I/O dielectric Tests	IEC 60870-3 class 2
Digital I/O, Surge withstand test	IEC 60801-5/Class 2
Radio interference test	IEC 60870-3/Class 2
Transient fast burst test	IEC 60801-4/4
Static Discharge	IEC 60801-2/4
Electromagnetic fields	IEC 60801-3-3
Temperature range (min/max)	°C 0/50
Relative humidity	% 93
Intelligent Electronic Devices (IED's)	Yes
- serial communication interface included?	Yes
- Protection & Control IED's connected same bus?	Yes
- self monitoring	Yes
- display of measured values	Yes
- remote parameterization	Yes
- disturbance record upload and analysis	Yes
Availability Calculation shall be furnished for each equipments as well as for the entire system	Yes

2. Detailed Requirements:

Number of years of proven field experience of offered system.	10Yrs.
(Note: proof of experience should be furnished. The components used in the offered system and those with field experience should be the same)	20 Yrs
Design life of substation Automation System	ISO 9001/9002 or equivalent
Manufacturers quality assurance system	
Dimensions of cubicle	
- Width	mm
- Depth	mm
- Height	mm
- Floor load	N/m ² max.600

3. Station Level Equipment:

Station Controller	Industrial PC Hrs
MTBF (Mean time between Failures)	Hrs
MTTR (Mean time to repair)	
Dual Station Computers Provided in redundant hot standby	Yes
Hot standby take over time	Seconds
Annunciator for Station PC system software	16 Windows
Number of years of proven field experience of offered software	5 Yrs
Operating System	Windows
All standard picture as per spec included in HMI	Yes
Process Status Display & Command Procedures	Yes
Event processing as per spec	Yes
Alarm processing as per spec	Yes
Reports as per spec	Yes
Trend Display as per spec	Yes
User Authority levels as per spec	Yes
System supervision & monitoring as per spec	Yes
Automatic sequence control as per spec	Yes
4. Gateway to National Load dispatch Center	
Number of years of proven filed experience of offered unit	5Yrs
Insulation tests	IEC 60255-5
Fast disturbance tests	IEC 61000-4-4,Calss 4
Industrial environment	EN 50081-2 Class A
Industrial grade hardware with no moving parts (PC based gateway is not accepted)	Yes
Design life of offered equipment	20 Yrs
Redundant communication channel	Yes Yes
Redundant CPU	Yes Hrs
Redundant DC/DC Supply	
MTBF (Mean time between Failures)	Hrs
MTTR (Mean time to repair)	
5. Station Bus:	
Physical Medium	Glass fibre optic
6. Interbay Bus	
Physical Medium	Glass fibre optic
7. Printer server	
MTBF	Hrs
8. Event Printer	
MTBF	Hrs
9. Hard Copy colour Printer	
MTBF	Hrs

10. Master Clock – GPS (Global Positioning System) Receiver:

	Hrs
--	-----

11. Bay control Unit - HV

Number of years of proven field experience of offered unit	5 Yrs
--	-------

Separate Bay controller unit provided for each bay & feeder	Yes
---	-----

Type of bay controller offered HV/MV	HV
--------------------------------------	----

Select Before Operate with Open Execute & Close Execute	Yes
---	-----

Single bit dependence Interlocking, bay & Station wide	No Yes
--	-----------

Synchrocheck function	Specify range
- Maximum Voltage difference	Specify range
- Maximum Frequency difference	Specify range
- Maximum Phase difference	Specify range

Double command blocking	Yes
-------------------------	-----

Independent settable parameter groups	4
---------------------------------------	---

Local Display Unit	Yes
--------------------	-----

Sequence of event recorder	256
----------------------------	-----

- Events	1 ms
- Time resolution	Yes

Disturbance recorder function	Yes
-------------------------------	-----

Comprehensive self-supervision	Yes
--------------------------------	-----

Battery free backup of events and disturbance records	IEC 60255-5
---	-------------

Insulation tests	IEC 61000-4-4, Class 4
------------------	------------------------

Fast disturbance tests	Hrs
------------------------	-----

MTBF	Hrs
------	-----

MTTR	°C
------	----

Temperature range: IED's	°C	-10 to +50
--------------------------	----	------------

- Operation	°C	-10 to +50
- Transport and storage		

Relative humidity:	%	93
--------------------	---	----

- Operating max./min	%	93
- Transport and storage		

12. Back up control mimic -HV

Control functionality:

Control of breaker as well as all isolators/earthing switch

(Control functionality should not be affected if bay controller fails) Yes

Key-Locked Yes

Interlock override function Yes

Separate backup control mimic provided for each bay & feeder Yes

13. Bay Control Unit - MV

Number of years of proven field experience of offered unit 5 Yrs

Separate Bay controller unit provided for each bay & feeder Yes

Control functionality implementation in software:
Select before Operate with Open Execute & Close Execute Yes

Interlocking, Bay & Station Wide Yes

Synchrocheck function

- Maximum Voltage difference Specify range
- Maximum Frequency difference Specify range
- Maximum Phase difference Specify range

Yes

Local Display Unit

Sequence of event recorder Specify

- Events 1 ms
- Time resolution Yes

Disturbance recorder function Yes

Comprehensive self-supervision IEC 60255-5

Insulation tests IEC 61000-4-4, Class 4

Fast disturbance tests Hrs

MTBF Hrs

MTTR Hrs

Temperature range: IED's °C -10 to +50

- Operation °C -10 to +70
- Transport and storage

Relative humidity: % 93

- Operating max./min % 93
- Transport and storage

14. Back up control mimic - MV

Control functionality: Yes

Control of breaker as well as all isolators/earthing switches Yes

Separate backup control mimic provided for each bay & feeder

15. System Performance:

Exchange of display (First reaction)	< 1 S
Presentation of a binary change in the process display	< 0.5 S
Presentation of an analogue change in the process display	< 1 S
From order to process output	< 0.5 S
From order to updated of display	< 1.5 S

8.6.6 DIGITAL FAULT AND DISTURBANCE RECORDER [DFDR]

For standardization of operation performance, facilities and spare requirements, the Digital Fault And Disturbance Recorder [DFDR] to be supplied under this project shall be from Qualitrol, UK or Approved Equal.

The DFDR shall have the following features:

The equipment shall be an independent stand alone system to monitor analogs and digital signals from all 230kV and 110kV feeders including transformer and bus-coupler bays that requires to be monitored.

The manufacturer shall prove the system reliability of good site performances by providing substantial evidence of the systems already installed and commissioned for at least a duration of 5 years, accompanied by the customer recommendations and type test reports from internationally acclaimed laboratories.

The DFDR system shall be modular in design for easy expansion, upgrade and easy maintenance.

The acquisition system or it's storage unit shall not be based on a PC platform.

System shall be equipped to monitor, detect and record simultaneously Fast transient faults (short term) and Slow phenomena disturbances (Long term) like power swing, frequency variation, voltage drop, etc. covering all the required feeders.

All input signals shall be able to scan and record simultaneously at least 2 or 3 user programmable sampling rates from 500Hz to 6kHz for Fast (Short terms) transient monitoring and from 1Hz to 500Hz for Slow phenomena (Long terms) monitoring in order to detect and record Fast (short terms) and Slow phenomena (Long terms) events.

At least 25 Sec of memory for transient fault data recording (at 6 kHz – sampling rate) and over 1000 Sec for Slow (at 30 Hz) phenomena recording shall be provided in addition to the auto maintained inbuilt Hard Disk unit which shall be installed for data storage. The inbuilt Hard Disk Unit shall be managed and operated by the identical industrially proven operating system of the DFDR.

The graphical data should be recorded in respect of all feeders simultaneously (snapshot image). The recording should contain the data prior to the event, post event including the dynamic length of the event / fault without any alterations.

The system should possess a library of sensors (triggering criteria), which should be selected by the user and able to detect and record various type of incidents. The system shall be able to detect incidents by the selected starting criteria and should be able to produce a record.

The recordings shall contain the graphical data of Physical inputs (voltage, currents, digitals) and virtual inputs. [e.g. Frequency, dp/dt , dq/dt (3 Phases / Single Phase), RMS values etc..]

The DFDR shall be able to communicate with Local and / or Remote Master Station using Master communication and Analysis software. This software should permit the user either locally or remotely to download the recorded data, to ascertain the system operational status, change parameters etc.

Master communication should be able to communicate via RS 232 (Direct connection), through modem (dial up telephone line) and LAN [Ethernet (TCP / IP) – IEEE 802.3] networking.

The following functions shall be performed by the DFDR, Fault Location, (including impedances and report), Graphical display of data, Phase measurement & display, Transient Fault Recording, Dynamic swing recording, Harmonics measurement & display, Integrated SER function, Calculated channels etc.

System shall be able to calibrate at site, and the required menu driven software and other required accessories shall be supplied along with a Notebook computer and color printer etc.

The systems shall be equipped for time synchronization by the external GPS clock receiver for real time synchronizing (including Antenna).

Local printing facility shall be provided with the system.

Master station (a latest version of PC) and relevant software shall be supplied with the equipment for analysis and communication.

Provision for Power Quality monitoring or continuous monitoring (periodical recording) shall be made available for at least 4 feeders.

Energy Meter (Tariff Metering) :

Meter requirement:

Programmable meter

Adjustable different tariff

110-400V flexible input voltage setting

1(10) A current rating

Accuracy class to be ± 0.2 for kwh and ± 0.5 for kvarh

RS232/485 Port for Medem interface

Standard metering protocol for remote interface

Data storage of 16 channel@30min interval and of 90days

Optical head and software to upload and download of meter data

Password protection for programming and for configuration

Configurable display, including meter ID, Power quadrant display etc.

Provision for quick reading scroll, reset etc. (Programmable)

Additional requirement:

Online test facility of meter (with TTB) and with Security Sealing Provision.

TTB's should be at the suitable accessible panel front location with meter

Meter cabinet should be exclusive for tariff metering only and have sufficient Security Sealing provision, provided with 220V, 5A two pin socket outlet for modem power, Auxiliary bias power, Testing Equipment power etc.

All main metering CT, VT should be terminated to metering panel directly including star point (4 wire).

Backup metering circuit may be shared for other purpose.

VT MCB (both main and backup) should be located in the metering panel. Downstream VT MCB rating should be less than that of upstream.

All CT & VT terminals should have Security Sealing provision.

Normal display list:

Scroll order Display Item Name

Complete LCD Test

Present date

Present time

Current billing total kWh-Del

Current billing total kWh-Rec

Current billing total kVARh-(Q1+Q4)

Current billing total kVARh-(Q2+Q3)

Current billing maximum kW-Del

Current billing maximum kW-Del Date

Current billing maximum kW-Del Time

Current billing cumulative kW-Del

Current billing maximum-Rec

Current billing maximum kW-Rec Date

Current billing maximum kW-Rec Time

Current billing cumulative kW-Rec

Phase A Voltage

Phase B Voltage

Phase C Voltage

Phase A Current

Phase B Current

Phase C Current

Phase A Voltage angle

Phase B Voltage angle

Phase C Voltage angle

Phase A Current angle

Phase B Current angle

Phase C Current angle

System PF-arithmetic

Line frequency

Alternate Mode Display list:

Scroll order Display Item Name

Complete LCD Test

Present date

Present time

Current billing total kWh-Del

Current billing total kWh-Rec

Current billing total kVARh-(Q1+Q4)

Current billing total kVARh-(Q2+Q3)

System PF-arithmetic

Line frequency

Load profile (Cumulative meter reading) and Instrumentation profile Data in the following format should be stored in each 30 min interval for at least 100 days.

Interval Data (Load profile):

Interval Data Mode: Cumulative ENGINEERing Units

Time kWh-Del kWh-Rec kVARh-(Q1+Q4) kVARh-(Q2+Q3) Date: 1/31/2015

Interval Data (Instrumentation):

Set-1

Time End Phase A Voltage End Phase A Voltage End Phase A Voltage Average System
kW

Date:1/31/2015

13:45 0.0008 0.0004 0.0004 -0.7002

Self Read Feature for at least 12 month's billing history.

SCHEDULE OF TECHNICAL REQUIREMENTS DIGITAL FAULT AND DISTURBANCE RECORDER [DFDR]

Sl.	ITEM	UNITS	
(A) GENERAL			
1	Manufacturer's name & address		
2	Type		
3	Power Supply -Power supply for printer	VDC VAC	110 230
(B) ANALOGUE INPUTS			
1	Number of Channel		216
	-Expandability		Min. 336
2	Nominal Current	Amp	1A/5A
3	Nominal voltage - Current	Vac/Vdc mA/Amp	
4	Frequency response		
5	Cut-off frequency (a) Bandwidth		dB
	(b) Attenuation at		dB
	(c) Auto adjusted anti-aliasing filters for chosen sampling rate	Yes/No	Yes
d	Simultaneously programmable sampling rate for all feeders/inputs -Locally Changeable		Min 2 for FAST and SLOW Recording
	-Remotely Changeable	Yes/No	Yes
			Yes
e	Possible sampling rates		3 different sampling rates: Samples/sec Samples/sec Samples/sec
			Slow. 1Hz-500Hz fast: 0.5 kHz – 6kHz
			continuous (variable rate)
6	DC coupled inputs	Yes/No	Yes
7	Resolution	bits	12 or better

8	Accuracy	%	Min 0.5
9	Burden		
	1. Current Circuit at IN	VA	
	2. Voltage Circuit	VA	
10	Overload		
	1. Current	% In	100% In continuously, Min 600 % in for 1 Second
	2. Voltage circuit	% Vn	2Vn and max. 350 Vn

(C) DIGITAL INPUTS

1	Number of Channel		648
	-Expandability (Without and time skew)		min. 1008
2	Selectable input level	Vdc	N/O or N/C, 110 VDC
3	Type		Potential or potential free contact
4	Resolution	ms	

(D) MEMORY

1	Size	MB	64 MB or Higher
2	Type		Solid State
3	Pre-fault time (fast scanning rate)	sec	0.1-2 user programmable
4	Post-fault (fast scanning rate)	sec	0.1-2 user programmable
5	Pre and Post-fault time (slow scanning rate)	sec	min. 180 user programmable
6	In-Built hard disk (auto-maintained)	GB	min. 4 GB
	Sl.	ITEM	UNITS

(E) SENSORS/ TRIGERRING CRITERIA

All sensors/triggers are preferable Programmable and Virtually recordable	Yes/No	Yes
1. Logical combination sensor	Yes/No	Yes

2.	Three phase over or under Voltage / Current	Yes/No	Yes
3.	Mono phase over or under Voltage / Current	Yes/No	Yes
4.	*du/dt, dp/dt, dq/dt, [Single/3 Phases], df/dt. etc.	Yes/No	Yes
5.	RMS [Voltage / Current]	Yes/No	Yes
6.	Zero Sequence	Yes/No	Yes
7.	Negative, Positive Sequence	Yes/No	Yes
8.	Frequency	Yes/No	Yes
9.	DC Step	Yes/No	Yes
10.	Pendling / Swing	Yes/No	Yes
11.	Digital level and edge	Yes/No	Yes
12.	Sensor trigger	Yes/No	Yes
13.	Event Trigger	Yes/No	Yes
14.	Manual Trigger	Yes/No	Yes
15.	Remote Trigger	Yes/No	Yes

(F) CLOCK SYSTEM

1.	Internal Clock	Yes/No	Yes
2.	Accuracy		
3.	External Synchronization	Yes/No	Yes
4.	Time resolution between 2 synchronized pulses		

(G) OUTPUT ALARM RELAY CONTACT

1.	Max. operation Voltage DC/AC	Vac / Vdc	250 Vac or above, 60 Vdc or above
2.	Make and carry for 0.5 sec	A	Min 8A
3.	Carry Continuously	A	Min 5A
4.	Break (DC) – resistive	W	

(H) INTERFACE FOR DATA COMMUNICATION

1.	Full definition compression	Yes/No	Yes
2.	Maximum transmission rate	bits / Sec	
3.	Standard serial port (EIA-232-D)	Yes / No	Yes
4.	Printer Port	Yes/No	Yes
5.	Dedicated serial port for modem	Yes/No	Yes

(I) PRINTER DATA

1. Printer amplitude (scaling peak to peak)
2. Time Scale (mm / s)
3. Printer resolution mm
4. Auto printing Yes/No Yes
- (J) Fault Priority transmission Yes/No Yes
- (K) Fault location (distance calculation) Yes/No Yes
- (L) Test certificates from internationally recognized Laboratories Yes/No Yes

(M) COMMUNICATION AND REMOTE ANALYZING UNIT

- | | | |
|-------------------------------|--------|-------------------------------|
| 1. Processor Pentium | (MHz) | Yes, at least 450 MHz Pentium |
| | Yes/No | |
| 2. Co-Processor Pentium | Yes/No | Yes |
| 3. Main memory capacity | (Mb) | Yes, at least 64 MB |
| | Yes/No | |
| 4. Color graphics board S-VGA | Yes/No | Yes |
| 5. Screen S-VGA | Yes/No | Yes |
| 6. Hard disk unit | Yes/No | Yes, at least 40 GB |
| 7. Printer | Yes/No | Yes |
| 8. Modem | Yes/No | Yes. |

*Note: du/dt=Change of voltage, dp/dt=Change of active power, dq/dt=change of reactive power, df/dt=Change of frequency.

8.6.7 FIBRE OPTIC MULTIPLEXER EQUIPMENT FOR COMMUNICATION AND PROTECTION

This specification describes the communication requirements for the transport of voice, data and protection signals, including ENGINEERing, configuration, testing, installation and commissioning.

For standardization of operation performance, facilities and spare requirements, the Fiber Optic Multiplexer Equipment for Communication and Protection to be supplied under this project shall comprise of equipment which can totally be integrated into the existing Telecommunication system in TNEB Network including the Telecommunication Network Management System.

Contractor shall provide a drawing that shows the planned arrangements of fiber optic multiplexer equipment for communication and protection. All materials and equipment offered shall be brand new, from the manufacturer's normal and standard construction, designed and manufactured according to the latest technological methods.

Summary of Standards

Any international standards referenced in the specifications and our outdated shall be replaced with the corresponding replacement.

The Equipment shall comply with the latest ITU-T recommendations for the plesiochronous and synchronous hierarchies.

The equipment shall be independent type tested.

In particular the mentioned recommendations shall be covered:

The PDH interfaces shall conform to the following recommendations: ITU

ITU-T G.702: General aspects of digital transmission systems – Terminal equipment - Digital hierarchy bit rates

ITU-T G.703: Digital transmission systems – Terminal equipment – General Physical/electrical characteristics of hierarchical digital interfaces

ITU-T G.704: Digital transmission systems – Terminal equipment – General Synchronous frame structures used at 1544, 6313, 2048, 8448 and 44 736 kbit/s hierarchical levels

ITU-T G.706: General aspects of digital transmission systems – Terminal equipment - Frame alignment and cyclic redundancy check (CRC) procedures relating to basic frame structures defined in recommendation G.704

ITU-T G.711: Pulse code modulation (PCM) of voice frequencies

ITU-T G.712: Transmission performance characteristics of pulse code modulation channels

ITU-T G.732: General aspects of digital transmission systems – Terminal equipment - Characteristics of primary PCM multiplex equipment operating at 2048 kbit/s

ITU-T G.735: Characteristics of primary multiplex equipment operating at 2048 kbit/s and offering synchronous digital access at 384 kbit/s and/or 64 kbit/s

ITU-T G.736: General aspects of digital transmission - Characteristics of a synchronous digital multiplex equipment operating at 2048 kbit/s

ITU-T G.737: Characteristics of external access equipment operating at 2048 kbit/s and offering synchronous digital access at 384 kbit/s and/or 64 kbit/s

ITU-T G.823: The control of jitter and wander within digital networks, which are based on the 2048 kbit/s hierarchy.

ITU-T G.826: Error performance parameters and objectives for international, constant bit rate digital paths at or above the primary rate

The architecture of optical SDH interfaces shall conform to the following recommendations:

ETS/EN

ETS 300 147: Synchronous digital hierarchy multiplexing structure.

ETS 300 417: Transmission and Multiplexing (TM); Generic requirements of transport functionality of equipment

ETS 300 417-1-1 / EN 300 417-1-1 V1.1.2: Generic Processes and Performance

ETS 300 417-2-1 / EN 300 417-2-1 V1.1.2: SDH and PDH Physical Section

Layer Functions

ETS 300 417-3-1 / EN 300 417-3-1 V1.1.2 : STM-N Regenerator & Multiplex Section Layer Functions

ETS 300 417-4-1 / EN 300 417-4-1 V1.1.2 : SDH Path Layer Functions

ITU

ITU-T G.707: Network node interface for the synchronous digital hierarchy

ITU-T G.783: Characteristics of synchronous digital hierarchy (SDH): equipment functional blocks

ITU-T G.803: Architecture of transport networks based on the synchronous digital hierarchy (SDH)

ITU-T G.805: Generic functional architecture of transport networks

ITU-T G.826: Error performance parameters and objectives for international, constant bit rate digital paths at or above the primary rate

ITU-T G.841: Types and characteristics of synchronous digital hierarchy (SDH) network protection architectures

ITU-T G.957: Optical interfaces for equipment and systems relating to the synchronous digital hierarchy

ITU-T G.958: Digital line systems based on the synchronous digital hierarchy for use on optical fibre cables

ITU-T M.2101.1: Performance limits for bringing into service and maintenance of international SDH paths and multiplex section

ITU-T T.50: International Reference Alphabet (IRA) - Information technology 7 bit coded character set for information interchange

The synchronization and timing of optical SDH interfaces shall conform to the following recommendations:

ETS/EN

ETS 300 417-6-1 / EN 300 417-6-1 V1.1.2: Synchronisation Layer Functions

ETS 300 462-1 / EN 300 462-1-1 V1.1.1: Transmission and Multiplexing (TM); Generic requirements for synchronization networks; Part 1: Definitions and terminology for synchronization networks

EN 300 462-4-1 V1.1.1: Transmission and Multiplexing (TM); Generic requirements for synchronization networks; Part 4-1: Timing characteristics of slave clocks suitable for synchronization supply to Synchronous Digital Hierarchy (SDH) and Plesiochronous Digital Hierarchy (PDH) equipment

ETS 300 462-5 / EN 300 462-5-1 V1.1.2: Transmission and Multiplexing (TM); Generic requirements for synchronization networks; Part 5: Timing characteristics of slave clocks suitable for operation in Synchronous Digital Hierarchy (SDH) equipment

ITU

ITU-T G.813: Timing characteristics of synchronous digital hierarchy (SDH) equipment slave clocks (SEC)

Abbreviations

ADM Add-drop multiplexed ALS Automatic Laser Shutdown BIP (Bit Interleaved Parity)

CAS Channel Associated Signalling CAP Carrier-less Amplitude and Phase CRC
Cyclic Redundancy Check DTMF Dual Tone Multi-Frequency

EN European Norm

EOW ENGINEERing Order Wire

ETS European Telecommunications Standards GPS Global

HDSL High Density Subscriber Line

IEC International Electrical Commission ITU International Telecommunication Union IP
Internet Protocol

ISDN Integrated Services Digital Network MCMI Multi Coded Mark Inversion

MS Multiplex Section

NE Network Element

NMS Network Management System LAN Local Area Network

OS Optical Section

OSPF Open Shortest Path First

PDH Plesiochronous Digital Hierarchy PPP Point-to-Point Protocol

RS Regenerator Section

SDH Synchronous Digital Hierarchy

SNMP Simple Network Management Protocol SOHSection Overhead

STM Synchronous Transport Module TCP Transmission Control Protocol TTI Trail
Trace Identifier

VC Virtual Container

VF Voice Frequency

General requirements

The digital multiplex equipment shall be universal, software-controlled, and provide various interface cards to connect tributary interfaces signals such as voice, teleprotection and data to aggregate interfaces. On aggregate level 2Mbit/s and 8Mbit/s electrical interfaces complying with ITU-T recommendations G.703 / G.704 and 2Mbit/s HDSL interfaces shall be available. In addition, optical STM- 4 aggregate interfaces on 620Mbit/s shall be available. All modules shall form an integrated part of a shelf.

The multiplexer shall provide means to drop and insert individual 64 kbit/s signals and allocate them to determined time slots in the 2Mbit/s streams. Path protection on 64 kbit/s and 2Mbit/s shall be supported.

It shall be suitable for operation in substation with harsh environment with high electromagnetic interference, be highly reliable and provide secure communication for real time signals such as voice, SCADA, tele protection and status/control signals.

The equipment offered shall already be working successfully in telecommunication networks operated by power utilities. It shall comply to the latest ITU-T standards and be able to be interconnected with telecommunication equipment.

Any equipment in the network shall be manageable from a control centre and there shall be means to supervise external/existing equipment as well.

As a minimum module for the following user signals shall be available as plug- in units for the digital multiplexer:

Analogue subscriber interface: subscriber and exchange side

4-wire E&M voice interface

G.703, 64kbit/s data Interface

X.24/V.11 (RS-422), Nx 64kbit/s data interface

Alarm collection interface

Teleprotection command interface

Binary signal (status and control) interface

2Mbit/s electrical interface for unframed signals acc. to ITU-T G.703 and framed signals acc. to G.703 and G.704.

Additionally, the equipment shall provide the following aggregate interfaces:

STM-4 (620 Mbit/s) optical 1+1 interface for medium and long distances, with automatic laser shut down.

STM-4 (620 Mbit/s) optical add-drop interface for medium and long distances, with automatic laser shut down

STM-4 (620 Mbit/s) electrical interface

2 Mbit/s HDSL interface

The equipment shall be equipped with a ringing generator for analogue subscriber interfaces.

General Conditions

The same equipment shall be used as a terminal, for through connections (transit, repeater) and as add-drop multiplexer (ADM) with integrated optical line modules.

First order multiplexing (2048 Mbit/s), second order multiplexing (8448 Mbit/s/s) and STM-4 multiplexer shall be integrated.

Conference for voice channels and point-multipoint function for data signals shall be possible.

The equipment shall be of fully modular design, based on a single shelf.

Channel capacity: Digital Cross Connection

The equipment shall be equipped with a redundant cross connection function with decentralized cross connection functions on each board.

The cross connect capacity shall be minimum 40x2Mbit/s, or 200x64kbit/s non- blocking.

Redundant centralised functions

The equipment shall be equipped with redundant circuits for all centralised functions.

Power Supply

The multiplex equipment shall operate at 48VDC +/- 15%. Redundant power- supply shall be supported.

ITU Compliance

The Equipment shall comply to the latest ITU-T recommendations for the plesiochronous and synchronous hierarchies, such as:

G.702-704, G.706, G.711-714, G.732, G.735-737, G.742, G.826, G.823, Q.552

Electromagnetic compatibility and safety regulations

The equipment shall comply with the EN50022, EN50082, IEC 801-2, IEC 801-6 and shall be conformant with CE.

Ambient Conditions

Storage and transport: -40 ... +70°C; 98% (no condensation) Operation: -5 ... +45 °C,
humidity of max. 95% (no condensation)

Mechanical construction

The equipment shall be of robust design. All tributary and aggregate units shall be integrated in the same shelf.

All connectors shall be accessible from the front.

Network management system

The equipment shall be software programmable, either by a local craft terminal - preferably notebook - or a centralized Network Management System (NMS).

Traffic through the multiplexer shall under no circumstances depend on Network Management System, i.e. the multiplexer has to operate without being connected to any management system.

The Network Management System shall be used to supervise the PDH and SDH network.

Path protection

The equipment shall provide means to protect 64kBit/s channels. The protection shall be end to end from one interface (telephone or data) to the other. It shall switch automatically from the main channel to the standby channel. It shall be configurable whether the system switches back to the main channel (reversible switching) or not (non-reversible).

If a path has switched to its standby route because the main route is disturbed this shall be indicated with an alarm.

The switching shall be done within the multiplexer without using the Network Management System.

Section protection

The equipment shall provide means to protect 8Mbit/s and 155 Mbit/s connections. It shall be possible to use two independent links: one as the main and the other as the standby. The system shall automatically switch to the standby connection and generate an alarm if the main connection is disturbed.

The switching shall be done within the multiplexer without using the Network Management System.

Network Topology

It shall be possible to build point to point - , linear-, ring-, T, and meshed networks.

Synchronisation

The equipment shall be synchronisable with an external clock, with connected 2048 Mbit/s signals and/ or with internal oscillator. The synchronization shall be configurable and it shall be possible to distribute the synchronization to other equipment as well.

The system shall have means to switch to select the synchronisation source as well as means to prevent the system from switching synchronisation loops. The equipment shall be capable select the synchronisation source by means of the SSM (Synchronisation Status Messaging) feature according to ITU-T G.704 or priority based.

Alarms

Each module shall supervise its functions and shall have an alarm-indication LED on its front. All alarms shall be collected by the NMS.

Each node shall be capable to collect up to 50 external alarms.

Test Loops

The equipment shall provide means to loop signals on 64kBit/s level as well as on 2Mbit/s level.

It shall indicate an alarm if a loop is activated. It shall have the possibility to determine the time after which an activated loop is switched back.

Maintenance facilities

Every Network Element shall have a built-in Signal Generator and Analyser to analyse communication paths. It must be possible to cross connect the Generator and Analyser to transmission channels and terminate the signal in other Network Elements. The configuration must be possible locally with the craft access terminal and remotely with the NMS or the craft access terminal.

It must be possible to loop-back signals locally and remotely using the craft access terminal or the NMS.

Requirements for Transport Level 13.6.1SDH Aggregate Units

The interface shall be designed for use on single mode fiber at 1310nm and 1550nm. The optical connectors shall be E2000.

The following main functions shall be supported: Termination of the OS-, RS-, MS- and VC-4 layer

Extraction and insertion of the SOH communications information Through connections of VC-12 and VC-3

The following maintenance functions shall be supported:

Status indications

Loops

Restart after ALS TTI monitoring BIP Error Insertion

The following SDH interfaces shall be available:

6 × STM 4 optical port interface 4 × STM 1 optical port interface 2× STM 4 electrical port interface

2× STM 1 electrical port interface

13.6.2 HDSL Aggregate Units

2Mbit/s HDSL interface

The HDSL interface shall provide means to interconnect the multiplexer over two pairs of copper wire up to 12km using CAP modulation (Carrier-less Amplitude and Phase). It shall communicate either with another interface of the same type or with a remote desktop terminal.

2Mbit/s HDSL Desktop Terminal

This Terminal shall provide a HDSL interface to transmit 2Mbit/s over two pairs of copper over a distance up to 12 km. It shall be housed in a metallic indoor case. The following interfaces shall be available:

- G.703, 2Mbit/s, 75 ohm
- G.703, 2Mbit/s, 120 ohm
- X.21/V11, Nx 64kBit/s (N = 1 .. 32)
- V.35, Nx 64kBit/s (N = 1 .. 32)
- V.36 / RS449, Nx64kBit/s (N = 1 .. 32)

LAN connection:

10/100 Base T Ethernet connection for e.g. router supporting LAN protocols: IP, IPX; Routing Protocols: RIP; WAN protocols: HDLC, PPP, Frame Relay (including RFC 1490). It shall inter-operate with Cisco, Wellfleet, 3Com etc. and be manageable locally, remotely, and with Telnet and SNMP. Two such Desktop Terminals shall be connectable to provide a 2Mbit/s link over two pairs of copper.

HDSL Repeater:

An HDSL repeater solution for distances longer than 12km shall be offered including a remote powering solution.

HDSL Line Protection:

The HDSL equipment shall (where necessary) be protected against influences of induced voltages up to 10 kV.

Tributary Units

4-Wire Interface (VF interface)

This interface shall provide 8 voice channels with a bandwidth of 300 Hz .. 3.4 kHz and 2 signaling channels ($M \Rightarrow E$, $M' \Rightarrow E'$) per voice channel.

Each interface shall be configurable to operate with or without CAS. With CAS it shall use the a and b bits for the two signaling channels.

The level shall be software adjustable within the following range: Input: +7.5 .. -16 dBr

Output: +7.0 .. -16 dBr

Modules where each interface can be individually configured with 1+1 path protection shall be available.

Analogue Subscriber Interface

An interface with at least 10 subscribers as well as high-density analogue subscriber card with 60 subscribers shall be available. The ringing generator shall be integrated in the subscriber module interface. The ringer frequency shall be adjustable for 20Hz, 25Hz, and 50Hz.

The following main functions shall be supported:

Downstream signaling:

Ringing

Metering Polarity reversal

Reduced battery

No battery

Upstream signaling: On/off-hook

Pulse and DTMF dialing Flash impulse

Earth key General:

Constant current line feeding Line test

Permanent line checks

CLIP (On-hook VF transmission) Metering after on-hook

Exchange Interface

This interface shall provide 12 interfaces to connect remotely connected analogue subscribers to an exchange. It shall provide the following functions:

pulse dialing

tone dialing (DTMF) earth key function

metering function(12 kHz or 16 kHz) flash impulse

polarity reversal indication of busy lines

The following parameters shall be configurable by software: input voice level -5 .. +4 dB

output voice level -7.5 .. -1 dB metering pulse enable/disable signaling bit definition

loop back of voice to the telephone

Party line Telephone System (ENGINEERing Order Wire)

An Engineering order wire (EOW) facility shall be provided at each multiplexer. The EOW shall be configured as a party line and use in band DTMF signaling to call another EOW-Terminal. The Terminal shall have an integrated DTMF decoder allowing to program a subscriber call number (1..4 digits), and two group call numbers (1..4 digits each).

V. 24/V.28 RS232 Interface

It shall support the following bit rates: 0 .. 0.3 kbit/s transp. (V.110)

0.6 .. 38.4kbit/s synchronous / asynchronous (V.110).

Modules where each interface can be individually configured with 1+1 path protection shall be available.

V.11/X.24 Interface

This interface shall comply to the ITU-T X.24 recommendation for signal definition and to V.11 for electrical characteristics.

It shall support the following bit rates:

48, 56, Nx 64 kbit/s ($N = 1 \dots 30$) synchronous

0.6 .. 38.4kbit/s synchronous / asynchronous (X.30)

Modules where each interface can be individually configured with 1+1 path protection shall be available.

V.35 Interface

This interface shall comply with the ITU-T V.35 and V.110 recommendations. It shall support the following bit rates:

48, 56, Nx 64kbit/s ($Nx = 1 \dots 30$) synchronous

0.6 .. 38.4kbit/s synchronous / asynchronous

Modules where each interface can be individually configured with 1+1 path protection shall be available.

V.36 / RS 449 Interface

This interface shall comply with the ITU-T V.36 and V.110 recommendations. It shall support the following bit rates:

48, 56, Nx 64kbit/s (N = 1 .. 30) synchronous

0.6 .. 38.4kbit/s synchronous / asynchronous

Modules where each interface can be individually configured with 1+1 path protection shall be available.

64 kBit/s Co directional Interface

This interface shall comply with the ITU-T G.703 part 1.2.1 for co directional data transfer.

A module shall have at least 8 interfaces.

Modules where each interface can be individually configured with 1+1 path protection shall be available.

LAN Interface

There shall be a 10/100 Base T interface available with Router Bridge and FRAD Function available. The following specification shall be covered:

Ethernet connection: 10/100 Base T LAN protocols: IP, IPX

Routing Protocols: static IP route, OSPF2 V2

WAN protocols: PPP, Frame Relay (including RFC 1490)

The interface shall be manageable locally, remotely, with the management system of the platform.

The LAN interface shall support linear-, ring- and star-configurations. The WAN side shall support link capacities Nx64kBit/s and 2Mbit/s.

Alarm Interface

This interface shall provide means to collect various alarms, which will be displayed, on the Network Management System. It shall be used to manage non- PDH equipment with the PDH Network Management System.

It shall have at least 24 binary inputs and at least 4 outputs, which can be switched by the Network Management System.

It shall be possible to connect an input to an output so that if an alarm occurs, the output contact will be switched.

It shall be possible to label an alarm. The label-text shall be read from the interface module so that it can be indicated on the Network Management System as well as on the local craft terminal.

Teleprotection Interface

The protection of the lines shall be arranged as detailed in Section 5. Teleprotection equipment shall be provided for permissive tripping and direct tripping on the lines.

The permissive tripping signals are required to operate circuit breaker trip relays in conjunction with the distance protection and directional earth fault relays.

The direct tripping signals are required to operate remote circuit breaker tripping relays.

Technical Requirements:

This interface shall provide means to transmit four bi-directional command channels.

The signals shall be adjustable from 24 to 250VDC by means of software.

All inputs and outputs shall be isolated and with EMC immunity for harsh environment.

Security, Dependability and Transmission speed shall be selectable and programmable.

It shall be able to drop and insert commands, transfer commands as a transit station, it shall be possible to have AND- and OR-connections between commands.

The interface shall support T-nodes.

The Teleprotection interface shall provide an integrated non volatile event- recorder which shall be synchronizable either internally or by GPS or a command counter which counts trip commands.

The teleprotection interface shall provide means for signal delay measurement. 1+1 protection must be available; the switching shall be done within less than 10ms.

The interface shall do automatic loop test every 60s.

Under no circumstances shall the interface cause trip-commands in case of power supply failure or when put in or out of service.

It shall be possible to synchronize all teleprotection interfaces with one GPS in one station. The GPS time shall be distributed over the teleprotection channel.

An 8-bit command addressing shall be used to prevent tripping if the signal is inadvertently re-routed through the telecommunication network.

Optical Protection Relays Interface

This interface shall have an optical port to connect protection relays for teleprotection to the multiplexer. It shall operate on 1300nm use MCMI line coding and be suitable for teleprotection relays.

Optical amplifier

In case of long distance communication, which cannot be covered by a standard optical interface, optical amplifier shall be applied.

The amplifier shall provide a power budget of at least 48dB for bit rates from 8 Mbit/s up to 622 Mbit/s

on a pair of single-mode fibre for single wavelength (single channel) have no dispersion limits for STM-4 applications up to 250km.

Binary Contact Interface

This interface shall provide means to transmit binary signals. The inputs and outputs shall be isolated.

The inputs shall be suitable for 24VDC .. 60VDC. Outputs shall be solid state relays.

The interface shall provide a 24VDC short circuit proofed auxiliary power supply.

It shall be able to drop and insert commands, transfer commands as a transit station, it shall be possible to have AND- and OR-connections between commands.

The Teleprotection interface shall provide an integrated event recorder, which shall be synchronizable either internally or by GPS.

2Mbit/s G.703 / G.704 Interface

This interface shall comply with the ITU-T G.703 and G.704 recommendations.

The interface module shall have at least four interfaces to be activated individually. It shall be possible to have 128 interface modules a multiplexer.

In order to connect different equipment, the interfaces shall be available with the impedance of 120 ohms and 75 ohms.

The interface shall support CRC-4 multi-frame according to ITU-T G.704 (enabled and disabled by software).

The CAS signaling according to ITU-T G.704 table 9 shall be activated optionally.

The interface shall be able to extract the 2.048 MHz clock, which can be used to synchronize the multiplex equipment.

The interface module shall support 2Mbit/s loop-back of the incoming signal as well as the loop-back of the internal signals.

OPERATIONAL TELEPHONE SYSTEM

There are two separate telephone systems under NLDC, that is, Operational Telephone System

(IP based) and Administrative Telephone System (Traditional circuit switch based).

An IP Phone facility shall be provided at the CP1 230/110kV GIS substation. The IP Phone shall be incorporated by IP connection from upstream substation through IP network in the Operational Telephone System which is controlled from the existing call manager at NLDC.

At least three telephone sets proper to the above-mentioned Administrative Telephone System shall be provided at each new substation.

The contractor shall consult the Employer and confirm whether more additional telephone sets/instruments for the systems need to be provided including their types and specifications.

SCHEDULE OF REQUIREMENTS FOR FIBER OPTIC MULTIPLEXER EQUIPMENT

SL.NO.	DESCRIPTION	UNIT	REQUIRED
1.0	GENERAL:		
1.1	Type of multiplexer		SDH: ADM
1.2	Complying to ITU-T rec.		Yes
1.3	Transmission Capacity	Mbit/s	STM-4: 620
1.4	Access capacity on 64 kbit/s	channels	Minimum 200
1.5	Access capacity on 2 Mbit/s	channels	Minimum 40
1.6	Redundant central processor		Shall be available
1.7	Digital cross connect function		Fully non-blocking
2.0	Available AGGREGATES:		
2.1	Optical aggregates (ITU-T G.957)		L-1.1, L-1.2
3.0	Available TRUNK INTERFACES:		
3.1	HDB3, 2 Mbit/s interfaces per module	No.	Minimum 8

SL.NO.	DESCRIPTION	UNIT	REQUIRED
3.2	Complying to ITU-T rec.		G.703, transparent G.704, selectable
3.3	HDSL, 2Mbit/s interface: no of copper wires	No. ch ch / pair of wire	4 or 2 30 or 15 30 / 2 pairs 30 / 1 pair 15 / 1 pair
4.0	Available USER INTERFACES		
4.1	Voice interfaces for trunk lines:		
4.1.1	1 + 1 com path protection, available for all		yes
4.1.2	Analogue, 4wire with E&M: Input level Output level	dBr	+7.5 .. -16 +7.0 .. -16.5
4.1.3	Analogue, 2wire with E&M: Input level Output level	dBr	+6.5 .. -12.5 -1.0 .. -20
4.1.4	Digital, 2Mbit/s CAS or PRI		yes
4.2	Voice interfaces for remote subscriber:		
4.2.1	2wire, subscriber side	dBr	-5 .. +4 / -7.5 .. -1
4.2.2	2wire, PABX side	dBr	-5 .. +4 / -7.5 .. -3
4.3	Integrated teleprotection		
4.3.1	Interface for Commands:		
4.3.1.1	Number of independent commands	No.	4
4.3.1.2	Transmission time max.	ms	6

SL.NO.	DESCRIPTION	UNIT	REQUIRED
4.3.1.3	Signal voltage	Vpeak	250
4.3.1.4	1 + 1 com path protection		yes
4.3.2	Interface(s) for Differential Protection:		
4.3.2.1	Electrical interface: G.703	kbit/s	64
4.3.2.2	Optical Interface	kbit/s	Minimum 64
4.4	Data: channels per module		
4.4.1	1 + 1 com path protection, available for all		yes
4.4.2	V.24/V.28 (RS-232): up to 38.4kbit/s	No.	4
4.4.3	V.11/X.24 (RS-422): 64kbit/s	No.	4
4.4.4	V.35: 64kbit/s	No.	4
4.4.5	V.36 (RS-449): 64kbit/s	No.	2
4.4.6	G.703: 64kbit/s	No.	8
4.4.7	Ethernet: 10/100 Base T WAN capacity Protocols	No. Mbit/s	1 Min: 2x 2Mbit/s Min.: IP
4.5	Integrated alarm gathering module:		
4.5.1	Number of external alarms per module	No.	Min. 20
4.5.2	Auxiliary power supply for ext. contacts		Yes
4.6	Network Management System		
4.6.1	Type/Name of configuration tool		
4.6.2	For fault / configuration management		Yes / yes
4.6.3	For local / remote operation		Yes / yes

SL.NO.	DESCRIPTION	UNIT	REQUIRED
4.6.4	Data communication network (DCN)		Ethernet / IP or Ethernet / OSI
4.7	Ambient Conditions:		
4.7.1	Storage: ETS 300 019-1-1, class 1.2	°C / % hum	-25 .. + 55 / class 1.2
4.7.2	Transport: ETS 300 019-1-2, class 2.2	°C / % hum	-25 .. + 70 / class 2.2
4.7.3	Operation: ETS 300 019-1-3, class 3.1E	°C / % hum	-5 .. +45 / class 3.1E
4.8	Power Supply		
4.8.1	Operation	VDC	48 / 60 (-15/+20%)
4.8.2	Fully redundant power supply		yes

8.6.8 230kV Outdoor Surge Arresters

General

Surge arresters shall be of the type employing non-linear metal oxide resistors without spark gaps. The Contractor shall demonstrate by calculations that the surge arresters will adequately protect the switchgear arrangement proposed.

Operating Duty and Performance

The protective characteristics and discharge duties shall be determined by the Contractor. The arresters shall give consistent protection to their associated equipment against over voltages produced by lightning, switching, station internal or external faults, and other system disturbances.

The arresters shall be rated and tested such that they are able to discharge a specified maximum energy due to the application of temporary voltages of form and magnitude which can occur in service as determined by insulation coordination studies to be carried out by the Contractor, without coming into the temperature region where thermal runaway could result upon subsequent application of maximum transient and steady state voltage conditions.

Particular attention shall be given to the high discharge currents which some of the arresters may experience in service due to the requirements to discharge the energy of the shunt capacitors and reactive compensating equipment or in other circumstances.

The design of the arresters shall take into account and shall maximize the degree of current sharing between complete arresters. Similarly, the design shall also take into account and shall maximize the degree of current sharing between parallel columns of the same arrester.

The reference current of the arresters shall be high enough to eliminate the influence of grading and stray capacitance on the measured reference voltage. The Bidder/Contractor shall furnish the values and supporting calculations along with the Bid. The arresters shall be fully stable thermally under site conditions and shall take care of the effect of direct solar radiation.

Constructional Features

Surge arresters shall be housed in porcelain insulators designed to withstand extremes of the environment described. The insulation shall have a minimum creepage distance of 25 mm/kV rated system phase to phase voltage. The method of sealing against the ingress of moisture shall be of a type well proven in service and the manufacturing procedures shall include an effective leak test which can be demonstrated to the inspecting ENGINEER if required.

The internal components of arresters shall be arranged to minimize radial voltage stresses, internal corona and to ensure minimal capacitive coupling with any conducting layer of pollutant on the outside of the porcelain housing. Except where approved, organic materials are not permitted.

Good electrical contact shall be maintained between resistor blocks taking account of any thermal expansion and contraction of the block or mechanical shock during transport and erection, by installing a well proven clamping system.

Metal oxide arresters installed outdoors shall be able to dissipate, when new, twice the energy generated in the resistor blocks when energized at their maximum continuous operating voltage immediately having been subjected to the discharge duties specified in IEC 60099-4 and assuming that the porcelain housing and the surrounding air is at least 5°C higher than the maximum ambient air temperature specified.

Good quality control of the manufacturing process of the resistors shall be ensured by rigorous testing procedures. The procedures shall ensure that the characteristics of the blocks are, and will remain, within the specified limits when new and throughout the anticipated life of the arresters. Samples may be selected at random by the ENGINEER for special tests to be agreed with the manufacturer.

All surge arresters shall be fitted with a pressure relief diaphragm which shall prevent explosive shattering of the porcelain housing in the event of an arrester failure and the arrester shall have been tested according to the high and low current tests specified in IEC 60099-1.

Fittings and Accessories

Arresters shall be supplied complete for installation in an outdoor switchyard, including insulating bases and surge counters, one per phase, and, if applicable, grading rings. The material

used for terminals shall be compatible with that of the conductors to which they are to be connected.

Each arrester shall be identified by a rating plate in accordance with the requirements of IEC 60099-4. In addition an identification mark shall be permanently inscribed on each separately housed unit of a multi-unit arrester so that units can be replaced in the correct position in the event of them being dismantled.

Surge counters shall have an internal assembly which is matched to the line discharge capability of the arrester and shall include a leakage current meter with a bi-linear scale for ease of reading. Auxiliary contacts are to be provided to signal remote indication of counter operation.

Tests

Arresters shall be designed and tested in accordance with the requirements of IEC 60099-4. Any departure shall be the subject of agreement between the ENGINEER and the Contractor. Routine tests shall be carried out in accordance with the Specification.

8.6.9 33 kV & 11kV OUTDOOR TYPE OFF-LOAD ISOLATOR

Installation	:	Outdoor (Corrosion Proof)
Type	:	Air
Construction	:	Open
Operation	:	Gang
Operating Mechanism	:	Manual
Mounting Position	:	Vertical or Horizontal on supporting structure as required
Number of Pole	:	3 (Three)
Frequency	:	50 Hz
Nominal System Voltage	:	33 KV / 11 KV
Rated System Voltage	:	36 KV / 12 KV
Power frequency voltage withstand to earth	:	70kV(rms) / 28kV

Power frequency voltage withstand across open contacts	: 70kV(rms) / 28kV
Lightning impulse withstand to earth(1.2/50μs)	: 170 kV peak /75kV
Lightning impulse withstand across open contacts(1.2/50μs)	170 kV peak / 75kV
Rated Normal Current	: 630A
Rated Short Time Withstand Current	: 31.5 kA (3 sec.) / 20 kA (3 sec.)
Material of Contact Surface	: Silver plated copper
No. of Auxiliary switches	: 6 NO + 6NC
Standard	: Performance, design & testing shall be in accordance with the latest edition of applicable IEC – 62271-102.

Features

Single – Break Pattern [Vertical break or Horizontal break, OFF load type.

Channel type mounting base insulator, blast.

Coupling tubes for gang operation and adjustable operating rod with insulating link and intermediate guide for operating rod.

Auxiliary switch, operated by the phase coupling tube, to control circuits for operating indicators, alarms, electrical inter-locking with the respective breaker to ensure that the isolator can only be operated when the breaker is in “OFF” position etc. with at least 100% spare contacts.

Earthing steel pads with provision for earth lead.

Glands for multi-core control cables.

Provision for pad locking in “ON” & “OFF” position.

Provision of key interlocking.

Stainless Steel 304 Nuts, bolts & all accessories for mounting on structures.

Interlocking magnet for electrical interlocking.

All ferrous parts shall be hot dipped galvanized with three coats of powder epoxy after completion of machining.

Galvanizing shall be in accordance with BS-729.

All control devices shall be suitable for operation on 110 V DC supplies from Sub- station.

Operating mechanism shall be fully tropicalised and housed in corrosion proof housing. Complete supporting steel structure. All supporting steel structure shall be hot dipped galvanized with three coats of powder epoxy after completion of fabrication.

Isolating devices shall be accordance with IEC-62271-102. They shall be complete with supporting steel work and installed to maintenance of any section of the sub-station plant when the remainder is alive and shall be so located that the minimum safety clearances are always maintained.

The air gap between terminals of the same pole with the isolator open shall be of a length to withstand a minimum impulse voltage wave of 115 Percent of the specified impulse insulation rating to earth.

Isolating switches shall be designed for life operation and isolators shall be hands operated. Where used for feeders they shall be capable of switching transformer-magnetizing currents. Main contacts shall be of the high-pressure line type and acing contacts provided shall be to the ENGINEER's approval.

Service conditions require that isolating switches shall remain alive and in continuous service for periods of up to 2 years in the climatic conditions specified without operation or maintenance. These contacts shall carry their rated load and short circuit currents without over heating or welding and at the end of the two year period the maximum torque required at the operating handle to open 3-phase isolator shall not exceed 350 NM.

All feeder isolators shall be fitted with approved three phase link earthing devices, mechanically coupled or interlocked with the main isolator so that the earthing device and main isolator can not be closed at the same time.

Isolating devices shall be interlocked with circuit breakers and isolators as necessary to prevent the possibility of making or breaking load current.

Isolator operating mechanisms shall be of robust construction, carefully fitted to ensure free action and shall be un-effected by the climatic conditions at site. Mechanism shall be as simple as possible and comprise a minimum of bearing and wearing parts. Approved grease lubricating devices shall be fitted to all principal bearings. The mechanism shall be housed in weather proof, rain and watertight enclosure complete with auxiliary switches, terminal blocks and cable gland

plates. All steel and malleable iron parts including the supporting steelwork shall be galvanized as per BS-729.

8.6.10 33 KV & 11KV OUTDOOR CURRENT TRANSFORMER

Application	:	Metering and Protection
Installation	:	Outdoor.
Construction	:	Sealed Tank
Insulation	:	Oil
Number of Phase	:	Single
Rated Frequency	:	50 Hz
Mounting	:	On Supporting Structure
System Primary Rated Voltage	:	33 kV Ph to Ph / 11 kV Ph to Ph
Maximum System Voltage	:	36 kV Ph to Ph / 12 kV Ph to Ph
System Earthing	:	Effectively earthed
Basic Insulation Level (1.2/50 Micro-sec.)	:	170 kV(peak) / 75 kV
Power Frequency Withstand Voltage (1 Min. 50 Hz).	:	70 kV(rms) / 28 kV
Ratio	:	800-400/5/5/5A 1600/5/5/5A
Primary	:	Single Winding
Secondary	:	Three Winding (1-Metering & 2-Protection)
Accuracy Class	:	0.5 for metering, X for Protection.
Burden	:	30 VA

Min knee point voltage	:	>600V @ max. ratio for Protection <40V @ max. ratio for Metering
Short Time Current Rating	:	31.5 KA (3 sec.) / 20 kA (3 sec.)
Extended Current Rating	:	120% of Rated Current
Over Current Rating	:	10
Creepage Distance	:	25mm/kV (Min)
Standard	:	Performance, design & testing shall be in accordance with the latest edition of applicable IEC – 60044-1.

Features:

Current transformer shall have porcelain outdoor type bushing (Not tank type).

The equipment must be tropicalised and suitable for the outdoor location.

Stainless Steel 304 nuts, bolts and all accessories required for mounting on structure.

All ferrous parts shall be hot-dip galvanized with three coats of powder epoxy after completion of machining, Galvanizing shall be in accordance whether BS-729.

Each terminals shall have Stainless Steel 304 nuts and bolts.

Diagram plate and rating nameplate shall be provided.

Supporting clamps, all accessories shall be provided with the CTs for installation on supporting steel structure for time feeders CTs.

Supporting lattice type steel structure of sufficient height to coordinate with the sub- station equipment/materials shall be supplied with CTs for installation of CTs for transformer feeders.

8.6.11 33 KV / 11 KV OUTDOOR TYPE VACUUM CIRCUIT BREAKER

1	Type	Outdoor type VCB
2	Standard	IEC 62271-100
3	Rated voltage	36 kV / 12 kV

4	No. of poles	Three (3)
5	Rated short-duration power frequency withstand Voltage (1 min.)	70 kV rms / 28 kV rms
6	Rated lightning impulse withstand voltage	170 kV peak / 75 kV peak
7	First pole to clear factor	1.3
8	Rated current	630 A
9	Rated short circuit breaking current	31.5 kA rms / 25 kA rms
10	Rated short circuit making current	80 kA peak / 50kA
11	Short time withstand current for 1 sec.	25 kA rms / 20 kA rms
12	Total closing time	<150 ms
13	Total breaking time	<100 ms
14	Operating mechanism	Motor spring stored energy
15	Rated duty cycle	O-0.3S-CO-3min-CO
16	Number of closing coils	1
17	Number of tripping coils	2
18	Number of auxiliary contacts for:	
	Making	Min. 8
	Breaking	Min. 8
	Middle position	0
19	Creepage Distance	25mm/kV (Min)
20	Protection class	IP55
21	Standard	Performance, design & testing shall be in accordance with the latest edition of

		applicable IEC – 62271-100, 60694 .
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Features:

Grading terminal connector.

All current carrying parts shall be made of copper.

Externally visible circuit breaker position indicator.

Electrically remote controlled operating mechanism.

Shall be capable of the interrupting duties produced by the switching of transformer magnetizing current and the switching of line charging current. Tests certificate demonstrating this ability of the circuit breakers shall be submitted with the offer.

Circuit Breaker closing mechanism shall be 230 volt AC motor wound spring- operated type such that the closing speed is independent of the operator.

Shall be two tripping coils and one closing coil.

Hand closing and tripping shall be done through manual levers.

Trip free mechanism i.e. tripping is independent.

Local “Close” and “Trip” controller.

Operation Counter.

Supporting Steel Structure.

Bushing Insulator as Specified in IEC-60137.

Corrosion Proof sheet steel control kiosk, with hinged door on three sides and necessary multi-core cable glands. Controls from this position will normally be used under maintenance and emergency conditions only. AC 230V lighting system inside the door of control kiosk shall be provided.

ARC suppression type contacts.

Manually operating devices for slow closing for inspection and maintenance. It shall not be possible to slow close a breaker when in normal services.

Earthing pad with provision for earth leads.

Standard sundries like anti-condensation heaters, MCBS wiring board etc.

Evidence of prototype tests together with test certificate from a recognized institution covering

the equipment shall be furnished with the offer. The test duty shall be as per the requirements of relevant IEC standards.

All bolts and nuts shall be made of stainless steel 304.

All steel structure supports shall be hot dip galvanized with three coats of epoxy powder.

8.6.12 TERMINATION POINT CONDUCTOR AND JUMPERS

Installation	:	GIS Substation Gantry Area, Outdoor.
Type	:	Aluminum Conductor Steel Reinforced (ACSR)
Code Name	:	As required.
Conductor Size	:	As per Current carrying capacity.
Standard	:	Performance, design & testing shall be in accordance to the latest editions of ASTM B-232.
Shipment	:	On standard non-returnable wooden reels Gross weight shall not exceed 2000 Kg per reel.

Special Features

Shall be of continuous length between supports.

Conductors to be used shall be stressed not more than 33% of their breaking strength.

Overhead line conductors carried by the Substation Gantry structures shall be erected with such a tension that when the conductors are subject to a transverse wind pressure of 640 pascal's on the whole projected area, the factor of safety is not less than 2 (Two).

When dissimilar metals are in contact, approved means shall be provided to prevent electro-chemical action and corrosion.

8.6.13 ELECTRICAL HARDWARE FOR 230kV OVERHEAD LINE TERMINATION POINT

230kV Overhead Line connection to composite type outdoor termination unit in the 230kV OHL Gantry Area shall be of ACSR and shall be in accordance with BS 215, 159 and 2898 in respect of current rating and material analysis.

The number and diameters of the individual wires forming the finished conductor shall be subject to approval. All necessary terminals and connectors shall be provided under this Contract and also between equipment provided on this Contract.

All connectors shall be of compression type and made of Aluminum alloy suitable for the conductor. The current carrying capacity of all connectors & clamps shall not be less than that of equivalent length of the respective conductor.

Load support clamps shall be complete with stainless steel 304 bolts, nuts, lock washers etc. and of the appropriate size.

All clamps and fittings and their components shall be electro-chemically compatible with the conductor material and those made of steel or malleable iron shall be galvanized as per BS-729.

Joints and connections shall be such as to permit easy dismantling. All necessary terminals and connections (bi-metallic) shall be provided for connection to the equipment.

Suspension and tension conductor clamps shall be of approved types and shall be as light as possible. Suspension and tension clamps shall be designed to avoid any possibility of deforming the stranded conductor and separating the individual strands.

Tension conductor clamps shall not permit slipping of or damage to or failure of the complete conductor or any part, thereof at a load less than 70% of the breaking load of the conductor.

Unless otherwise approved, ACSR conductors and connections shall be so arranged and supported that under no circumstances, including short circuit conditions, the clearances between live metal and earth of earthed metal work or between other conductors be less than the specified distances.

Where dissimilar metals are in contact, approved means shall be provided to prevent electro-chemical action and corrosion.

Catalogue with making on the catalogues of the hardware proposed shall be submitted with the offer.

8.6.14 Electrical Equipment Enclosures

Equipment enclosures for electrical equipment shall comply with IEC 60079, IEC 60529 and IEC 60947-1 as applicable. Equipment enclosures for use in hazardous areas other than explosive gas atmosphere shall comply with National and Local Regulations relating to this application.

Unless otherwise specified, minimum equipment enclosure classifications for non-rotating electrical equipment shall be as follows: -

Indoors only in totally enclosed rooms with provision for limiting ingress of dust	IP31
Indoors except as noted otherwise	IP54
Outdoors and indoors in areas subject to water spray or heavy condensation	IP55W

The enclosure classification of main and auxiliary cable boxes with the cable(s) terminated shall not be less than that of the associated equipment, subject to a minimum classification of IP55.

Current Ratings

Normal Current Ratings Current ratings in accordance with IEC 60059 shall be adopted, unless otherwise agreed with the ENGINEER.

Every current carrying part of the equipment shall be capable of carrying its siterated current continuously under the site ambient conditions as specified and shall not be rated on the basis of air conditioned rooms even when these are specified. In no conditions shall the specified maximum temperature be exceeded.

The current ratings specified are the continuous current ratings required at the Site, under the specified maximum temperature conditions.

Temperature Rise

Full provision shall be made for solar heat gain on all outdoor apparatus and any differential temperatures attained as a result of the impingement of solar heat.

The allowable temperature rise shall be in accordance with the relevant Standard, except where the ambient temperature exceeds the maximum permitted in that Standard, when the permitted temperature rise shall be reduced by one degree Celsius for every degree Celsius the maximum ambient temperature exceeds the maximum permitted in the Standard.

To allow for high ambient site temperatures, the allowable temperature rise for transformers shall be reduced by a maximum of 10°C. In such cases where the Contractor is unable to guarantee the permitted maximum temperature reached under site conditions, taking account of solar heating, then sunshades shall be provided to the ENGINEER's approval.

The maximum temperature attained by components under the most onerous service conditions shall not cause damage or deterioration to the equipment or to any associated or adjacent components.

The Contractor shall submit his calculations to the ENGINEER to prove that all plant has been sufficiently derated to suit the site conditions and any changes required by the ENGINEER shall be made at no extra cost.

Short-time Current Ratings

Electrical equipment shall be adequately supported and braced to withstand the forces associated with the maximum short-circuit currents specified or pertaining, whichever is the greater, and assuming that the inception of the short-circuit is at such a time that gives maximum peak currents. No provision for current decrement shall be made unless specifically permitted by the appropriate Standard, or elsewhere in this Specification.

Equipment shall be so constructed as to withstand the specified maximum short-circuit currents for the time specified in the Schedules without the temperature exceeding the specified maximum short-time temperature or value stated in the relevant standard, under these

conditions. The equipment shall be considered as being operated at the maximum permitted continuous temperature prior to inception of the short circuit.

The final temperature attained as a result of the passage of short-circuit current shall not cause permanent damage, or deterioration sufficient to reduce the normal operating characteristics below the specified or most onerous operating requirements, whichever is the highest.

Voltage Ratings

Normal Voltage Ratings

Unless otherwise specifically stated, any reference to voltage rating shall be deemed to refer to the nominal rated voltage or voltages of electrical equipment. Standard voltage levels in accordance with IEC 60038 shall be adopted, unless otherwise specified by or agreed with the ENGINEER.

All electrical equipment shall, except where otherwise specified, be capable of continuous operation at a voltage in the range of $\pm 15\%$ of the nominal voltage and at a frequency in the range of 48 to 51 Hz coincidentally without deterioration.

The temperature rise of electrical equipment continuously operating at the specified extreme voltage and frequency shall not exceed the temperature rise when operating at nominal voltage and frequency by more than 5 °C

Short-time Voltage Ratings

All electrical equipment shall be so designed such as to withstand abnormal system voltages as required by the applicable BS, IEC or acceptable International Standard.

Electrical Insulation

Insulating materials shall be suitably finished so as to prevent deterioration of their qualities under the specified working conditions. Account shall be taken of the IEC 60085 recommendations.

Ebonite, synthetic resin-bonded laminated material and bituminised asbestos cement-bonded panels shall be of suitable quality selected from the grades or types in the appropriate IEC, or approved National Standard.

The insulation of all machine windings, solenoids, etc. other than those immersed in oil or compound, shall be of Class F materials, unless otherwise specified elsewhere.

All cut or machined surfaces and edges of resin-bonded laminated materials shall be cleaned and then sealed with an approved varnish as soon as possible after cutting.

Linseed oil and untreated materials of fibre, leatheroid, presspahn, asbestos or other similar hygroscopic types of materials shall not be used for insulation purposes. Untreated leatheroid and presspahn may be used for mechanical protection of winding insulation.

The use of asbestos is not permitted without the permission of the ENGINEER.

Wherever practicable, instrument, apparatus and machine coil windings, including wire wound resistors, with the exception of those immersed in oil or compound, shall be thoroughly dried in a vacuum or by other approved means and shall then be immediately impregnated through to the core with an approved insulating varnish. Varnish with a linseed oil base shall not be used.

No material of a hygroscopic nature shall be used for covering coils. Where inter-leaving between windings in coils is necessary, only the best manila paper, thoroughly dried, which permits penetration by the insulating varnish or wax, shall be used.

Polychlorinated Biphenyl (PCB) type materials shall not be used anywhere in the equipment or in any component.

Insulating Oil

Insulating oil shall comply with the requirements of IEC 60296. Insulating oil shall be provided by the Contractor for all oil-filled apparatus and 10% excess shall be provided for topping up purposes in sealed drums. The Contractor shall provide at no additional cost any oil treatment facilities he may require for his own use in order to ensure that insulating oil meets the requirements of the specification.

Control and Selector Switches

Control switches shall be of the three position type with a spring return action to a central neutral position and without a locking feature.

Circuit breakers shall have control switches which shall be labelled Open/N/Close or (O/N/I) and arranged to operate clockwise when closing the circuit breakers and anti-clockwise when opening them.

Control switches of the discrepancy type shall be provided where specified. Such discrepancy control switches shall be arranged in the lines of the mimic diagram. Such switches shall include lamps and be of the manually operated pattern, spring loaded such that it is necessary to push and twist the switch past its indicating position for operation. The lamp shall be incorporated in the switch base and shall flash whenever the position of the controlled device is at variance with the position indicated by the control switch. Hand dressing of the control switch to the correct position shall cause the lamp to extinguish.

Pushbutton test switches shall be provided along the control panel which will illuminate all indicating discrepancy lamps as well as spare lamps on the control panels. The scheme shall be complete with all necessary diodes and other equipment required for satisfactory operation.

Switches for other apparatus shall be operated by pushbuttons, shrouded or well recessed in their housings in such a way as to minimise the risk of inadvertent operation.

Multi-position selector switches shall have a lockable stayput action. Each position of the selector switches shall be suitably labelled to signify the functions in accordance with the approved wiring diagrams. The switch handle shall be of the pistol grip spade type to the approval of the ENGINEER.

It shall not be possible at any time to close any switching device from more than one location simultaneously, and suitable lockable selector switches shall be provided to meet this requirement. Tripping signals from all locations shall function at all times.

Particular variations of the above requirements may be agreed with the ENGINEER for special instrument or control equipment, viz. main control room desks and panels, and electrical equipment cubicles.

The contacts of all control and selector switches shall be shrouded to minimise the ingress of dust and accidental contact, and shall be amply rated for voltage and current for the circuits in which they are used.

Panels, Desks and Cubicles

Unless otherwise specified, panels, desks and cubicles, shall be of floor-mounted and free-standing construction and be in accordance with the enclosure classification specified in IEC 60079, IEC 60529 and IEC 60947-1 as applicable . All control and instrumentation panels in any one location shall be identical in appearance, construction, and colour finishes.

Panels shall be rigidly constructed from folded sheet steel of 3mm minimum thickness to support the equipment mounted thereon, above a channel base frame to provide a toe recess.

Overall height, excluding cable boxes, shall not exceed 2.5m. Operating handles and locking devices shall be located within the operating limits of 0.95m and 1.8m above floor level. The minimum height for indicating instruments and meters shall be 1.5m unless otherwise approved by the ENGINEER.

Panels shall be mounted on an approved form of anti-vibration mounting whenever necessary.

All panels, desks and cubicles shall be vermin-proof. All cable entries to equipment shall be sealed against vermin as soon as possible after installation and connecting-up of the cables to the approval of the ENGINEER.

All cubicles, desks and panels shall be provided with a natural air circulation ventilation system. All control equipment shall be designed to operate without forced ventilation.

For outdoor equipment, metal to metal joints shall not be permitted and all external bolts or screws shall be provided with blind tapped holes where a through hole would permit the ingress of moisture. For harsh environments, all screws, nuts, bolts and washers shall be stainless steel 304.

Door sealing materials shall be provided suitable for the specified site conditions. Doors shall be fitted with handles and locks. Where walk-in type panels are supplied the door shall be capable of being opened from inside the panel without the aid of a key after they have been locked from the outside. Hinges shall be of the lift-off type, and shall permit the doors when open, to lie back flat so as not to restrict access. Means shall be provided for securing the doors in the open position.

Cubicles and cubicle doors shall be rigidly constructed such that, for example, door mounted emergency trip contacts can be set so that mal-operation will not be possible due to any vibrations or impacts as may reasonably be expected under normal working conditions.

The bottom and/or top of all panels shall be sealed by means of removable gasketed steel gland plates. Gland plates for bottom entry shall be at least 250mm above the floor of the cubicle.

Panels shall be suitably designed to permit future extension wherever appropriate or specified.

Each panel shall include rear access doors internal power sockets and door-operated internal lighting, and be clearly labelled with the circuit title at front and rear, with an additional label inside the panel. Panel sections accommodating equipment at voltages higher than 110V (nominal) shall be partitioned off and the voltage clearly labeled. Each relay and electronic card within panels shall be identified by labels permanently attached to the panel and adjacent to the equipment concerned. Where instruments are terminated in a plug and socket type connection both the plug and the socket shall have permanently attached identifying labels.

Instrument and control devices shall be easily accessible and capable of being removed from the panels for maintenance purposes. Terminations, wiring and cabling shall be in accordance with the requirements of this section of the specification.

For suites of panels inter panel bus wiring shall be routed through apertures in the sides of panels and not via external multicore cabling looped between the panels.

All panels, whether individually mounted or forming part of a suite, shall incorporate a common internal copper earthing bar onto which all panel earth connections shall be made. Suitable studs or holes to the ENGINEER's approval shall be left at each end of the bar for connection to the main station earthing system and possible future extension.

Earth connection between adjacent panels shall be achieved by extending the bar through the panel sides and not by interconnecting external cabling.

Where intrinsically safe circuitry is routed from a hazardous area to a safe area instrument panel, it shall be connected through Zener Barriers located in the safe area (instrument panel) of suitable rating and mounted on an insulated earthing busbar having facilities for connection of a separate dedicated outgoing cable to a "clean earth" system.

110V DC and 48V DC Battery Chargers Panels for Control Supplies of 230kV and 110kV GIS Local and Remote Control Panels, Auto Power Transformers Remote Local and Remote Tap Changer Control Panels, 33kV and 11kV Outdoor Type Circuit Breaker and Isolator Control Panels, 11kV Switchgear Control Panels, Metering and Protection Relay Panels, Telecommunication / LAN Racks and Cabinets, Substation Automation Control Panels, and SCADA Panels, etc., shall be connected from a Normal Three Phase Power Supply and Standby Generator.

Contractor shall design the arrangement, size and rating of the Standby Generator with 20 % spare capacity.

Power Supply for Fire Alarm System Panels, FM200 System Panel, Deluge Water System Panel, Substation Nitrogen Injection Fire Protection (NIFPS) System Cubicle Panel, Central Battery System for Emergency Lighting System, and Space Heaters for cubicles and panels shall be connected from a duplicate Standby Generator and UPS system. Contractor shall design the size and rating of the Standby Generator and UPS System with 20 % spare capacity.

The following alarms shall be provided for the Standby Generator and UPS System to monitor the systems:

1. Voltage High
2. Voltage Low
3. No voltage
4. ON, OFF, TRIP
5. Earth Fault

The alarms shall be signaled back to the Control Room.

Instruments having pressure pipe connections containing oil, water, steam or flammable or toxic fluids shall be excluded from the Control Room.

All cubicles, desks and panels shall be painted externally with a high gloss paint of Munsell 5Y-7/1 colour. The interiors of all cubicles, desks and panels shall be painted matt white.

All cubicles, or panels mounted external to control and apparatus rooms shall be fitted with thermostat controlled anti-condensation heaters.

Instruments & Meters

Indicating Instruments

All indicating instruments shall be of the flush mounted pattern with dust and moisture proof cases complying with BS 2011, Classification 00/50/04, and shall comply with IEC 51-1.

Unless otherwise specified, all indicating instruments shall have 96mm or 144mm square cases to DIN standard or equivalent circular cases.

Instrument dials in general should be white with black markings and should preferably be reversible where double scale instruments are specified.

Scales shall be of such material that no peeling or discolouration will take place with age under humid tropical conditions.

The movements of all instruments shall be of the dead beat type. Wherever possible, instruments shall be provided with a readily accessible zero adjustment.

Electrical Meters

All electrical meters shall comply with IEC 521 and, unless otherwise specified, shall be of accuracy Class 0.5. Three-phase power measuring instruments shall be of the three-phase unbalanced load pattern wherever the current and voltage references permit.

Where precision grade metering is specified meters shall be calibrated to precision grade accuracy to IEC 521. Due allowance shall be made for the errors of current and voltage transformers with which they shall work and whose accuracy class shall be Class 0.5.

Where commercial grade metering is specified the meters shall be calibrated to commercial grade accuracy to IEC 521.

Meters shall be single directional and shall be fitted where required with suitable devices for the transmission of impulses to a summator. Var-hour meters shall be complete with phase shifting transformers as necessary.

Front of panel test terminal blocks shall be provided for all meters.

Summators shall be equipped to summate the circuits specified and shall be equipped where required with suitable contacts for the re-transmission of impulses to a printometer. They shall register in kilowatts the value of the impulses received from each kilowatt-hour meter. Printometers shall be of an approved type having the specified demand interval.

Each feeder shall be provided Main 1 and Main 2 energy meters. The energy meter shall be 3-element, 4-wire arrangement of programmable digital type and shall have proven performance and shall consist of different types, either from the same manufacturer or different manufacturers. The accuracy class of the energy meter shall be 0.5.

Indicating Lamps and Fittings

All indicating lamps shall be adequately ventilated and as far as practicable, lamps of a common type and manufacture shall be used throughout the Contract.

Lamps shall be easily removed and replaced where possible from the front of the panel by manual means preferably not requiring the use of extractors.

Where specified every circuit breaker panel shall be equipped with one red and one green indicating lamp, indicating respectively circuit closed and circuit open and an amber lamp for indicating 'auto-trip'. Where specified for in the lines of mimic diagrams, indicating lamps may be of the three-lamp single-aspect type.

The variety of indicating lamps provided shall be rationalised to reduce maintenance and spares requirements. The lamps shall be clear and shall fit into a lamp holder. The rated lamp voltage shall be at least 20% in excess of nominal supply voltage, whether A.C. or D.C. The lamps shall have an operating life of at least 10,000 hours, under site conditions. In the event that other indicating devices, such as light emitting diodes, are used in place of lamps then these shall have the same life expectancy and performance capability as the lamps they replace.

The lamp glasses shall comply with IEC 60073 and be in the standard colours, red, green, blue, white and amber. The colour shall be in the glass and not an applied coating. Transparent synthetic materials may be used instead of glass subject to the approval of the ENGINEER.

Where illuminated pushbuttons are used for control purposes, the illuminated pushbuttons shall be engraved with a clear instruction such as 'push to open' or 'push to close', and the lamp shall illuminate in accordance with the above colour code after the instruction has been carried out and the device has operated.

Unless otherwise agreed with the ENGINEER all lamp colours shall conform to the following practice: -

Red	Energized or operative position
Green	De-energized or inoperative position

Amber	Fault or abnormal condition
White	Healthy or normal condition
Blue	Other purposes, to be used with descriptive label

Lamp test facilities shall be provided for all switchboards, control panels etc. to enable all lamps to be tested whilst the equipment is in service. Operation of the lamp test facility shall not cause any other device to operate.

Indication circuits shall be fused.

Anti-Condensation Heaters

All switchboards, panels, cubicles and the like shall incorporate thermostat controlled electric heaters capable of providing movement of sufficient heated air to avoid condensation. The apparatus so protected shall be designed so that the maximum permitted rise in temperature is not exceeded if the heaters are energised while the apparatus is in operation.

The switchboard anti-condensation heaters shall be fed from a 240V single phase and neutral supply from a UPS System Panel, manually switched by a two-pole switch with red lamp, mounted on the back of the board, panel or cubicle and bus wired through the board. Labels shall be provided on the switch stating "Heater Supply". Heater terminals shall be shrouded and labelled "Heater". Power Supply to the UPS shall be fed from normal power supply and emergency power supply with standby generator.

Motor anti-condensation heaters where fitted shall be fed from an LV single phase and neutral supply bus wired through the board. The supplies shall be individually fused and will be switched by auxiliary contacts on the contactor and isolated by auxiliary contacts on the contactor isolator.

Control and Instrument Panel Wiring, Cable Terminations, and Terminal Boards

General

All electrical equipment mounted in or on switchgear, panels and desks, shall have readily accessible connections and shall be wired to terminal blocks for the reception of external cabling.

The wiring shall comply with BS 6231 and shall be capable of withstanding without deterioration the conditions at Site, due allowance being made for such temperature conditions as may arise within any enclosure. The insulating material shall be flame retardant in accordance with IEC 60332.

All wiring shall be of adequate cross-sectional area to carry prospective short-circuit currents without risk of damage to conductors, insulation or joints.

The following classes of copper conductor, as defined in IEC 60228, shall be used for panel wiring:

- (a) Class 1 conductors up to a maximum of 0.9 mm diameter where necessary for wire-wrapped terminations and similar techniques,

- (b) Class 2 conductors except where specified otherwise,
- (c) Class 5 and Class 6 conductors between points subject to relative movement.

The following minimum conductor sizes shall be used:

- (a) 2.5 mm² for current transformer secondary circuits with a rated secondary current of not exceeding 1A.
- (b) 1.5 mm² except where specified otherwise,
- (c) 0.5 mm² for alarm and indication circuits with a continuous or intermittent load current not exceeding 1A.

Where an overall screen is used, this shall be a metallic screen or low resistance tape, with a drain wire as above.

Wiring shall be supported using an insulated system which allows easy access for fault finding and facilitates the installation of additional wiring.

Small wiring passing between compartments which may be separated for transport shall be taken to terminal blocks mounted separately from those for external cable connections.

Connections to apparatus mounted on doors or between points subject to relative movement shall be arranged so that they are subjected to torsion rather than bending.

Ribbon cables or similar preformed cables with plug and socket connectors may be used for light current wiring. Plug and socket connectors shall be polarised so that they can only be inserted into one another in the correct manner.

If so required, the Contractor shall submit for the ENGINEER's approval samples of the types of wire, numbered ferrules, and terminal washers or lugs as appropriate which he propose to use.

Identification of Wires

All wiring and cores in control and instrument cables shall be identified in accordance with the associated schematic and/or wiring diagrams either by means of discrete wire numbers or wire colours, except when an automatic or proprietary system of wiring is used, e.g. point-to-point wiring on a mother board.

When a wire numbering system is used, it should be in accordance with a functional marking system. Both ends of every wire and core in control and instrument cables shall be fitted with interlocking ring ferrules of white insulating material indelibly marked with black characters, complying with BS 3858. Heat shrink marking sleeves may be used, but adhesive markers are not acceptable.

When plug and socket connectors are used, they shall be uniquely identified as mating pairs and each connector pin shall be numbered. Wiring which is permanently connected to plugs or sockets need not be identified.

Each core of multipair wiring shall be identified by colour and terminal block identification together with an identification tracer per bundle.

Permanent identification of all terminals, wires and terminal blocks shall be provided.

A consistent system of wiring numbering shall be used throughout the plant, and it shall be agreed with the ENGINEER at the start of the Contract.

Terminals and Terminal Blocks

Terminal blocks shall have separate terminals for internal and external connections, and not more than one wire shall be connected to each terminal.

Adjacent terminals to which wires of different voltage, polarity or phase are connected shall be separated by a protruding insulating barrier. This requirement also applies to terminals carrying wires of the same voltage but originating from different sources.

Trip circuit wiring and instrument transformer secondary wiring shall be connected using hook type crimped terminations in screw clamp, spring loaded insertion type terminals.

Where clamp type terminals are used, Class 1 and Class 2 conductors may be terminated without lugs. Crimp lugs shall be used for Class 5 and Class 6 conductors. Means shall be provided for retaining the identifying ferrules of the wire end when it is disconnected. Pinch screw type terminals shall not be permitted.

Subject to approval of the ENGINEER, "wire-wrap", "termi-point" or equivalent methods of terminations of single strand conductors may be used.

Wires shall be grouped on the terminal boards according to their functions. All terminal blocks shall provide a degree of protection of not less than IP2X when correctly installed, either inherently or by provision of insulating covers.

Terminal boards shall be mounted vertically, not less than 150mm above the gland plates, and spaced not less than 100mm apart, on the side of the enclosure and set obliquely towards the rear doors.

Sufficient terminals shall be provided to permit all cores on multicore cables to be terminated. Terminals for spare cores shall be numbered and be located at such position as will provide the maximum length of spare core. At least 10% spare terminals shall in all cases remain after commissioning.

The tails of multicore cables shall be bound and routed so that each tail may be traced without difficulty to its associated cable. All spare cores shall be made off to terminals.

When two lengths of screened cable are to be connected at a terminal block (i.e. junction box) a separate terminal shall be provided to maintain screen continuity.

In the main and local control and equipment rooms means shall be provided on the terminal blocks of panels, desks, cubicles, etc., for testing all the instrument circuits without the need to remove the internal or external wiring from the block.

The Contractor shall submit full details and specification of the proposed means of termination where wire wrapping, soldering and similar methods are used. The adopted methods shall be to the ENGINEER's approval.

The Contractor shall identify all special tools, such as wire wrapping tools required for termination, and shall make provision for their supply in sufficient numbers.

The use of pre-formed factory tested cable connections to field mounted marshalling boxes shall be to the ENGINEER's approval.

Cable Boxes and Glands

General

Electrical equipment shall be provided with all necessary cable boxes, which shall be complete with all required fittings. All cable boxes shall be of adequate size to allow for the correct termination of the cable sizes required or specified, taking into account the crossing of cores to achieve the correct phasing, and to accommodate all cable fittings, including stress cones or other means of cable insulation grading, if required. All cable boxes shall be designed in such a manner that they can be opened for inspection without disturbing the gland plate or incoming cable.

All main cable boxes shall be air insulated for the termination of all types of cable at voltages up to and including 33 kV nominal system voltage, unless otherwise specified elsewhere in this Specification.

The enclosure classification of main and auxiliary cable boxes on motors with the cable(s) terminated shall not be less than that of the associated motor, subject to a minimum classification of IP55.

Clearance and creepage distances shall be adequate to withstand the specified alternating current voltages and impulse voltages for service under the prevailing site conditions. Means shall be provided for preventing accumulation of dirt, dust, moisture, vermin or insects such as to maintain the anticipated life of the equipment.

The terminals for 3 phase cables shall be clearly marked with the specified phase designations to enable the cables to be terminated in the correct sequence.

Flexible connections shall be provided between cable lugs and bushings for all cables of 300 mm² section and greater.

There shall be no possibility of oil entering the cable box from an associated oil filled compartment.

Inner sheaths shall be arranged to project at least 25mm above the gland plate to avoid moisture collecting in the crutch.

All cable boxes shall be designed to withstand the high voltage d.c. cable tests prescribed in IEC 60055, IEC 60502 or other applicable standard.

Cable lugs and terminations for the receipt of all power, control and instrumentation cable cores shall be provided.

Where air insulated terminations are used, the cable crutch within a cable box or equipment panel shall be protected by the use of a heat-shrink plastic trifurcating sleeve or equivalent placed over the cores and crutch.

The Contractor shall provide full information and instruction for his proposed method of terminating MV cables.

Removable gasketed steel gland plates shall be provided for multicore cables. The cable entry into the cable box shall be arranged so that there is adequate space to manipulate the cable for glanding and termination.

When single core cables are used, particularly for currents in excess of 500A, adequate steps must be taken to minimise the effects of eddy currents in the gland and bushing-mounted plate. An aluminum cable gland plate shall be used to prevent the effects of eddy currents in the gland and bushing-mounted plate.

Gland plates for externally mounted marshalling boxes shall be in the form of removable gasketed steel plates, forming part of the underside of the box. Indoor marshalling boxes may be fitted with gland plates on all four sides.

Cable Glands

Cable glands for extruded solid dielectric insulated cables (PVC, EPR, XLPE) shall be of the compression type and as specified in BS 6121 Part 1.

All glands shall be provided with an earthing tag or equal facility. For cables having conductors not larger than 4mm² serrated washers may be used in place of earthing tags to provide earth continuity.

Glands for armoured or screened cables greater than or equal to 240 mm² and all insulated glands for power cables shall be provided with an integral earthing lug. On cable glands up to and including 40 mm nominal size, the earthing connection shall have a short circuit rating of at least 25 kA for 1 second, and of at least 40 kA for 1 second on larger sizes.

Insulated glands shall be provided with removable connections for bonding across the gland insulation. The gland insulation shall withstand a wet insulation voltage withstand test of at least 2 kV a.c. for 1 minute.

Under conditions of severe corrosion, corrosion-resistant cable glands complying with BS 6121 Part 3 may be used, or the Contractor may use an alternative solution with the approval of the ENGINEER.

Polymeric cable glands complying with BS 6121 Part 2 may be used, but only when terminating unarmoured cables.

Glands for MICS cables shall be to the approval of the ENGINEER.

Box Filling Compounds

The type of compound shall be to the approval of the ENGINEER, who shall be supplied with sufficient information by the Contractor. The Contractor shall supply all compound required together with an additional quantity of not less than 10% of normal requirements.

Where hot-pouring compounds are employed the pouring temperature shall be verified by use of thermometers or similar instruments and the metallic case of all joints and terminal boxes shall be adequately pre-warmed to drive off moisture.

The Contractor shall take particular care to adhere to the recommended topping-up procedures and to ensure that no leakage or migration of the filling compound occurs. Should leakages occur during the maintenance period the ENGINEER will require the joint to be re-made at the Contractor's expense.

Oil or Compound-Filled Chambers

All joints of oil- or compound-filled fabricated chambers, other than those which have to be broken, shall be welded and care shall be taken to ensure that the chambers are oil-tight. Defective welded joints shall not be repaired but maybe re-welded subject to the written approval of the ENGINEER.

Insulating compound shall comply with BS 1858.

The correct oil or compound filling level shall be indicated on the inside and outside of chambers.

Joints and Gaskets

All joint faces are to be flat and parallel to the approval of the ENGINEER and arranged to prevent the ingress of water or leakage of oil with a minimum of gasket surface exposed to the action of oil or air.

Oil-resisting synthetic rubber gaskets are not permissible, unless the degree of compression is accurately controlled. For gaskets of cork or similar, oil resisting synthetic rubber may be used as a bonding medium.

Valves on Electrical Equipment Fluid Lines and Vessels

All valves shall be suitable for the service conditions under which they are required to operate. The design, construction and choice of materials shall take into account all operational deviations including pressure surge and Thermal shock.

All drain and filter valves shall be provided with gun metal adaptors suitable for connecting a flexible hose having a screwed coupling of approved size. Captive-screwed caps shall be provided for all such adaptors.

Junction and Marshalling Boxes

Junction and marshalling boxes for use in non-hazardous areas shall be of substantial sheet aluminium anodised coating construction to prevent corrosion, having an enclosure classification in accordance with the requirements of IEC 60079, IEC 60529 and IEC 60947-1. They shall be fitted with external fixing lugs and finished in accordance with the requirements of the specification for cleaning, painting and finishing. The boxes shall allow ample room for

wiring, with particular regard to the routing of wires from the point of entry. Boxes made from aluminium shall be subject to agreement with the ENGINEER.

Outdoor boxes shall have an anti-condensation finish and all boxes shall be designed such that any condensed water cannot affect the insulation of the terminal boards or cables. No cables shall be terminated into the top of outdoor boxes unless specifically approved by the ENGINEER.

All outdoor kiosks, cubicles and panels shall be provided with sun/rain shades. All kiosks, cubicles and panels not in air-conditioned rooms shall be provided with thermostat controlled anti-condensation heaters.

All kiosks, and cubicles shall be fitted with door operated internal illumination lamps.

All necessary gland plates shall be provided undrilled.

Boxes shall be complete with suitably inscribed identification labels.

Boxes for use in hazardous areas shall have all entries factory pre-drilled. Every unused screwed entry shall be sealed by means of a tamperproof screwed plug in accordance with IEC 60079.

Hazardous area boxes with bolted or screwed lids shall require the use of special keys or spanners, for lid removal.

Where weatherproof types of hazardous area boxes are not available, the gaps should be protected against the ingress of moisture, by an approved means compliant with local standards.

All box covers are to be arranged for padlocking and padlocks with keys shall be supplied.

All boxes shall be provided with adequate earthing bars and terminals.

8.6.25 Medium Voltage Switchgears

General

The Contractor shall furnish, install and commission medium voltage switchgear and all its related appurtenances, complete and operable, in accordance with Contract requirements. Works shall include installation of the appropriate concrete pad/foundation and other mounting accessories.

The switchgear and its components shall be designed, manufactured and type-tested in accordance with the latest applicable standards of IEC, NEMA and IEEE.

Product Requirements

MV switchgears shall be free-standing, indoor type, designed for operation on a 11 kV, 3-Phase, 3-wire and 50 hertz system.

The switchgear assembly shall consist of individual vertical sections housing various combinations of vacuum circuit breaker/or fusible load interrupter, switches and other auxiliaries, bolted to form a rigid metal-clad, dead front switchgear assembly. Metal side sheets

shall provide grounded barriers between adjacent structures and solid removable metal barriers shall isolate the major primary sections of each circuit.

The stationary primary contacts for circuit breaker shall be silver- plated and recessed within insulating tubes. A steel shutter shall automatically cover the stationary primary disconnecting contacts when the breaker is disconnected or out of the cell. Rails shall be provided to allow withdrawal of each 11 kV circuit breaker for inspection and maintenance without the use of a separate lifting device.

Each vertical section containing a switch shall have a single, full- length flanged front door and equipped with two rotary latch type handles that can be padlocked. Provision shall be made for operating the switch and storing the removable handle without opening the full-length door.

The medium voltage switchgear shall be an integrated assembly of withdrawable type vacuum circuit breaker that is coordinated electrically and mechanically for high voltage circuit protection. Medium voltage switchgear ratings are shown in the table below.

Medium Voltage Switchgear Ratings

Rated Voltage	11 kV nominal
Highest System Voltage	17.5 kV
Phases	3
Rated Frequency	50 Hz
Rated Short Circuit Breaking Current	50 kA
Rated Short Time Withstand Current	50 kA /3 sec.
Rated Short Circuit Making Current	125 kA
Rated Peak Withstand Current	125 kA
Rated Normal Current	4000 A / 1250 A

The manufacturer shall furnish accessories for installation, inspection, testing, operation and maintenance of the medium voltage switchgear. Standard factory tests shall be performed on the switchgear assembly to be supplied under this Contract. All tests shall be in accordance with the applicable requirements of the latest approved edition of IEC, ANSI and NEMA Standards.

Specifications for particular switchgear components and other requirements shall be as follows:

The main bus shall be copper and have fluidized bed epoxy flame retardant and track resistant insulation. The bus supports in between units shall be flame-retardant and track-resistant. The switchgear shall be constructed so as all buses, bus supports and connections shall withstand stresses that would be produced by currents equal to the momentary rating of the circuit breakers.

A set of 4,000-ampere and 1,250 A insulated copper main bus shall be provided and shall have provisions for future extensions. All bus joints shall be plated, bolted and insulated with easily installed boots. The bus shall be braced to withstand fault current equal to the close and latch rating of the breakers.

The temperature rise of the bus and connections shall be in accordance with ANSI standards and documented by design tests.

A copper ground bus shall extend the entire length of the switchgear. When required, a bare, fully rated neutral bus shall extend the entire length of the switchgear.

MV Switchgear Enclosure

The enclosure for the switchgear shall be dead front, free standing, pad-mounted.

Engraved nameplates, mounted on the face of the assembly, shall be furnished for all main and feeder circuits as indicated on the drawings. A master nameplate giving switchgear designation, voltage/ampere rating, short-circuit rating, manufacturers name, general order number and item number shall be likewise furnished.

All components and devices mounted within the assembly, such as fuse blocks, relays, push buttons, switches, etc., shall be suitably marked for identification corresponding to appropriate designations on the manufacturers wiring diagrams.

Surface finish shall be thermosetting, polyester powder paint applied electrostatically to pre-cleaned and phosphatized steel and aluminum for internal and external parts. The coating shall have corrosion resistance of 600 hours to 5% salt spray. Prior to shipment, the complete assemblies, indoor as well as outdoor, shall be given 1.5 to 2.0 mil thick exterior finish spray coat or air drying high gloss gray enamel.

8.6.26 11kV Capacitor Bank

GENERAL

The capacitor bank shall comprise five units of 1 MVAR rating 3 phase 11kV and shall be housed in metal clad outdoor cubicles. and a separate cubicle to accommodate the incoming 3 core 11kV cable, three phase 11kV off-load isolator and 11kV voltage transformer. The cubicles arranged in line to form a complete self standing board.

CAPACITORS

The 11kV capacitors shall comply with IEC 70/BS 1650 and shall be suitable in all respects for installation outdoor housed in metal clad cubicles, and for operation in the specified site conditions on the Medium Voltage system.

The capacitor shall be capable of the following permissible over loads as a minimum :

Current Voltage

- Output 1.3 times rated current continuously
- 1.1 times rated voltage of 11kV continuously
- 1.3 times rated output continuously

The capacitor container shall be of stainless steel welded construction. Alternative price shall be quoted with mild steel container which shall be protected with the following treatment :

- short blast
- zinc spray
- primary coat
- undercoat
- finishing coat

Bushings shall be of porcelain to withstand an impulse voltage of 75kV and shall have a minimum creepage of 275mm.

The capacitor shall include in-built discharge resistors inside the container permanently connected across the terminals to discharge the capacitor to 50 Volts in less than 5 minutes.

Lifting - fixing brackets shall be provided on low sides of the capacitor container.

OUTDOOR CUBICLES

Each I MVAR capacitor unit with its associated control and protection gear shall be housed in metal-clad outdoor cubicle of mild steel construction with minimum plate thickness of 3mm.

The cubicle shall include hinged front door with lockable chromium finish handle, bottom plate and removable rear and side cover plates secured in position from inside the cubicle. The entire cubicle shall be corrosion proof.

The cubicle as a whole shall be manufactured to degree of protection IP55.

In addition to the cubicles for housing the capacitor units, a separate cubicle shall be provided for accommodating the incoming 11kV cable, control cables, 11kV isolator and 11kV voltage transformer.

All six cubicles shall be arranged in line to form a complete free standing board with base frame and fixing bolts, for installation outdoor on concrete foundation. The board shall include a ridged canopy for protection from rain. Ventilation louvre shall be provided in the cubicle with the gauze for vermin proof.

The board shall be provided with tinned copper earth bar 40 x 4mm running, the entire length of the board with two earth terminals for connecting to the station earthing system.

INCOMING SUPPLY CUBICLE

The cubicle shall include the following :

- Cable entry and termination for 3 core 240 sq.mm Cu/XLPE/SWA/PVC cable, with all necessary dry type termination material including compression type brass gland with PVC shroud and earth tag, and crimping type lugs.
- Control cable entries and terminations, terminal blocks. 3 phase 11kV off-load isolator 400 amps rating.

- Three 11kV lighting arrestors.
- 11kV voltage transformer dry type resin encapsulated connected across two phases ratio 11kV/110V, 500VA min.
- Unbalance protection relays for each capacitor bank to trip the contactor of each bank in the event of unbalance.
- Two 11kV HRC fuses for protection of 11kV VT and one secondary HRC fuse link/MCB.
- 3 phase busbars covered with extruded insulation which shall be suitable for the site conditions.
- Over voltage relay to protect capacitor bank against over voltage, tripping all contactors.

CAPACITOR CUBICLE

The cubicle shall include the following :

- 11.5kV 3 phase 1 MVAR capacitor unit comprising two 500KVA Star connected capacitor banks in parallel and star point of each interconnected.
- Three 11kV single phase reactors for protection against switching inrush currents.
- 11kV 3 phase contactor 400 amp suitable for continuous operation at maximum voltage of 12.5KV.
- Three 11kV HRC fuses 125 amps.
- 1kV busbars 400 amps covered with extruded insulation which shall be suitable for the site conditions.
- One current transformer of suitable ratio and burden on the interconnected star connection to energize sensitive unbalance relay for protection against unbalance current in the bank.

CONTROL CONSOLE

For automatic regulation of the station power factor by switching step by step the five capacitor units, a control console with necessary step by step control relay and associated ancillary equipment shall be supplied.

The console shall be wall mounting of moulded steel construction with minimum plate thickness of 2mm for indoor installation inside the substation building. The console shall include a hinged front door with lockable chromium finish brass handle.

The regulating and control relay shall operate from the 11kV/110V voltage transformer provided in the incoming cubicle of the capacitor board and 1 amp secondary current transformer on the 11kV incoming supply to the substation.

The 11kV contactors provided in the capacitor cubicles controlling individual capacitor units shall close or trip in sequence, step by step, initiated by the regulating and control relay.

The regulating and control relay shall have the following features as a minimum :

No. of steps	:	6 (with one spare)
Measuring principle	:	Power factor measured of phase shift between power supply voltage and CT current.
Target power factor	:	Range : 0.8 capacitive...1.00...0.8 inductive.
Display modes	:	digital
-		power factor (Cos phi)
-		capacitor steps
-		inductive setting value
-		target power factor
-		operation time delay

No volt release : all steps to be released and output contacts disabled within 10 milli sec. After voltage is restored normal operation to resume in sequence step by step.

Operation time delay : the time delay range between steps to be 0 to 5 minutes.

Accuracy requirement : Power factor shall be maintained with + or - 2.5% of the target value.

Manual over-ride : Manual selector switch with three positions; off/manual/auto.

Alarm : The regulator alarm contact to close with a blink in the display if either the compensating power is insufficient or there is no voltage at the regulator input.

The entire equipment provided in the control console shall be suitable for operation continuously in an ambient of 50 deg C.

The console shall be manufactured to degree of protection IP40.

The console shall be corrosion proof.

The console shall include all necessary secondary wiring, terminal blocks, compressor type brass glands for control cables to capacitor cubicles and 11kV switchboard at the station for CT secondary circuit.

All small wiring inside the capacitor cubicle and the console shall be carried out as per specification.

11kV CAPACITOR BANK TECHNICAL GUARANTEED PARTICULARS

SI.No. Description .

CAPACITOR BANKS

I Make

Model No.

Rated Voltage

Site MVAR rating at rated voltage KV MVAR

Permissible over-load capacity

a. as

percentag

e of rated

voltage

b. as

percentag

e of rated

current

c as

percentag

e of rated

MVAR

Loss of MVAR capacitor unit walls

Type of di-electric material

Insulation level

No. of insulation layers

Thickness of each layer

Loss angle value at

- 500C
- 800C

II VOLTAGE TRANSFORMERS

Make

Type

Class

Ratio
Burden

III CURRENT TRANSFORMERS

Make

Type
Ratio
Class
Burden

IV CONTACTORS

Make

Type
Rating
Current
Rated voltage : KV
Closing coil voltage : V
Coil current : Amp

V 11KV ISOLATIONS

Make

Type

Rating

VI. REGULATING AND CONTROL RELAY

Make

Type/Model
No. of steps
Measuring principle
Frequency
Power supply
Power factor range
Display modes
Operation sequence
Operation delay range
Accuracy
Construction
Degree of protection
Dimensions

i. Low Voltage Switchgears

These specification describe the General Technical Requirements for LVAC switchboards for supplies to GIS Substation Building Services and CP1 Facilities.

REFERENCES

Any international standards referenced in the specifications and our outdated shall be replaced with the corresponding replacement.

- IEC60044 Instrument Transformers IEC 60269 Low Voltage Fuses
- IEC 60439-1 Specification for low voltage switchgear and control gear assemblies IEC 60644
Specification for high-voltage fuse links for motor circuit applications
- IEC 60898 Electrical Accessories - Circuit-breakers for overcurrent protection for household and similar installations
- IEC 60947-1 Low-voltage switchgear and Control Gear - General
- IEC 60947-2 Low-voltage switchgear and Control Gear - Circuit-breakers
- IEC 60947-3 Low-voltage switchgear and Control Gear - Switches,
disconnectors and fuse combination units
- IEC 60947-4 Low-voltage switchgear and Control Gear - Electromechanical Contactors and motor starters

SWITCHBOARD DESIGN

Main switchboards and MCB sub-distribution boards for substation and building supplies will be constructed to IEC 439, (BS EN 60439) in accordance with the following:

The classification of the main switchboards shall be:

The external design of switchboards shall be of the multi-tier, multi- cubicle type.

Installation shall be indoors.

Switchboards shall be free standing and fixed to the floor.

Enclosures degree of protection shall be not less than IP42.

Switchboards shall be of metal clad construction.

All instrumentation and metering shall be fixed to a hinged lockable compartment.

Switchboards and all associated equipment shall be suitable for use on a 415/240 volt, three

phase, four wires, and 50 Hz system having the neutral solidly earthed.

Each circuit shall be clearly labelled to show the destination of the associated cable and the “ON” and “OFF” positions of the switches.

Distribution boards for exterior use shall be galvanised, weatherproof and to category IP55 degree of protection.

The equipment shall be of the single busbar type with circuit equipment housed in separate compartments.

Where two or more incoming circuit breakers are provided at substations, these shall be mechanically and electrically interlocked to prevent more than one circuit closing at the same time.

The enclosures of all switchboards shall be dustproof and vermin proof. Access doors shall be mounted using concealed hinges. All removable covers shall be fitted with captive screws. Anti-condensation heaters with control switches shall be provided on switchboards. They shall be suitable for a tropical climate.

Rating

Incoming supplies to all switchboards shall be protected at the point of supply. All switchboards shall be suitably rated for a prospective short-circuit breaking capacity of 44 kA/3secs. at 415V

Busbars

Busbars shall be capable of carrying the full rated current continuously without exceeding the maximum temperature specified in IEC 60439 under site ambient conditions.

Busbars shall be of copper, individually covered with a heat resistant phase coloured PVC. Busbar links between panels shall not be used. Neutral busbars shall have the same cross sectional areas as the phase busbars. Busbars shall be of the same current rating throughout their length and shall be capable of extension at both ends with the minimum disturbance to the busbar and cubicle enclosure.

Busbar and Circuit Shutters

For draw out equipment shutters shall be provided over busbar and circuit orifices to close automatically and positively when the equipment is isolated or withdrawn. Means shall be provided for padlocking the sets of shutters. Busbar orifice shutters shall be painted signal red and labelled ‘BUSBAR’ in white letters. Circuit orifice shutters shall be painted lemon yellow.

One blanking cover of each size shall be provided to prevent access to a circuit compartment when the equipment has been completely withdrawn from the panel.

Circuit Labels

Approved type title labels are to be fitted externally on the front cover of each distribution board giving details of the points controlled by each circuit. The circuit list shall be typed or printed stating the location of the equipment served, rating of the protective unit and the circuit loading. The lists shall be mounted on the inside of the cover door and shall be protected by an acrylic sheet slid into a frame over the circuit list, the list and cover to be easily removable to permit circuit modifications.

CIRCUIT BREAKERS

All MCB and MCCB circuit breakers shall be high speed fault limiting, thermal/magnetic type with quick break, trip free mechanisms which prevent the breaker being held in against overloads or faults, shall comply with IEC 60947 and be fitted with overcurrent releases of both thermal and instantaneous type. Short circuit performance shall be to IEC 60947.

Where circuit breakers incorporate thermal overload protection and short-circuit protection, their settings shall be subject to agreement with the ENGINEER.

Tripping arrangements shall be such as to ensure simultaneous opening of all phases. Arc extinction shall be by de-ionising arc chutes.

Circuit breakers on the incoming circuits shall have facilities for locking in the “off” position.

The fault interrupting capacity of the circuit breaker shall not be less than that of the switchboard itself, or if this is not the case, back up fuses shall be included.

SWITCH-FUSES

Each switch-fuse unit shall be housed in a separate metal compartment and provided with a hinged metal door, interlocked with the switch mechanism so that:

The door cannot be opened whilst the switch is closed.

The door, on opening, automatically locks the switch in the “off” position. Facilities shall be incorporated to allow for the deliberate release of this interlock for maintenance purposes, should it be desired to observe the switch in operation.

An insulating barrier shall be fitted to segregate the fuses and neutral link from the switch and the connections of the latter shall be effectively shielded by an inner metal screen when the compartment door has been opened to obtain access to the fuses.

The switch-fuses may be either of the combination fuse-switch type or of the type with the switch and fuse in separate units. In either case, interlocking shall be provided to prevent access to the fuses until the associated switch is opened and provision shall be made for padlocking the switch in the “on” and “off” positions.

The switch shall have a quick make and quick break action, independent of the speed at which the switch handle is operated, and shall be entirely suitable for switching the inductive loads

associated with motor circuits.

OIL FILTRATION SOCKET OUTLET AND PLUG

The Contract shall include heavy duty weatherproof three phase and neutral interlocked switched socket outlets and plugs suitable for supplying the transformer oil filtration units.

INSPECTION AND TESTING

Inspection and testing plan during manufacture and after installation on site shall be submitted for approval by the ENGINEER for approval.

8.6.15 Low Voltage Capacitor Banks

Capacitors shall be properly selected to attain 98% power factor.

Group of motors fed in motor control center shall be provided with capacitor bank with automatic switching of controller for power factor correction with the following specifications:

Standard	:	IEC 831 or Approved Equal
Type	:	Dry type Design
Frequency	:	50Hz
Degree of protection	:	IP42
Execution	:	Indoor
Discharge Resistor sized in	:	Permanently connected built-in discharge resistors are to ensure safe discharge of the capacitor to less than 50V 1 min. after switch off.
Losses	:	0.5 W/kVAR
Max. ambient temperature	:	+50deg. C
Min. ambient temperature	:	-25o C

8.6.16 Motor Control Centers

General

The work covered by this Specification includes the design and manufacture of motor control centre (MCC) equipment completely assembled. The Manufacturer shall also provide technical assistance during the installation and placement in service of the equipment.

All equipment shall be designed, built, rated, tested and shall perform in accordance with the latest editions of the applicable standard.

Service conditions

The MCC and all components therein, shall function in a satisfactory manner within the rated capacity under the service conditions specified regardless of whether or not all necessary specific performances are set forth in this Specification or in the applicable standards.

Design Construction Details

General

The MCC within this Specification shall be compartmentalized and shall comply with IEC 439 Form 4 Type 7, and be rated to the levels specified in the Equipment Specification for operation on a 415 volt 3 phase 4 wire 50 Hz supply.

The MCC shall be constructed with suitably folded and stiffened corners and edges with an integral supporting structure, and shall be manufactured as per section in Low Voltage Switchgears.

The MCC shall be free standing, front connected and front wired. The front of the MCC shall have doors supported with chrome plated pintle hinges. The door shall not extend more than 450 mm perpendicular to the MCC face. The door locking shall be designed to prevent opening when subjected to forces caused by an internal fault. Master locking system on all doors.

All openings shall be fitted with a suitable non distorting compressible seal, which shall engage onto the MCC panel's stiffened return surround on one side and the door's rear face within the stiffened return on the other side.

Each section of the MCC shall be supported on the identical 75 mm RHS hot dip galvanized plinth, fully braced and welded, turned outwards.

Gland plates shall be fitted to the top and the bottom of the MCC and at the incoming supply cable entry, this gland plate shall be 3.5 mm aluminum, and all other gland plates shall be made out of the MCC construction material. All gland plates shall be gasketed and bolted.

A minimum of 150 mm clear space shall be available above and below the gland plate for access to the glands.

Air duct shall be provided for every VFD / Soft Starters compartment to eliminate hot air circulation inside MCC.

Wiring diagram pockets shall be provided.

Provision for 25% spare for future expansion shall be provided.

Component Arrangement

The MCC shall be 600 mm deep, 2200 mm high with plinth, width of a modular panel shall be 1000 mm with door size of twin 450 mm.

All electrical equipment shall wherever possible be mounted on DIN rails on metal mountings. If equipment has to be attached directly onto the mounting plate, they shall be secured by screws in the pretapped holes, self-tapping screws are not permitted.

Terminals shall be of a type providing a positive mechanical clamp on connection, fully shrouded and suitable for mounting on DIN standard rail. Double banked terminals in one composite molding shall not be used.

No apparatus or terminal block shall be mounted within 300 mm vertically from the internal floor level.

All wiring shall wherever possible be wired in ducts. Cable ducting shall be so sized and arranged that the total number of cables and wires to be installed in the duct do not exert pressure on the lid or cause deformation of the duct. Signal wiring where possible be segregated from other wiring.

The minimum clearance between panel mounted equipment, cable looms, ducting, terminals and MCC framework or panels shall be 50 mm.

Shipping

The MCC shall be delivered on site in sections not longer than 4M. Each section shall be suitable braced and have lifting points so that during a crane lift no distortion will take place. Assembly instruction shall accompany the equipment.

Bus Bars

Grounding Bar shall be provided.

Busbars shall be of tinned, hard drawn, high conductivity copper. They shall be insulated throughout their lengths by means of phase color sleeving. The busbar assemblies and joints shall be in accordance with the manufacturers/suppliers recommendations.

The rating, supports and bracing of all main connections between all main circuit switching mechanisms and busbars shall be designed for operation at the same short-time withstand current rating as that specified for the busbars.

Live connections to and from busbars shall be either fully insulated or suitably screened and all covers screening the busbars and connections shall be provided with adequate warning labels

Current transformers shall be bar type, to BS 3938 accuracy and output mounted on the cabling side of the ACB or MCCB.

MCC's shall be provided with a hard drawn, tinned, copper earth bar located clear of any gland plate or cable access. The earth bar shall have a minimum cross-sectional area of 120 mm². The earth bar shall be the full length of the panel and split only at sections used for transport and installation purposes. Where splits occur, the bar shall be joined by a minimum of two bolted connections. Provision shall be made at each end of the earth bar for connection to a main earthing system

The sectional area of the neutral bar shall be equal to the sectional area of the phase bar.

Other Requirements

Identification, test and inspections, drawings, wiring and approvals of MCCs shall comply with the relevant sections within this Specification. Instrument cubicles shall be separate; the layout shall be approved by the ENGINEER.

All fields wiring to remote control panels or instrument shall be terminated into a terminal rail, not wired directly to devices.

Miniature Circuit Breakers, Fuses, and Links

Facilities shall be provided for protection and isolation of circuits associated with protection, control and instruments. They shall be of approved type and grouped, as far as possible, according to their functions. They shall be clearly labelled, both on the panels and the associated wiring diagrams.

Facilities shall be provided to enable the control circuits for any circuit-breaker to be individually isolated for maintenance purposes.

Facilities for protection and isolation of control and tripping circuits are preferably to be mounted on the outside of control panels in approved positions.

All fuses shall incorporate HRC cartridges to BS 88 or IEC 60269.

Fuse holders shall be designed to lock the cartridges firmly into position without the use of screw clamping devices.

Miniature circuit-breakers (MCB's) shall comply with IEC 60898.

Where MCB's are used on control, protection and alarm supplies, tripping shall cause an alarm to be displayed.

Motor Starters and Contactors for Separate Mounting

In special cases for motors below 30 kW, and non-essential non-plant auxiliaries, such as roller shutter doors, and where approved by the ENGINEER, separately mounted starters for motors may be provided. Each such motor starter shall be equipped with two or three pole control gear, as appropriate, for direct-on-line starting and shall be complete with a fully shrouded lockable isolating switch, mechanically interlocked with the means of access.

All starters shall be supplied by one manufacturer, except where otherwise approved by the ENGINEER.

Contactors shall be of robust design and shall comply with IEC 60947.

All contactors and their associated apparatus for minor motors shall be capable of operating without overheating for all specified motor operating conditions, and including for a period of five minutes at normal frequency if the supply voltage falls to 80% of nominal voltage.

For motors up to 30kW rating motor starters shall be provided with direct connected thermal overload and phase failure industrial pattern protection tripping devices, integral with the motor contactor. Phase failure protection shall operate with out-of-balance currents not exceeding 85% of motor full load current. Separate contacts for a remote trip alarm shall be provided, and connected up if required.

For motors above 30kW starters shall not be wall mounted but included in a switchboard, except with the approval of the ENGINEER. For such circuits motor protection relays with a more

accurate and easily adjustable overload setting shall be used, which are sensitive to out-of-balance currents not exceeding 20% of full load, and shall include instantaneous earth fault elements. Alternatively, instantaneous earth fault protection may be incorporated in the motor circuit breaker. The earth fault protection shall not operate for unbalanced current surges during motor starting.

8.6.17 Variable Frequency Drives (VFD)

General

The Frequency drives shall be of Voltage Source Inverter Pulse Width Modulated (VSIPWM) with GTO/IGBT/IGCT/SGCT/DTC technologies or later version, which performs precise speed and torque control of standard squirrel cage motors with optimum efficiency. All frequency drives shall be suitable for data connectivity with PLC/SCADA system and shall have suitable communication port and protocol. The drives must be easily programmable. The drives shall be provided with surge protection, programmable lockable code. The Frequency drive shall have following characteristics:

- Accurate open loop torque control
- Torque step rise time typically less than 5 ms
- Speed control inaccuracy typically 0.1% to 0.5% of nominal speed
- 150% overload capacity for 60 second

Total Harmonic distortion shall comply with the provisions of IEEE 519. Necessary metering, self-diagnostic arrangement (including display and alarm facilities) shall be provided for local/remote monitoring.

Technical parameters

Main connection

Voltage	: 3 phase, 415 +/- 10 % permitted tolerance
Frequency	: 45 to 65 Hz, maximum rate of change 17%/s
Imbalance	: Max. +/- 3% of nominal phase to phase input voltage
Fundamental	: 0.97 (at nominal load)
Power factor	

Motor connection

Voltage	: 3 phase, from 0 to applied incoming supply voltage, 3-phase symmetrical
Output Frequency	: 0 to 250 Hz
Frequency	: 0.01 Hz
Resolution	

Continuous : $1.0 * I_{2N}$ (normal use)
Current

Short Term : $I_{2max} = 1.1 * I_{2N}$
Overload Capacity
(1min./10min)

Field Weakening : 8 to 300 Hz
point

Acceleration Time : 0 to 1800 sec

Deceleration Time : 0 to 1800 sec

Efficiency : Min. 97% at nominal power level

Environment limits

Ambient : 0 to 45 deg. Cent.
temperature

Standard control connections

- 3 programmable differential analogue inputs (1 voltage signal, 2 current signals)
- 7 programmable digital inputs
- 2 programmable analogues outputs (current signal)
- 3 programmable digital outputs (from C relays)
- Optional analogue and digital extension modules can be added as well as a wide range of field bus adapters.

Protection

- Over current
- Short circuit at start-up
- Input phase loss
- Output phase loss
- Motor overload
- Earth fault
- Overvoltage
- Under voltage
- Over temperature
- Motor stall

Application macros

The features a selection of built-in, pre-programmed application macros for configuration of inputs, outputs, signal processing and other parameters. It shall have interfacing facilities to communicate data to SCADA system. These include:

- FACTORY SETTING for basic industrial applications
- HAND/AUTO CONTROL for local and remote operation
- PID CONTROL for closed loop processes
- TORQUE CONTROL for process where torque control is required.
- SEQUENTIAL CONTROL for processes where torque control is required.
- USER MACRO 1 and 2 for user's own parameter setting
- Comprehensive testing and diagnostic function

Tests

Each unit of Variable frequency drive shall be tested at the manufacturer's work. Test result must satisfy the efficiencies on various loads and at different frequency levels against their quoted values during bidding.

8.6.18 Soft Starters for MV and LV Motors

MV Soft Starter particulars

Description	Unit	Particulars
Type, Application and criteria for sizing		Clear Water Distribution Pumps (Starting current to be limited to 2.5 to 3 times the rated current of the motor)
Connection		On phase/neutral side of stator winding
Quantity	Nos.	Distribution Pump Stations
Rated voltage	kV	11 (12) for MV
Rated lightning impulse withstand voltage		
- Across the isolating distance	kV (peak)	70
- Phase to phase, between phases and across open switching devices	kV (peak)	60
Rated short duration power frequency withstand voltage		
- Across the isolating distance	kV (rms)	26

Description	Unit	Particulars
- Phase to phase, between phases and across open switching devices	kV (rms)	26
Installation		Indoor
Enclosure		
- Sheet steel thickness	mm	2
- Degree of protection		IP4X
- Color finish shade		Light Grey Semi Glossy
External cable details		6.4 / 11 kV, 3C x (*) Aluminum, XLPE, armoured
Type of cooling		Air cooled
Bypass arrangement	Required	By Vacuum contactor/Built-in with soft starter
Control supply	V	110V DC / 230 V AC as required for the control

LV Soft Starter particulars

Description	Unit	Particulars
Type, Application and criteria for sizing		Pumps and Blowers (Starting current to be limited to 2.5 to 3 times the rated current of the motor)
Connection		On phase/neutral side of stator winding
Rated voltage	kV	0.415 for LV
Rated lightning impulse withstand voltage		
- Across the isolating distance	kV (peak)	46
- Phase to phase, between phases and across open switching devices	kV (peak)	40
Rated short duration power frequency withstand voltage		
- Across the isolating distance	kV (rms)	12

Description	Unit	Particulars
- Phase to phase, between phases and across open switching devices	kV (rms)	10
Installation		Indoor
Enclosure		
- Sheet steel thickness	mm	2
- Degree of protection		IP4X
- Color finish shade		Light Grey Semi Glossy
External cable details		6.4 / 11 kV, 3C x (*) Aluminum, XLPE, armoured
Type of cooling		Air cooled
Bypass arrangement	Required	By Vacuum contactor/Built-in with soft starter
Control supply	V	110V DC / 230 V AC as required for the control

(*) Value to be ascertained by the Contractor after submitting design calculations subject to approval.

Constructional and Performance Features

Motor soft starters shall be switched reactance type or flux compensated type or electronic type.

Soft starter panel shall be indoor, metal clad with separate metal enclosed compartments for

- a) control, metering and current transformers for differential protection, if specified
- b) shorting (bypass) arrangement
- c) bus bars
- d) power cable terminations
- e) push buttons with indicating lamps.

Soft starter shall achieve soft starting by torque control for gradual acceleration of the drive thus preventing jerks and extending the life of equipment.

Starting current shall be limited to 2.5 to 3 times the rated current of the motor. The soft starter manufacturer shall co-ordinate with motor manufacturer for this purpose.

Separate removable gland plates shall be provided for power and control cables.

Each cubicle shall be fitted with a label in the front and rear of the cubicle, indicating the panel designation, rating and duty. Each relay, instrument, switch, fuse and other devices shall be provided with separate labels.

Necessary wiring diagram shall be provided considering starting interlock, trip circuit, starting and running mode signal.

It shall be possible to manually start the motor locally from the starter panel or in Auto mode through PLC.

Main Bus bars

Bus bars shall be fully insulated by encapsulation in epoxy resin, with moulded caps protecting all joints. Bus bars shall be supported on insulators capable of withstanding dynamic stresses due to short circuit. Bus bars shall be of hard drawn copper conductor and of high conductivity, EC grade copper of 99.7% purity.

Earthing

A copper earthing bus shall be provided at the bottom and extended throughout the length of the panel. It shall be bolted / welded to the framework. All non-current carrying metal work of the panel shall be effectively bonded to the earth bus. Hinged doors shall be earthed through flexible earthing braid.

Panel Accessories and Wiring

Panel shall be supplied completely wired internally up to equipment and terminal blocks and ready for the external cable connections at the terminal blocks. Inter panel wiring between compartment of the same panel shall be provided.

All auxiliary wiring shall be carried out with 1100 volts grade, single core, stranded copper conductor with PVC insulation. The sizes of wire shall be not less than 1.5 sq. mm.

Terminal blocks shall be of stud type, 10 A rated, complete with insulated barriers. Terminal blocks for CTs shall be provided with test links and isolating facilities.

All spare contacts and terminals of cubicle mounted equipment and devices shall be wired to terminal blocks.

Accuracy class for indicating instruments shall be 1.0 or better. Instruments shall be 110 mm square, 240° scale for flush mounting with only flanges projecting.

Push buttons shall be provided with inscription plates engraved with their functions. Indicating lamps shall be of clustered LED type. Space heaters of adequate capacity shall be provided inside each panel. They shall be suitable for 230 V, 1 ph, 50 Hz supply. They shall be complete with MCB and thermostat.

Each panel shall be provided with 230 Volts, 1 phase, 50 Hz, 5 A, 3 pin receptacle with MCB located in a convenient position. An interior illuminating lamp together with the operating door switch and protective MCBs shall be provided.

The DC and AC auxiliary supply shall be distributed inside the panel with necessary isolating arrangements at the point of entry and with sub-circuit MCBs as required.

Tests

Each unit of soft starter shall be tested as per relevant standards at the manufacturer's work. Test result must satisfy all the characteristics during starting and acceleration against their quoted values during bidding.

Cable Terminations

Cable termination boxes shall be suitable for air termination of cables. They shall be sealed with a neoprene gasket to provide dust and weather protection.

Cable boxes for voltages in excess of 1 000 V shall be treated with anti-tracking varnish.

8.6.19 Distribution Boards

Distribution Boards for use as service disconnecting means shall be circuit breaker equipped. Design shall be such that any individual breaker can be removed without disturbing adjacent units or without loosening or removing supplemental insulation supplied as a means of obtaining clearances as required.

Where "space only" is indicated, provisions shall be included to allow future installations of breaker sized as indicated. All panelboard locks included in the project shall be keyed alike.

Directories shall be typed to indicate load served by each circuit and mounted in a holder behind transparent protective covering.

The enclosure shall be constructed as per section on Low Voltage switchgears.

The door seal shall be of high quality and a pressured catch handle shall be employed.

Exterior cables (power source cables as well as feeding cables) shall be directly connected to the MCCB or isolator. Adequate space for exterior wiring shall be provided.

A permanent connection diagram identifying the feeders shall be provided in holder fitted with a transparent cover inside the door on completion of construction.

Provision for 25% spare for future expansion shall be provided.

Busbars shall be of tinned, hard drawn, high conductivity copper. They shall be insulated throughout their lengths by means of phase color sleeving. The busbar assemblies and joints shall be in accordance with the manufacturers/suppliers recommendations.

Live connections to and from busbars shall be either fully insulated or suitably screened and all covers screening the busbars and connections shall be provided with adequate warning labels

Grounding Bar shall be provided. The sectional area of the neutral bar shall be equal to the sectional area of the phase bar.

UL-listed bus current ratings shall be provided as indicated. Bus bars shall be supported on bases independent of the circuit breakers. Main buses and back pans shall be designed so that breakers may be changed without machining, drilling, or tapping.

An isolated neutral bus shall be provided in each panel for connection of circuit neutral conductors. A separate ground bus marked with a green stripe along its front and bonded to the steel cabinet for connecting grounding conductors shall be likewise provided.

8.6.20 Electric Motors

Motors shall comply with the requirements of IEC 60034 and IEC 60072 as amended and supplemented by this specification.

Type and Rating

Except where specified otherwise or economically justified, all a.c. motors shall be of the constant speed, cage induction type with windings adequately braced for direct-on-line starting at the rated voltage. They shall be suitable for control by either circuit breaker or fused contactor.

Motors shall be continuously rated, Duty Type S1. Exceptions shall be permitted only when the intermittent or short time duty cycle can be accurately defined by the Contractor.

Three phase a.c. motors shall be rated for the voltages specified in the Specification and Single Line Diagrams. The minimum rated output of HV motors shall comply with IEC 34-1. The maximum rated output of LV motors shall not exceed 150 kW, except where approved by the ENGINEER.

Induction Motors Starting Method shall be of the following types :

- | | | |
|----------------------|---|--|
| 1. Less than 10 kW | : | 415V Direct On Line (DOL) |
| 2. 10 to 100 kW | : | 415V Star-Delta / Variable Frequency Drive |
| 3. 101 Kw TO 999 Kw | : | 690V Inverter / Soft Starter / VFD |
| 4. More than 1000 kW | : | 11kV Primary Resistance Starter / Soft Starter / VFD |

NOTE : Air duct shall be provided for every VFD / Soft Starters/ Primary Resistance Starters compartment to eliminate hot air circulation inside the MCC.

11kV Medium Voltage Motors

All medium voltage motors shall be provided with a primary resistance starter, soft starter or a variable frequency drive with by-pass option for RVAT (Reduced Voltage Auto Transformer) control in case of soft starter or VFD failure.

Each starter is to have isolation, over current and thermal protection, a contactor, control voltage C/B and terminals for output power and control cables. The power wiring shall be red, yellow and blue. The minimum size of all control wiring shall be 2.0mm². The over current and thermal protection shall be coordinated so that both motor and starter equipment is protected.

Starting or stall current shall not be greater than 7 times the motor full load current.

Process display of every Soft Starter/Variable Frequency Drive shall be located in front of each compartment.

Warranty for Electric Motors

A minimum one-year manufacturer's warranty shall be provided for all motors. Warranty shall commence from the date of acceptance.

Insulation

Motors shall be insulated with materials complying with IEC 85. All motors shall have Class F insulation but the temperature rise shall not exceed the limits applicable to Class B.

Conditions of Operation

A.C. motors shall be capable of continuous operation under the service conditions within the Zone A voltage and frequency variations specified in IEC 34-1 Figure 13.

Unless otherwise specified, the motors shall be capable of continued operation at 75% rated voltage and rated frequency for a period of 5 minutes without injurious heating. In the event of loss of supply, all motors shall be suitable for restarting against the full residual voltage in the motor winding during motor run-down.

Starting Performance

Unless otherwise specified or required, cage induction motors up to and including 40 kW shall have a starting performance better than or equal to Design N in accordance with IEC 34 (External inertias for 50 and 60 Hz motors shall be in accordance with BS 4999 Part 112). Cage induction motors above 40 kW shall have a starting performance better or equal to Design D in accordance with BS 4999 Part 112. The starting current at full voltage shall not exceed 6 times full load current.

The starting torque at 80% voltage shall be adequate for starting the driven load under the most arduous conditions, such as open fan vane or open pump discharge valve. The accelerating torque at any speed and 80% rated voltage shall be not less than 10% of motor rated torque. In any event the motor starting torque at 100% rated voltage, and at all speeds between standstill and the speed at which breakdown torque occurs, shall be not less than 1.7 times the torque obtained from a load curve which varies as the square of the speed and is equal to 100% motor rated torque at rated speed.

The margins between the torques of the motors and driven plant shall include suitable allowances for impeller wear, fouling etc. during the life of the plant.

Electric motors shall be suitable for two successive starts with the motor already at full load working temperature, subject to the motor being permitted to decelerate to rest under operating conditions between successive starts.

After a cooling period of 30 minutes at rest another starting sequence of two successive starts shall be permissible.

Bearings

The type of bearings used in the motor shall be fully compatible with those used in the driven equipment.

The type of bearing, bearing numbers and regressing interval shall be stamped on each motor rating plate.

Bearings shall comply with the applicable ISO standards.

Bearings shall be designed to exclude the ingress of dust and water and sealed to prevent leakage of lubricant along the shaft.

Enclosures and Methods of Cooling

The degree of enclosure protection for motors shall be as follows unless otherwise specifically approved by the ENGINEER:

1. IP54 for indoor locations not subject to hosing.
2. Not less than IP 55W for outdoor locations, and indoor locations subject to hosing.
3. Where motors are exposed to solar radiation, sunshades shall be fitted, if required by the manufacturer to meet his guarantees.

The cooling classification for motors shall be as follows unless otherwise specifically approved by the ENGINEER:

- IC4AlA1 or IC5AlA1 for LV motors, or IC4AlAO for small power LV motors.
- IC4AlA1, IC5AlA1, IC6A1A1 or IC7AlW7 for HV motors.
- Ferrous metals should be used for the frames and end shields of all ratings of motors.

Aluminium and its alloys shall only be used when the manufacturer can demonstrate that such materials are entirely suitable for the particular application at its installation location.

Fans of identical motors shall be interchangeable without affecting motor balance.

Anti-condensation Heaters

To minimise condensation in all outdoor 415V, 690V, and 11kV intermittently used motors when out of service, heaters of an approved type and rating, suitable for operation from a 230 V a.c. single phase supply, shall be fitted inside the lower half of the stator frame.

The control of anti-condensation heaters shall be so arranged that they are normally energised when the motor is not running.

Terminals and Terminal Boxes

Winding terminations shall generally comply with BS 4999 Part 145. Separate non-compound filled, terminal boxes shall be provided for each of the following, as applicable:

- (a) Main (line) connections.
- (b) Star point connections.
- (c) Anti-condensation heater connections.
- (d) Instrumentation and alarm devices.

All terminal boxes with the cables terminated shall have an enclosure classification not less than that of the motor itself. All terminal boxes shall be of an adequate size for the satisfactory termination of the cable(s) required or specified, including all applicable termination components.

All HV terminal boxes shall be provided with a desiccant indicator, externally sealed.

Terminals and terminal leads shall be to approval and shall be substantially designed for connection to a system having the symmetrical short circuit rating of the source switchboard, as limited by fuses, where applicable.

The clearances and creepage distances shall apply also to insulated terminals and connectors.

Porcelain terminal bushings and insulators shall not be used.

Main and star point terminal boxes of HV motors shall be of steel. Cast iron may only be used for LV motor terminal boxes and auxiliary terminal boxes.

Star point terminal boxes shall only be provided where required to accommodate neutral end current transformers and shall be positioned opposite the main terminal box.

Main HV terminal boxes at voltages exceeding 7.2 kV (Um) shall be of a type which restricts internal faults to earth faults only. Where pressure relief terminal boxes are used, they shall be designed to relieve the products of an internal fault safely to the outside, and not into the interior of the motor.

Provision shall be made for earthing the cable armour and the cable insulation screens, where applicable, in accordance with the cable termination method being used.

In auxiliary cable boxes either stud terminals or clamp terminals shall be provided.

The anti-condensation heater terminal box shall have a warning label adjacent to it, stating "Motor heater - terminals live".

Earth Terminal

All motors shall be provided with a means of earthing the frame, which shall be to the approval of the ENGINEER.

D.C. Motors

D.C. motors which are to operate from batteries shall be capable of operating under the service conditions at any voltage in the range of 80% to 110% of the nominal value.

Motors of the constant speed type shall be designed to operate with a permanent series resistor of suitable rating and with a contactor such that starters with tagged resistors are not required.

All d.c. motors shall be provided with brushgear which does not require to be moved to suit load conditions.

Motors connected to rectifier equipment shall meet the conditions of supply voltage and frequency specified for a.c. motors. Where necessary, rectifier equipment shall be fitted with a current limiting device.

8.6.21 Push buttons and Separately Mounted Local Pushbutton Stations

Pushbuttons, which may be of the illuminated or non illuminated type, shall be shrouded or well recessed in their housings in such a way as to minimize the risk of inadvertent operation.

In instances where "enable" pushbuttons are required they shall be electrically interlocked with the normal control such that deliberate operation of the "enable" push-button is required before the normal control can take place.

The colour of pushbuttons shall be as follows:

- When mounted on pushbutton stations adjacent to running plant the stop button shall be coloured red and the start button coloured green.
- When mounted on the front of the contactor panel the stop button shall be coloured red and the start button coloured green.
- When mounted on panels or desks with adjacent indication lights both buttons shall be coloured black, unless required otherwise by the ENGINEER.

Loose pushbutton stations, unless supplied as weatherproof free standing enclosures, shall be of the metal clad weatherproof type suitable for wall or bracket mounting with a minimum enclosure classification of IP55. All outdoor mounted pushbutton stations shall incorporate a protective cover or guard (e.g. toughened glass door) to prevent inadvertent operation.

Control stations shall be clearly labeled showing the duty or drive to which they are applicable. Location of ammeters shall be agreed with the ENGINEER.

Pushbuttons used on covered desks, panels etc. may of necessity require to be of special types (e.g. miniature, illuminated). The specifications and requirements for these special pushbuttons shall be agreed with the ENGINEER.

Emergency stop pushbuttons shall be provided adjacent to all motors and machinery with exposed moving parts, couplings etc. to prevent danger, and on main and local control panels. These pushbuttons shall have a large "mushroom" head, be coloured red and incorporate a protective cover or guard to avoid accidental operation. These buttons shall automatically lock in the depressed position, requiring twist or key resetting. Contacts shall be provided to cause

tripping of the associated circuit, prevent restart of the circuit and bring up an alarm in the Central Control Room.

Stop pushbuttons mounted local to motors shall trip the associated circuit breaker or contactor regardless of the control position selected.

The contacts of all pushbuttons shall be shrouded to minimize the ingress of dust, and accidental contact, and shall be amply rated for voltage and current for the circuits in which they are used.

8.6.22 Earthing and Bonding

The Contractor shall design and submit the complete Subgrade Earthing System, Potential Gradient Earthing System, and Above Ground Earthing System for the CP1 230/110/11kV Substation and the whole CP1 Sea Water Reverse OSMOSIS Plant Buildings and Facilities for ENGINEER's approval.

The maximum permissible earthing system resistance of 1 ohm shall be designed for the Subgrade Earthing System to be able to (a) stabilize the circuit potentials with respect to ground and limit the overall potential rise, (b) to protect life and property from overvoltage, (c) to provide low impedance path to fault currents, (d) to ensure prompt and consistent operation of protective devices during ground faults and (d) to keep the maximum voltage gradient along the surface inside and around the substation within safe limits during ground fault.

The main earthing conductors for connection to all electrical equipment, cables, motors, panels, etc., shall be provided for connection to the main earthing system.

All non-current carrying metal parts of electrical equipment shall be bonded to an earth terminal or terminals mounted on the equipment and readily accessible.

All equipment terminals provided for an external earth connection shall be identified by indelible means unless such terminals are directly and visibly mounted on metallic equipment frames or earth bars, when such marking may be omitted.

Identification marks for earth terminals shall comprise the colours green/yellow in combination or a reproduction of the symbol no. 5019 in IEC 60417.

Assemblies containing electrical equipment, including switchboards, control boards and control desks, shall be provided with a separate copper earth bar running the length of the assembly. All metal parts and the earth terminal or terminals shall be bonded to this earth bar. Earthing connections shall not depend upon the bolting of steel/steel joints between adjacent panels or cubicles.

Earth bars shall be made of tinned Cu busbars of adequate size and suitably supported and braced to carry the rated short circuit current for the associated electrical circuits for the rated short- circuit current duration, without damage or excessive heating likely to damage joints, associated or adjacent components.

Switchgear and control gear assemblies shall be provided with two or more earth terminals unless otherwise specified. The copper earth bar shall be sized to withstand the maximum system earth fault current for three seconds without deterioration.

The size of the copper earth bar in control panels, control desks or similar enclosures containing low voltage apparatus shall be such as to comply with the specified requirements for withstanding prospective short-circuit currents. The size of this bar shall be a minimum of 100 mm² cross-sectional area, providing that sufficient mechanical integrity is provided by adequate supports and terminals, and also providing this size is not less than the size of the largest incoming power supply conductor.

The metal cases of all instruments, relays and the like shall be connected to the panel earth bars by copper conductors of not less than 1.5 mm² cross-sectional area, or by other means to the approval of the ENGINEER.

If the plant contains electronic equipment which is vulnerable to possible conductive interference, or if the equipment generates electrical noise, which could interfere with other plant or equipment, then separate earths may be supplied and the actual means of interconnecting with the station earth system shall be agreed with the ENGINEER.

The electrical installation shall where required be connected to the general mass of the earth by an earthing conductor. The material used for the earthing conductor shall be as follows:

1. Conductors above ground shall be tinned copper tape or minimum 150 mm² Cu/PVC green/yellow conductor.
2. Conductor buried in the ground for subgrade earthing system or embedded in concrete for potential gradient earthing system shall be minimum 150 mm² bare copper conductor.

The subgrade earthing system shall comprise one or more earth electrodes, bare copper earthing conductors, wire mesh or a combination of these in order to obtain the required earth resistance of 1 ohm.

Earth electrodes shall be of heavy duty copper alloy of not less than 25 mm in diameter and 3000 mm long. Where multiple rods are used they shall be separated by a distance of not less than twice of the driven length.

Each earth electrode shall be connected to the earthing conductor by exothermic welding and shall be connected to the copper earthing bus bar inside the 300mm x 300mm earth pit. These connections shall each be housed in individual concrete inspection chamber set flush to the finished ground level and shall allow disconnection for testing of individual electrodes. The chamber shall be permanently marked 'Electrical Earth'.

All materials used for the earth electrode installation shall be purpose made for the application and site conditions and shall be approved by the ENGINEER.

Unless otherwise stated all excavation for the installation of the earth electrodes and the inspection pit shall be carried out by the Contractor.

After the earth installation has been completed the Contractor shall demonstrate to the ENGINEER that the resistance of the electrodes to earth and the continuity of the earth network are within the limits specified. Any additional earth electrodes and test instruments required for the tests shall be provided by the Contractor.

Marker posts and plates shall be provided to mark the route of buried conductor and electrodes. The markers shall be similar to those provided for cable routes.

The requirement for lightning protection shall be checked as per code of practice for lightning protection – IS: 2309 and if found necessary the same shall be provided by the Contractor.

Main equipotential bonding conductors shall be provided to connect the earth electrode system to conductive parts forming the Works.

Circuit Protective Conductors

An independent circuit protective conductor shall be provided for each circuit and may comprise one or any of the following as appropriate:

1. A separate core within a multicore cable.
2. A separate conductor installed within a conduit or trunking.

Steel conduit or trunking shall not be used as a circuit protective conductor the metal sheath of an armoured cable shall be bonded to the metalwork of the apparatus and to the apparatus earth bar if any.

3. The copper sheath of a mineral insulated copper sheathed cable
4. An independent earthing conductor that run adjacent to
the circuit it protects.

Circuit protective conductors associated with the main circuits supplying switchboards and large electrical loads, i.e. motors in excess of 75 kW shall form a separate core of a multicore cable feeding the device or shall be an independent insulated copper conductor run adjacent to the supply cable. The size of the circuit protective conductor shall be calculated in such a manner as not to take into consideration the contribution of any other parallel earth paths.

The armouring of the supply cable shall not form the sole means of earthing a switchboard or large electrical load.

Where the cable armouring or sheath is used as the circuit protective conductor it shall be securely bonded at both ends to the metalwork of the apparatus and to an earth bar. Particular care shall be taken to ensure continuity across items of apparatus situated within a cable run and should the design of such items of apparatus not give adequate and lasting continuity through its structural body then additional earthing clips and conductors shall be provided to independently bond the cable sheaths together. Similarly additional earthing clips shall be provided to bond the cable sheaths/armour to any piece of apparatus fitted with a special earth terminal should the earth connection for the termination gland be inadequate. Any additional earthing clips shall be fitted within the apparatus wherever possible.

Instrumentation Earth

An instrumentation earth bus shall be provided in each control panel. This shall comprise a copper 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.

SPD's associated with the control and instrumentation system shall be earthed to the instrument earth in accordance with the SPD manufacturer's recommendations.

8.6.23 Lightning Protection System

General

This Section specifies the lightning protection system for the building(s) or structure(s). This system provides safety for the building and occupants by preventing damage to the structure caused by lightning.

The design of this system is to be in strict accordance with this section of the specification.

The work covered under this section of the specifications consists of design, furnishing labor, materials and services required for the completion of a functional and unobtrusive lightning protection system approved by the ENGINEER.

The entire lightning protection system shall be designed and installed in accordance with the following codes and standards :

- A) National Fire Protection Assoc. (NFPA) Document # 780
- B) Underwriters' Laboratories, Inc. (UL) Standard # 96A
- C) Lightning Protection Institute (LPI) Standard # 175

Contractor shall design and submit a complete shop drawing of the lightning protection system for ENGINEER's approval prior to commencement of the installation.

The shop drawing shall show the extent of the system layout designed for the structure along with details of the products to be used in the installation.

The system installation shall be made by a contractor that specializes in the installation of lightning protection systems and be under the supervision of an LPI Certified Master Installer or Master Installer – Designer.

All materials shall comply in weight, size, and composition with the requirements of a nationally recognized testing laboratory. All equipment shall be properly listed and labeled. The system furnished under this specification shall be the standard product of a manufacturer regularly engaged in the production of lightning protection equipment and a member of LPI.

Equipment shall be the manufacturer's latest approved design of construction to suit the application where it is to be used in accordance with accepted industry standards and with NFPA, LPI, & UL requirements.

Acceptable Manufacturers – A/C Security Lightning, LLC (www.aclightingprotection.com) Advanced Lightning Technology, Ltd. (www.altfab.com) East Coast Lightning Equipment, Inc. (www.ecle.biz) FURSE, ABB Ltd. (www.furse.com; www.abb.com) Harger, Inc. (www.harger.com) Independent Protection Company, Inc. (www.ipclp.com) PENTAIR/ERICO (www.erico.com) Preferred Lightning Protection (www.preferredlp.com) Robbins Lightning, Inc. (www.robbinslightning.com) Thompson Lightning Protection, Inc. (www.tlpinc.com)

Materials

Class I materials shall be used for systems on structures not exceeding 75 feet in height and Class II materials shall be used for systems on structures exceeding 75 feet above grade.

Copper shall be of the grade ordinarily required for commercial electrical lightning protection work, generally designated as being 95 percent conductive when annealed.

Lightning protection materials shall be coordinated with building construction materials to assure compatibility. Copper lightning protection materials shall not be installed on aluminum surfaces. Copper system components within 2 feet of chimney exhausts shall be tin coated to protect against deterioration.

Strike termination devices shall be provided to place the entire structure under a zone of protection as defined by the Standards. Air terminals shall project a minimum of 10 inches above protected areas or objects. Air terminals shall be located within 2 feet of exposed corners and roof edges.

Metallic bodies having a thickness 3/16" or greater may serve as strike termination devices without the addition of air terminals. These bodies shall be made a part of the lightning protection system by connection(s) according to the Standards using main size conductors and bonding fittings with 3 square inches of surface contact area.

Cable conductors shall provide a two-way path from strike termination devices horizontally and downward to connections with the ground system. Cable conductors shall be free of excessive splices and sharp bends. No bend of a conductor shall form a final included angle of less than 90 degrees nor have a radius of bend less than 8 inches. Structural elements and design features shall be used whenever possible to minimize the visual impact of exposed conductors.

Cable down conductors may be concealed within the building construction or enclosed within PVC conduit from roof to grade level. Down conductors shall be spaced at intervals averaging not more than 100 feet around the protected perimeter of the structure. In no case shall any structure have fewer than two down conductors. Where down conductors are exposed to environmental hazards at grade level, guards shall be used to protect the conductor to a point 6 feet above grade.

In the case of structural steel frame construction, cable down conductors may be omitted and roof conductors shall be connected to the structural steel frame at intervals averaging not more than 100 feet around the protected perimeter of the structure.

Exposed cable conductors shall be secured to the structure at intervals not exceeding 3 feet – 0 inches. Fasteners, nails, screws, or bolts shall be of suitable configuration for the intended

application and of the same material as the conductor or of electrolytically compatible materials. Galvanized or plated steels are not acceptable.

Connectors and splicers shall be of suitable configuration and type for the intended application and of the same material as the conductors or of electrolytically compatible materials.

Ground terminations suitable for the soil conditions shall be provided for each downlead conductor. Where the structural steel framework is utilized as main conductors for the system, perimeter columns shall be connected to the grounding system at intervals averaging 60 feet or less on the protected perimeter. For any structure in excess of 60 ft. in vertical elevation above grade, a ground loop interconnecting all ground terminals and other building grounded systems shall be provided.

Common interconnection of all grounded systems within the building shall be accomplished using main size conductors and fittings. Grounded metal bodies located within the calculated bonding distance as determined by the formulas of the Standards shall be bonded to the system using properly sized bonding conductors.

Surge suppression shall be provided at every system entrance to the structure to prevent massive lightning over voltages from entering the structure. Additional surge protection for internal electronic equipment may be determined through cost-benefit analysis by a trained ENGINEER.

The installation shall comply with the requirements of NFPA 780, UL 96A, and LPI 175.

The installation of the lightning protection system components shall be done in a neat and workmanlike manner.

Roof penetrations required for down conductors or for connections to structural steel framework shall be made using through-roof assemblies with solid rods and appropriate roof flashings. The roofing contractor shall furnish the methods and materials required at roofing penetrations of the lightning protection components and any additional roofing materials or preparations required by the roofing manufacturer for lightning conductor runs to assure compatibility with the warranty for the roof. (Note: The roofing contractor will be responsible for sealing and flashing all lightning protection roof penetrations as per the roof manufacturer's recommendations.

The lightning protection roof penetrations and/or method of conductor attachment should be addressed in the roofing section of the specifications.

Upon completion of the lightning protection installation, the installing contractor shall provide ENGINEER an as-built drawing of the system, along with copies of the certificates of completion.

8.6.24 Conduits and Accessories

Conduit installations shall comply with IEC standards 60364, 60621 and 60981. Installations shall also be compliant with local regulations, unless otherwise approved by the ENGINEER.

All conduit and conduit fittings shall comply with IEC 60423. Unless otherwise approved, all conduit and conduit fittings shall be threadable steel conduit with minimum enclosure

classification IP55, heavy mechanical protection and high resistance to corrosion inside and outside. No conduit smaller than 20mm diameter shall be used.

Standard circular boxes or machined face heavy duty steel adaptable boxes with machined heavy type lids shall be used throughout. For outdoor mounting all boxes shall be galvanised, weatherproof and fitted with external fixing lugs.

Where conduit is terminated so that the bare end of the conduit is exposed the conduit end shall be fitted with a brass bush.

The use of running threads, solid elbows and solid tees will not be permitted.

Conduit ends shall be carefully reamed to remove burrs. Draw-in boxes shall be provided at intervals not exceeding 10m in straight-through runs.

Conduit runs shall be in either the vertical or horizontal direction, unless otherwise approved, and shall be arranged to minimise accumulation of moisture. Provision for drainage shall be made at the lowest points of each run.

Conduits shall be supported on heavy galvanised spacer saddles so as to stand off at least 6mm from the fixing surface.

All conduits run in any circuit are to be completed before any cables are pulled in. Flexible metallic conduit shall be used where relative movement is required between the conduit and connected apparatus, and a separate earth continuity conductor shall be provided.

Liquidtight Flexible Conduit

Contractor shall use Liquidtight Flexible Conduit in connecting the motor power and local push button station control cables which is made of a flexible galvanized metal core with sunlight resistant thermoplastic outer jacket.

Liquidtight flexible conduit shall be manufactured in accordance with UL-360 - Steel Conduits, Liquid-Tight Flexible.

PVC coated gray color flexible conduits shall be used for the final connection to removable field apparatus such as motors, RTD probes and the like.

Conduit installed outside shall be stabilized against ultra violet light.

Where mounted on moving parts of machinery or where subject to mechanical damage the conduit shall be flexible PVC covered galvanized steel.

All flexible conduits shall be terminated in purpose built glands.

8.6.25 Cable Support System

Cable ladder racking, trays and ducting shall have a minimum of 20 percent spare capacity at the end of the contract.

All fixings to concrete or masonry shall be of the expansion type set in holes. Explosive powder-charged fixings shall not be used.

Fixings to structural steelwork shall be by clamping, not welding or drilling, except with the specific prior approval of the ENGINEER.

Cable support systems shall be installed in accordance with the manufacturer recommendations to give a maximum between support deflections of 10 mm when carrying the final number of cables to be installed.

All steel supports, frames, hangers and the like shall be electroplated and in most areas hot dip galvanized with three coats of powder epoxy.

All exposed threads on support systems, conduit and other places where the galvanizing finish has been removed shall be painted with galvanized paint and three coats of powder epoxy. Sprays cans types of paint shall not be used.

All lengths of the cable support system shall be bonded to earth.

The Contractor shall submit to the ENGINEER a layout of his proposed method of reticulation throughout the Plant showing positions of all cable ladder, tray or ducting system.

Cable Ladder

Cable ladders shall be manufactured from ***non-corrodible material including its supports***. They shall be completed with accessories including hangers, brackets and cable clips.

The contractor shall supply and erect all cable ladders and all brackets and fabricated steelwork necessary to support the cable ladder and shall ensure that they are adequate in all respects for the loading imposed.

All changes in direction shall be made using purpose made slow radius bends and cranks as manufactured for this purpose.

Cable ladders installed outside the building shall be provided with cover.

Cable Trays

Cable trays shall be manufactured from ***non-corrodible material including its supports*** and shall be provided in strict accordance with the manufacturer's printed instructions. Allowable cable fill areas shall meet the requirements of the specification. Prior to installation, cable tray fills shall be verified based on cables and trays actually provided.

Continuous grounding of cable trays including bonding jumpers shall be maintained in accordance with the grounding requirements of this specification.

Cable trays shall be installed using hangers and supports on 2.4 metre centres, maximum.

Cable tray systems shall be composed of straight sections, angle couplers, reducers, fittings, and accessories as defined in the latest IEC / British Standards.

The cable tray and fittings shall be hot-dipped galvanized steel with three coats of epoxy coating. It shall be also of the ladder type with 150 mm spacing with a minimum loading depth of 76 mm and nominal width as indicated. When required in corrosive locations, cable trays shall be made of rigid heavy duty industrial grade plastic material.

Where exposed to sewer or other environment that may cause corrosion, suitable non-corrodible materials shall be utilized to prevent corrosion. The ENGINEER shall approve the alternative non-corrodible material.

All nuts, bolts, and washers shall be stainless steel 304.

Loading capacities shall meet weight classification with a safety factor of 1.5.

Steel cable trunking may be used for running numbers of insulated cables or wires in certain positions to the approval of the ENGINEER. The trunking thickness shall not be less than 1.2 mm. Connection of conduit to trunking shall be with socket and male bush. All trunking shall be manufactured from hot-dip zinc coated steel sheet with three coats of powder epoxy.

8.6.26 Cables and Wires

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. 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.

EHV / MV / LV Cables shall comply with the following International Standards, including those referred to therein.

IEC 60183, 60227, 60502, 60885 and IS 7098, 5831, 8130, 1554, 10810.

Control cables shall be 2C, 3C, 4C, 7C, 12C and 19C type. Minimum size of conductor for control cables shall be 1.5 sq.mm. Copper.

All power cables shall be sized based on continuous current capacity, maximum permissible voltage drop of 3% and rated short circuit current withstand. In addition, de-rating factors for variation in ground/air temperature, grouping of cables, depth of laying, number of racks, etc. shall be considered for cable sizing.

All EHV, MV and LV cables shall be subject to routine tests in accordance with the relevant IEC and Indian Standard Specifications.

Test certificates shall be provided against each drum and/or cable length.

The tests carried out on every cable length and / or drum at manufacturer's premises shall include following tests as applicable but not limited to:

- high voltage dc insulation pressure test, between cores, each core to earth, metallic sheath or armour as applicable;
- insulation resistance test;
- core continuity and identification;
- conductor resistance test

- Elongation test
- Smoke density test
- HCl gas generation test
- Anti rodent test (Presence of lead)

Telecommunication Cables

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.

Internal Use

The cable shall have tinned copper conductors of 0.5 mm diameter with PVC insulation and PVC over sheath. 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, cables shall be installed in conduit, trunking or clipped direct.

Instrumentation Cables

Contractor shall include in his scope the supply and laying of instrumentation signal and instrument power supply cables and associated civil / mechanical work required for completing the system.

Cables shall be capable of satisfactorily withstanding without damage, transportation to site, installation at site, and operation under normal and short circuit conditions of the various systems to which the respective cables are connected when operating under the climatic conditions prevailing at the site as indicated in this specification.

Cable joints in instrument signals and power supply cables shall not be permitted.

Cables shall be capable of satisfactory performance when laid on trays, in trenches, conduits, ducts and when directly buried in the ground. Cables shall be capable of operating satisfactorily under a power supply system voltage variation of $\pm 10\%$, a frequency variation of $\pm 5.0\%$ and overall variation limited to $\pm 10\%$.

a) Cables for Digital Signals

650V/1100 V grade multicore cables, multistranded high conductivity annealed 1.0 sq.mm stranded tinned copper conductor, extruded PVC insulated, overall screened with braided wire or with aluminium mylar tape, ATC drain wire run continuously in contact with aluminium tape, inner sheathed with extruded PVC, armoured with galvanized steel wire overall sheathed with extruded PVC conforming to IS:1554 and IEC:189 Part II.

b) Cables for Analog Signals

650 V/1100 V annealed, tinned, high conductivity 1.0 sqmm stranded copper conductor extruded PVC insulated two/ three cores twisted into pair/ triad, laid up collectively, individual pair/ triad shielded and overall shielded with wire braiding or aluminium mylar tape, ATC drain wire run continuously in contact with aluminium side of the tape, inner sheathed with extruded PVC, armoured with galvanized steel wire, overall sheathed with extruded PVC conforming to IS:1554 and IEC:189 Part II.

SCADA System

Fiber optic cable shall be applied to the SCADA system to integrate PLCs located at each local control room and operator stations located at the SCADA 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/k m and 0.3 dB/km at 1310nm and 1550nm wave length light respectively. FOC shall be installed in HDPE conduits including all accessories like couplers, etc for underground installations.

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:

1. Supply voltage and frequency
2. Maximum voltage drop permissible
3. Type and magnitude of load
4. Fault level and duration related to circuit protection relays and fuses
5. Circuit over current protection
6. Route length and disposition of cables
7. Ambient temperature
8. Method of installation

All power cables shall be sized for continuous current carrying capacity at the ambient temperature of 50 deg.C. The design current of any circuit shall exceed the full load current of the supplied device by at least 25%. Power cables shall be sized to limit the maximum voltage drop to no more than 3 %.

Under motor starting conditions the corresponding voltage drop shall not affect the operation of the motor controls or the ability of the motor to start and run effectively and in any event shall not exceed 10%. While sizing cables for the remote operation of shunt trip coils the contractor shall take due account of the voltage drop caused by the momentary current surge taken at the instant of energisation.

Cable Colors

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+ N	-	red, yellow, blue & black
Single Phase	-	red & black, yellow & black, blue & black
Earth Wire	-	yellow/green
Control	-	blue (DC) Red (AC)

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 2.5 mm². Small power and control cables shall be of a minimum cross-section of 4.0 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 1.0 mm².

EHV/ MV and LV cables shall be sized as a minimum for a fault clearance time of 0.5 seconds for the incoming feeders and 0.16 seconds for switchboard feeders controlled by circuit breaker.

Cable Installation

All 230kV/110kV/11kV EHV/MV cables in the GIS Substation shall be installed in cable trenches in corrosion proof cable ladders / trays , supports & accessories. HDPE pipe sleeves with concrete encasement shall be used for entrance of cables into the cable basement and for road crossings.

A uPVC ducts with concrete encasement and manholes shall be installed for 11kV cables installed outdoor to supply the 11kV Electrical Rooms in the plant. HDPE pipe sleeves with concrete encasement shall be used for entrance of cables into the cable basement and for road crossings. Manhole shall be provided to terminate the HDPE pipe sleeves and uPVC ducts before entering the substation building cable basement.

Low Voltage Power Cables, Control Cables, and Instrumentation Cables installed outdoor shall also be installed in cable ducts encased in concrete and manholes. HDPE pipe sleeves with concrete encasement shall be used for entrance of cables into the cable basement and for road crossings.

Low Voltage Power Cables, Control Cables, and Instrumentation Cables installed indoor shall be installed in corrosion proof cable ladders / trays, supports and its accessories 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.

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.

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. A ***corrosion proof cable support system and its accessories*** shall be provided for power, control, and instrumentation cables.

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 this is not practical a separation of 150 mm shall be maintained between power, control, instrumentation cables when run on the same support system.

Heavy duty **corrosion proof** galvanized iron cable tray and ladder racking shall be used for cable support systems. **Heavy duty plastic cable tray and corrosion proof support systems** shall be used in areas used for the storage and handling of chlorine and other chemicals. These systems shall be used to route cables around walls and within cable trenches. Cables shall be securely fixed to the support systems. Bundling of cables shall be permitted where allowance for this practice has been made in sizing the cables.

Instrumentation Cabling

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.

SCHEDULE OF TECHNICAL REQUIREMENTS OF XLPE POWER CABLES

SL. No	Description	230kV	110 kV	33kV	11kV
1	Rated system voltage	230kV	110 kV	33kV	11kV
2	Max. permissible system voltage	245kV	145kV	36kV	12kV

3	Rated frequency	50Hz	50Hz	50Hz	50Hz
4	Max. operating current				
5	No. of cable	1/Phase	1/Phase	1/phase	1/phase
6	Cross sectional area				
7	Impulse withstand voltage	1050kV	650 kV	170 kV	75 kV
8	Power frequency withstand voltage	460kV	275 kV	70 kV	50 kV
9	Shape of conductor	Segment	Segment	Compact round	Compact round
10	Insulation thickness				
11	Min. bending radius				
12	DC resistance at 20°C				
13	Short circuit rating for 1 sec				
14	Three phase symmetrical fault current for 1 sec				

Type Test Requirements for XLPE Power Cable (110kV & 230kV):

1. Bending test on Cable
2. Ten Delta measurement test
3. Heating cycle voltage test
4. Partial discharge tests:
5. At ambient temperature, and at high temperature.

8.6.27 Cable Installation

Underground Cable Duct with Concrete Encasement

Underground duct lines shall be constructed with concrete encasement. The concrete encasement shall be rectangular in cross section and shall provide at least 75 mm concrete cover for ducts. Conduits shall be separated at least 50 mm apart. The kind of conduits used in any one-duct bank shall not be mixed. The top of the concrete envelope shall not be less than 460 mm below grade except those under roads and pavement, which shall be not less than 610 mm.

Duct lines shall have a continuous slope towards hand holes with a pitch of 75 mm in 30 meters. Except at conduit risers, changes in direction of runs exceeding a total of 10 degrees, either vertical or horizontal, shall be accomplished by long sweep bends having a minimum radius of curvature of 7.62 meters. Sweep bends may be made up of one or more curved or straight

sections or combinations thereof. Manufactured bends shall have the following minimum radii corresponding to the given conduit diameters, as shown in Table 3.

Minimum Radius Requirements

Conduit Diameter	Minimum Bending Radius
< 75 mm	457 mm
≥ 75 mm	914 mm

Conduits shall be terminated in end-bells where duct lines enter hand holes or cable trenches. Separators shall be of pre-cast concrete, high impact polystyrene, steel or any combination thereof.

The joints of conduits shall be staggered by rows and layers so as to provide maximum strength for the duct line. During construction, partially completed duct lines shall be protected from entry of debris by means of suitable plugs. As each section of a duct line is completed from hand hole to hand hole, a brush thorough having a diameter of the duct, shall be drawn until the conduit is clear of all particles of earth, sand and gravel; then immediately install conduit plugs. Where required, cast-in-place hand holes/manholes shall be provided complete with all accessories, drain facilities and strength indicated. Concrete hand holes/manholes shall have a smooth trowel finish for floors and horizontal surfaces. Walls shall be constructed on a footing of cast-in-place concrete. Walls and bottoms shall be of monolithic concrete construction.

Duct entrances and windows shall be located near the corners of structures to facilitate cable racking. Covers shall fit the frames without undue play. Steel and iron shall be formed to shape and size with sharp lines and angles. Casting shall be free from warps and blowholes that may impair their strength and appearance. Exposed metal shall have a smooth finish and sharp lines. All necessary lugs and brackets shall be provided. Pulling irons and other built-in items shall be set in place before depositing the concrete. A pulling-in iron shall be installed in the wall opposite each duct entrance.

Ground rods for hand holes shall be installed in electrical distribution will be 25 mm diameter by 3000 mm long copper-clad steel, which shall be connected to the cable shielding, metallic sheath at each joint or splice by means of a 22 mm² braided tinned copper wire. Ground rods shall be protected with a double wrapping of pressure sensitive plastic tape for a distance of 150 mm above and 150 mm below concrete penetrations. Ground wires shall be neatly and firmly attached to hand hole/manhole walls and the amount of exposed bare wire shall be held to a minimum.

Cables Installed in Conduit

Conduits shall be galvanised heavy gauge solid drawn or welded screwed steel type/ PVC 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 25 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.

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.

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 and approved by the ENGINEER before the building operation conceals the work.

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., shall not be permitted. Adapters shall incorporate a grub screw or a gland to prevent the flexible conduit becoming loose.

Cables 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 and not less than 2 mm for trays from 300 mm to 600 mm width.

Cable Ladders and Perforated Cable Trays, its supports, and accessories for outdoor installation shall be of ***hot dipped galvanized with three coats of powder epoxy coating*** in order to have resistance to corrosion. Cable tray for use in areas where chlorine gas and other corrosive chemicals that may be present shall be constructed from rigid non metallic PVC with UV Resistant. Cable tray supports shall be of a compatible finish (***hot dipped galvanized with three coats of powder epoxy coating***) with the associated cable tray.

All cable tray tees, intersection units, bends, turns and sets shall 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 manufacturer's 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 mid-span.

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 mid-span. 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 25% spare capacity.
The tray shall be run at least 150 mm clear of plumbing and mechanical services.

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 25% spare capacity.

The ladder racking shall be run at least 150 mm clear of plumbing and mechanical services.

Cable Clipped Direct

All cable hangers, clips, cleats and saddles shall be of an approved type and appropriate to the type and size of cable installed.

Their spacing shall be such as to ensure a neat appearance and prevent sagging of the cables at all times during their installed life.

Cable Installed in Internal Floor Trench

In Shallow trenches (maximum depth 600 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.

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

Cable Terminations and Joints

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 ganged to or pass through cabling plates the gland plate or cabling plate shall be constructed of non-magnetic material.

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.

Cable Fixings

Suitable Ties and strapping shall be used 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.

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.

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.

Marking Locations of Underground Cables in Ducts

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 'electric cable' in English and the vernacular.

8.6.28 Fire Proof Sealing (FPS) System

Fire proof sealing system shall be provided and shall consist of Fire- stops / fire-seals for sealing of cable / cable tray and conduit/ pipe penetrations, both horizontal and vertical, through brick or RCC walls / floors, to prevent the spread of fire from one area to Other areas by fire - resistant barriers.

The FPS system shall also include all the necessary accessories and equipment required for supporting, holding in position, fixing and installation of the fire-stop.

The FPS system shall comply in all respects with the requirements of the codes and standards mentioned herein IEC-331 and IEC-332.

Fire Stop / Seal

The FPS system adopted for cables or cable trays penetrating through walls and floor openings, or cables passing through embedded conduits / pipes / pipe-sleeves, constitutes a 'fire stop / seal', which is meant to prevent spreading of fire between areas separated by fire-resistant barriers.

Performance Requirements

Requirement of fire stops

- i. The material, design and construction of the fire stops shall be such as to provide a fire-rating of 120 minutes for a fire on any side and meet all requirements listed in this specification and the relevant codes and standards.
- ii. The materials used in the fire stops shall be non-hygroscopic, compatible with the type of cables.
 - iii. The fire stops shall be suitable for retrofitting of cables through the penetration seal without disturbing the sealing of the cables already existing.

Application of Fire Proof Sealing System

Fire stops

Fire stops shall be provided for cable penetration openings listed below:

- i. The passage of cables / cable trays pipe sleeves / embedded conduits through walls / floors.
- ii. Vertical raceways, if any, which carry cables between successive floors, through openings provided in the RCC floor slab, shall be sealed by fire stops at each floor level.
- iii. Cable entry through openings in floor slabs.

Contractor shall furnish the test certificates for the fire stops after award of Contract for Employer's Representative review. If the certificates are not satisfactory, all the tests shall be conducted free of cost. The offered system i.e., fire stops and fire breaks shall be identical (or better) with the system which is successfully type tested for the specified rating i.e. the composition density of the material, thickness of coating in case of fire breaks and any other properties of the material / system offered shall be identical or better than the tested system and shall be subject to Employer's Representative approval.

Performance Tests:

- a) The fire stops shall be subjected to the following type tests:
 - i. Fire Rating Test
 - ii. Hose Stream Test
- b) Type tests shall be conducted on different fire stop test specimens described above as per IEEE-634. The sizes of the fire stop test specimens shall be similar to the largest of the sizes being used in the plant.
- c) Preconditioning of fire stop test specimens

Before conducting the Fire Rating and Hose Stream tests, each test specimen shall be preconditioned for thermal ageing, water immersion and vibration.

Test on Fire Stops

During the Fire Rating test, the transmission of heat through the cable penetration fire stop shall not raise the temperature on its unexposed surface above the self ignition temperature of the outer cable covering, the cable penetration fire stop material, or material in contact with the cable penetration fire stop, with a maximum temperature limit on the unexposed surface of 2000C.

8.6.29 Nitrogen Gas Injection Fire Protection System

Contractor shall Design, Supply, Deliver, Test and Commission the Nitrogen Gas Injection Fire Protection System for the protection of the Power Transformers at the GIS Substation.

This specification covers the design and performance requirements of Nitrogen Gas Injection Fire Protection System for the 230/110/33kV, 150MVA ONAN/ONAF and 110/11/11kV, 50

MVA ONAN/ONAF Power Transformers.

It is not intended to completely specify all details of design and construction. Nevertheless, the system design and equipment shall conform in all respects to high standard of Engineering, design and workmanship and shall be capable of performing in continuous commercial operation in a manner acceptable to the Employer. The system design shall also conform to TAC/ NFPA norms.

The system offered shall comply with the relevant International Standards, conforming to any other approved international standards shall meet the requirements called for in the latest revision of relevant International Standard.

Ambient temperature for design of all equipment shall be considered as 45°C.

The system shall be reliable without making any mal operation. Even if undesirable nitrogen gas injection is made into the transformer tank under normal transformer condition without the internal faults, restoration of transformer by vacuum oil purification up to re-energizing shall complete as soon as possible after the undesired gas injection.

In case of an event of the control power failure, the system shall be able to be operated manually.

Various equipment to perform the required fire protection shall be provided under this Contract.

Reference of standards is listed below. Relevant International Standards other than BS standards shall be subject to approval by the Employer:

BS Standards

BS 381 C Colours for Identification, Coding & Special Purpose

BS 7629-1 Specification for 415/500 V fire resistant electric cables having low emission of smoke and corrosive gases when affected by fire.

BS 8434-1 Methods of test for assessment for power integrity of electric cables

BS 5839-1 Code of practice system design, installation, commissioning and maintenance for fire detection and fire alarm system

BS EN50267-2-1 Common Test Methods for Cables Under Fire Conditions

The 230/110kV/33kV and 110/11/11kV transformers shall be provided with Nitrogen Injection Fire Protection System (NIFPS). The detail description of fire protection system is given below. Accordingly the Contractor has to make necessary provisions in consultation with supplier of NIFPS for satisfactory operation without affecting the overall performance of transformer.

Oil filled Power Transformers shall be provided with a dedicated Nitrogen Injection Fire Protection System (NIFPS) for the ratings, mentioned in SLD which shall use nitrogen as fire quenching medium. The fire protective system shall prevent transformer/Reactor oil tank

explosion and possible fire in case of internal faults. In the event of fire by external causes such as bushing fire, OLTC fires, fire from surrounding equipment etc., it shall act as a fast and effective fire fighter. It shall accomplish its role as fire preventer and extinguisher without employing water and / or carbon dioxide. Fire shall be extinguished within 3 minutes (maximum) of system activation and within 30 seconds (maximum) of commencement of nitrogen injection. The fire protection system shall have been in successful operation for at least last five years for protection of Power Transformers of 230/110/33 kV and 110/11/11 kV voltage class. The list of past suppliers in local market along with performance certificate from users of the system shall be submitted for approval.

Activation of the fire protective system

Mal-functioning of fire prevention/ extinguishing system could lead to interruption in power supply. The bidder shall ensure that the probability of chances of malfunctioning of the fire protective system is practically zero. To achieve this objective, the bidder shall plan out his scheme of activating signals which should not be too complicated to make the fire protective system inoperative in case of actual need. The system shall be provided with automatic control for fire prevention and fire extinction. Besides automatic control, remote electrical push button control at Control box and local manual control in the fire extinguishing cubicle shall also be provided. The following electrical-signals shall be required for activating the fire protective system under prevention mode / fire extinguishing mode.

Auto Mode

For prevention of fire:

Differential relay operation

Buchholz relay paralleled with pressure relief valve or RP RR (Rapid Pressure Rise Relay)

Tripping of all circuit breakers (on HV & LV/IV side) associated with transformer / reactor is the pre-requisite for activation of system

For extinguishing Fire

Fire detector

Buchholz relay paralleled with pressure relief valve or RP RR (Rapid Pressure Rise Relay)

Tripping of all circuit breakers (on HV & LV/IV side) associated with transformer / reactor is the pre-requisite for activation of system.

Manual Mode (Local / Remote)

Tripping of all circuit breakers (on HV & LV/IV side) associated with transformer / reactor is the pre-requisite for activation of system

Manual Mode (Mechanical)

The system shall be designed to be operated manually in case of failure of power supply to fire protection system

Description

Nitrogen injection fire protection system should be a dedicated system for each oil immersed transformer / reactor. It should have a Fire Extinguishing Cubicle (FEC) placed on a plinth at a distance of 5-10 m away from transformer / reactor or placed next to the fire wall (if firefighting wall exists). The FEC shall be connected to the top of transformer/reactor oil tank for depressurization of tank and to the oil pit (capacity is approximately equal to 10% of total volume of oil in transformer/reactor tank) from its bottom through oil pipes. The fire extinguishing cubicle should house a pressurized nitrogen cylinder(s) which is connected to the transformer oil tank at bottom. The Transformer Conservator Isolation Valve (TCIV) is fitted between the conservator tank and Buchholz relay. Cable connections are to be provided from signal box to the control box in the control room, from control box to fire extinguishing cubicle and from TCIV to signal box. Fire detectors placed on the top of transformer/reactor tank are to be connected in parallel to the signal box by Fire survival cables. Control box is also to be connected to relay panel in control room for receiving system activation signals.

Operation

On receipt of all activating signals, the system shall drain pre-determined volume of hot oil from the top of tank (i.e. top oil layer), through outlet valve, to reduce tank pressure by removing top oil and simultaneously injecting nitrogen gas at high pressure for stirring the oil at pre-fixed rate and thus bringing the temperature of top oil layer down. Transformer conservator isolation valve blocks the flow of oil from conservator tank in case of tank rupture / explosion or bushing bursting. Nitrogen occupies the space created by oil drained out and acts as an insulating layer over oil in the tank and thus preventing aggravation of fire.

System components

Nitrogen injection fire protection system shall broadly consist of the following components. However, all other components which are necessary for fast reliable

and effective working of the fire protective system shall be deemed to be included in the scope of supply.

Fire Extinguishing Cubicle (FEC)

The FEC shall be made of CRCA sheet of 3 mm (minimum) thick complete with the base frame, painted inside and outside with post office red colour (shade to be in line with BS: 381 C : 1988 – Colors for Identification, Coding and Special Purposes). It shall have hinged split doors fitted with high quality tamper proof lock. The degree of protection shall be IP55. The following items shall be provided in the FEC.

Nitrogen gas cylinder with regulator and falling pressure electrical contact manometer.

Oil drain pipe with mechanical quick drain valve.

Electro mechanical control equipment for draining of oil of pre-determined volume and injecting regulated volume of nitrogen gas

Pressure monitoring switch for back-up protection for nitrogen release

Limit switches for monitoring of the system

Butterfly valve with flanges on the top of panel for connecting oil drain pipe and nitrogen injection pipes for transformer/reactors

Panel lighting (CFL Type)

Oil drain pipe extension of suitable sizes for connecting pipes to oil pit.

Space heater

Others if necessary

Control box

Control box is to be placed in the control room for monitoring system operation, automatic control and remote operation. The following alarms, indications, switches, push buttons, audio signal etc. shall be provided.

System on

TCIV open

Oil drain valve closed

Gas inlet valve closed

TCIV closed*

Fire detector trip *

Buchholz relay trip

Oil drain valve open*

Extinction in progress *

Cylinder pressure low *

Differential relay trip

PRV / RPRR trip

Transformer/reactor trip

System out of service *

Fault in cable connecting fault fire detector

Fault in cable connecting differential relay

Fault in cable connecting Buchholz relay

Fault in cable connecting PRV / RPRR

Fault in cable connecting transformer /reactor trip

Fault in cable connecting TCIV

Auto/ Manual / Off

Extinction release on / off

Lamp test

Visual/ Audio alarm*

Visual/ Audio alarm for DC supply fail *

Space heater

Others if necessary

* Suitable provision shall be made in the control box, for monitoring of the system from remote substation using the substation automation system.

Transformer Conservator Isolation Valve

Transformer conservator isolation valve (TCIV) to be fitted in the conservator pipeline, between conservator and buchholz relay which shall operate for isolating the conservator during abnormal flow of oil due to rupture / explosion of tank or bursting of bushing. The valve shall not isolate conservator during normal flow of oil during filtration or filling or refilling, locking plates to be provided with handle for pad locking. It shall have proximity switch for remote alarm, indication with visual position indicator.

Fire Detectors

The system shall be complete with adequate number of fire detectors (quartz bulb) fitted on the top cover of the transformer / reactor oil tank.

Signal Box

It shall be mounted away from transformer / reactor main tank, preferably near the transformer marshalling box, for terminating cable connections from TCIV & fire detectors and for further connection to the control box. The degree of protection shall be IP55.

Cables

Fire survival cables (capable to withstand 750° C.) of 4 core x 1.5 sq. mm size for connection of fire detectors in parallel shall be used. The fire survival cable shall conform to BS 7629-1, BS 8434-1 and BS 5839-1, BS EN 50267-2-1 or relevant International standards.

Fire Retardant Low Smoke (FRLS) cable of 12 core x 1.5 sq. mm size shall be used for connection of signal box / marshalling box near transformer/reactor and FEC mounted near transformer/reactor with control box mounted in control room.

Fire Retardant Low Smoke (FRLS) cable of 4 core x 1.5 sq. mm size shall be used for connection between control box to DC and AC supply source, fire extinguishing cubicle to AC supply source, signal box/ marshalling box to transformer conservator isolation valve connection on transformer/reactor.

Pipes

Pipes complete with connections, flanges, bends and tees etc. shall be supplied along with the system.

Other items

Oil drain and nitrogen injection openings with gate valves on transformer / reactor tank at suitable locations.

Flanges with dummy piece in conservator pipe between Buchholz relay and conservator tank for fixing TCIV.

Fire detector brackets on transformer / reactor tank top cover.

Spare potential free contacts for activating the system i.e., in differential relay, Buchholz relay, Pressure Relief Device / RPRR, Circuit Breaker of transformer/reactor

Pipe connections between transformer / reactor and FEC and between FEC and oil pit required for collecting top oil.

Cabling for fire detectors mounted on transformer /reactor top cover

Inter cabling between signal box, control box and Fire Extinguishing Cubicle (FEC).

Butterfly valves /Gate valves on oil drain pipe and nitrogen injection pipe which should be able to withstand full vacuum.

Supports, signal box etc. which are to be painted with enameled paint.

Technical Particulars

Fire extinction period from commencement of: 30 s. (max.)
nitrogen injection

Total duration from activation of fire protection: 30 minutes (Max.)
system to complete cooling

Fire detectors' heat sensing temperature	: 141 deg. C
Heat sensing area per detector	: Up to a radius of 800 mm
Transformer Conservator Isolation valve setting	: 60 liter/ min (minimum)mm
Capacity of nitrogen cylinder	: 68 liter (maximum) water capacity and shall hold 10m ³ (minimum) gas at pressure of 150 kg/cm ²
Power Supply For control box	: 110 V DC
For fire extinguishing cubicle for lighting	: 240 V AC

Mandatory Spare Parts

Cylinder filled with Nitrogen of required capacity: 1 No.
per substation

Fire detectors per transformer : 3 Nos.

Regulator assembly per substation : 1 No.

Tests

Reports of all type test conducted as per relevant IEC standards in respect of various bought out items including test reports for degree of protection for FEC / control box / signal box shall be submitted for approval.

The supplier shall demonstrate the functional test associated with the following:

Fire Extinguishing Cubicle, Control Box.

Fire Detector.

Transformer Conservator Isolation Valve

The performance test of the complete system shall be carried out after erection of the system with transformer at site. Detailed layout drawings, equipment drawing along with 4 sets of Operation and maintenance manual along with soft copies (in CDs) shall be submitted by the Contractor along with the consignment.

Fire Wall

The fire wall having suitable height shall be installed between transformers to prevent the healthy transformer from the spread of fire. The wall shall be constructed by reinforced concrete.

8.6.30 Deluge Water Spray System

Contractor shall Design, Supply, Install, Test and Commission a complete Deluge Water Spray Fire Protection System or Medium Velocity Water Spray System Operated by Deluge Valve as per NFPA 15 on the following Power Transformers at the GIS Substation Power Transformer Bays:

1. 230/110kV 150 MVA Auto Power Transformers
2. 110/11kV 50 MVA Auto Power Transformers

Medium Velocity Water Spray System (MVWSS) operated by Automatic Deluge Valve shall be designed to protect the Power Transformers at the 230/110 kV GIS Substation from any external fire.

Water spray nozzles shall be provided to protect the surface area of the Power Transformers from fire and provides cooling and prevents structural destruction in the event of fire. The deluge valve actuation shall be controlled by Hydraulic, Electric Relay command and Manual release mode.

Sprinklers with Quartzoid bulb (Temperature rating 68°C) shall be provided around the areas to be protected for deluge valve actuation in hydraulic release mode. In electric release mode, manual command using solenoid ON I OFF switch from remotely located control panel (PXI console) operates the integral solenoid valve which actuates the Deluge valve. In relay command based mode, the command output signal from the flame detectors (UV/IR2) located in the Transformer Bay are to be interfaced with the solenoid valve for automatic actuation of deluge valve in the event of flame detection. In manual release mode, local needle valve which is the integrated part of deluge valve assembly actuates the operation of deluge valve.

All the signal command is communicated to two dedicated command console (PXI console) provided in the control room of the GIS Substation. The signal from pressure switch which is

provided at the downstream of Deluge Valve gives status of deluge valve and the alarm annunciation to the command console.

The entire deluge system shall be provided with necessary flow components like filters, isolation valves, pressure gauges/ transmitters, fire pumps (electric / diesel engine), fire water tank, etc. as per the relevant P&I diagram . Based on pressure drop calculation, the outlet pressure of deluge valve shall be suitably set in pressure reducing deluge valve to meet the minimum pressure required at the farthest nozzle in the circuit. The arrangement of the spray nozzles/deluge valves shall be in such a way they do not pose any hindrance to the operating personnel during day-to-day operations in the work area as well as protect the equipment during operation of the Automatic Deluge Sprinkler water system.

All related drawings for the Deluge water Spray System shall be designed and submitted by the Contractor for ENGINEER's approval.

8.6.31 FM200 SYSTEM

Contractor shall Design, Supply, Deliver, Test and Commission a FM200 Fire Protection System for the GIS Substation, Administration Building and CPI Facilities:

1. 230kV GIS Switchgear Room
2. 110kV GIS Switchgear Room
3. 11kV Switchgear Rooms
4. Metering, Control and Protection Panel Rooms
5. LV Switchgear / MCC Rooms
6. UPS/Battery Charger Rooms
7. Battery Rooms
8. Substation Automation System and SCADA Control Room
9. Tel/LAN Rooms
10. Generator Rooms
11. Electrical Rooms

This specification outlines the requirements for a “Total Flooding” FM-200 clean agent fire extinguishing system. The work described in this specification includes all Engineering, labor, materials, equipment and services required to install and test the FM-200 fire extinguishing system.

The design, equipment, installation, testing and maintenance of the Clean Agent Suppression System shall be in accordance with the applicable requirements set forth in the latest edition of the following codes and standards.

- A. NFPA 2001 - Clean Agent Fire Extinguishing Systems.
- B. NFPA 70 - National Electric Code.
- C. NFPA 72 – National Fire Alarm and Signaling Code.

- D. FM - Factory Mutual Approval Guide.
- E. UL - Fire Protection Equipment Directory.
- F. NEMA - Enclosures for Industrial Controls and Systems.
- H. All Requirements of Authority Having Jurisdiction (AHJ)

The standards listed, as well as all other applicable codes, standards, and good ENGINEERing practices shall be used as "minimum" design standards.

The Suppression System installation shall be made in accordance with the drawings, specifications and applicable standards. Should a conflict occur between the drawings and specifications, the specifications shall prevail.

The work listed below shall be designed and submitted by the Contractor to the ENGINEER for approval.

- A. System control panel and accessories.
- B. Interlock wiring and conduit for shutdown of HVAC, dampers and/or electric power supplies, relays or shunt trip breakers.
- C. Connection to local/remote fire alarm systems or listed central alarm station(s).

The manufacturer of the suppression system hardware and detection components shall be ISO 9001 and 14001 registered.

The name of the manufacturer shall appear on all major components.

All devices, components and equipment shall be the products of the same manufacturer.

All devices, components and equipment shall be new, standard products of the manufacturer's latest design and suitable to perform the functions intended.

All devices and equipment shall be UL Listed and/or FM Approved.

The installing contractor shall be trained by the supplier to design, install, test and maintain fire suppression systems.

When possible, the installing contractor shall employ a NICET certified special hazard designer, Level II or above, who will be responsible for this project.

The installing contractor shall be an experienced firm regularly engaged in the installation of automatic Clean Agent, or similar, fire suppression systems in strict accordance with all applicable codes and standards.

The installing contractor must have a minimum of five (5) years experience in the design,

installation and testing of Clean Agent, or similar, fire suppression systems. A list of systems of a similar nature and scope shall be provided on request.

The installing contractor shall maintain, or have access to, a Clean Agent recharging station. The installing contractor shall provide proof of this ability to recharge the largest Clean Agent system within 24 hours after a discharge. Include the amount of bulk agent storage available.

The installing contractor shall be an authorized stocking distributor of the Clean Agent system equipment so that immediate replacement parts are available from inventory.

The installing contractor shall show proof of emergency service available on a twenty-four-hour-a-day, seven-day-a-week basis.

The installing contractor shall submit the following design information and drawings for approval prior to starting installation on this project.

Working plans indicating detailed layout of system, locating each component (e.g. agent cylinder, control panel, electric/manual pull station, audible and visual alarms). Include control diagrams, wiring diagrams, written sequence of operation or cause to effect matrix along with battery calculations, and pipe locations including size and length. Refer to NFPA 2001 Section 5.1.2.

Product data for each piece of equipment comprising the system including storage cylinders, control valves and pilot controls, control panels, nozzles, push-button stations, detectors, alarm bells or horns, switches, and annunciators.

Design calculations derived from the Janus Design Suite™ computer program written specifically for FM-200 and verified by both Underwriters Laboratories and Factory Mutual. Analysis shall include calculations to verify system terminal pressures, nozzle flow rates, orifice code number, piping pressure losses, component flow data, and pipe sizes considering actual and equivalent lengths of pipe and elevation changes. Flow calculation shall also supply pressure venting estimates as required by NFPA 2001. In addition, the flow calculation software shall print specifications of all piping used in the design (mass, ID, etc.). Designers using this software shall be trained and certified by the Manufacturer.

All drawings, calculations and system component data sheets shall be submitted for approval to the local fire prevention agency, owner's insurance underwriter, and all other authorities having jurisdiction before starting installation. Submit approved plans to the ENGINEER for record.

SYSTEM REQUIREMENTS

- A. The fire protection system shall be a Total Flooding System utilizing FM-200 clean agent. System is a fixed installation where equipment is designed and installed to provide fire extinguishing capability for hazards described.
- B. The system shall be designed to deliver an FM-200 minimum design concentration in accordance with NFPA 2001, 2012 Edition, in all areas and/or protected spaces,

at the minimum anticipated temperature within the protected area. The system should be designed to discharge its liquid contents in 10 seconds or less.

- C. The system shall be complete in all ways. It shall include all mechanical and electrical installation, all detection and control equipment, agent storage cylinders, FM-200 agent, discharge nozzles, pipe and fittings, manual release and abort stations, audible and visual alarm devices, auxiliary devices and controls, shutdowns, alarm interface, caution/advisory signs, functional checkout and testing, training and all other operations necessary for a functional, UL Listed and/or FM Approved FM-200 Clean Agent Suppression System.
- D. The system(s) shall be actuated by photoelectric detectors installed for maximum area coverage of 250 sq. ft. (23.2 m²) per detector, in both the room and above ceiling protected spaces. Photoelectric detectors shall be installed in underfloor protected spaces. If the airflow is one air change per minute, photoelectric detectors only shall be installed for maximum area coverage of 125 sq. ft. (11.6 m²) per detector. (Ref. NFPA 72).
- E. Detectors shall be Cross-Zoned detection requiring two detectors to be in alarm before release.

MATERIALS AND EQUIPMENT

The FM-200 Clean Agent System materials and equipment shall be standard products of the supplier's latest design and suitable to perform the functions intended. When one or more pieces of equipment must perform the same function(s), they shall be duplicates produced by one manufacturer.

All devices and equipment shall be UL Listed and/or FM approved.

The fire suppression agent shall be FM-200 gas; clean dry, non-corrosive, non-damaging, non-deteriorating, and meeting the requirements of NFPA 2001. The agent shall be suitable for use in normally occupied spaces. Agent shall be listed as "Acceptable" on the EPA's SNAP list.

FM-200 AGENT STORAGE AND DISTRIBUTION

Each system shall have its own supply of clean agent.

Each system can protect a single hazard or multiple hazards can be protected by a single system with a common supply of clean agent through the use of selector or zone-type valves

The system design can be modular, central storage, or a combination of both design criteria.

Systems shall be designed in accordance with the manufacturer's guidelines.

Each supply shall be located within the hazard area, or as near as possible, to reduce the amount of pipe and fittings required to install the system.

The clean agent shall be stored in Storage Cylinder Assemblies. Cylinders shall be super-pressurized with dry nitrogen to an operating pressure of 360 psi @ 70°F (24.8 bar @ 20°C). Cylinders shall be of high-strength low alloy steel construction and conform to NFPA 2001 and the regulations of the Department of Transportation and/or CE.

Cylinders shall be fitted with a resilient pressure seat type forged brass valve and shall have a threaded steel anti-recoil protective cap or grooved style anti-recoil protective plate for handling and shipment.

The primary cylinder assembly(s) shall be actuated by a resettable electric actuator with optional mechanical override located at each primary agent cylinder or connected bank of cylinders. Non-resettable or explosive devices shall not be permitted

Each primary cylinder shall be able to actuate up to 15 slave cylinders. The distance between the primary cylinder and the farthest slave cylinder (including any rises or drops) shall not exceed 100 ft (30.48 m) in either direction when using flexible hose or copper tubing for pilot actuation. The distance between the primary cylinder and the farthest slave cylinder (including any rises or drops) shall not exceed 25 ft (7.62 m) in either direction when using 1/4 in (8 mm) schedule 40 pipe for pilot actuation.

The cylinders shall be mounted using wall racks on solid walls. The cylinders and racks shall be arranged to allow a service aisle for cylinder removal and cylinder weighing.

Cylinders of a maximum storage capacity greater than 130 lbs (59 kg) shall come fitted with Liquid Level Indicators.

Each cylinder assembly shall have a pressure gauge and low pressure switch to provide visual and electrical supervision of the cylinder pressure. The low pressure switch shall be wired to the control panel to provide an audible and visual supervisory condition signal in the event the cylinder pressure drops below 280 psi (19.3 bar). The pressure gauge shall be color coded to provide an easy, visual indication of cylinder pressure.

Each cylinder assembly shall have a pressure relief provision that automatically operates before the internal pressure exceeds 850 psi (58.6 bar) to 1000 psi (68.9 bar).

When more than one cylinder is connected to a common manifold, a check valve shall be provided with each cylinder.

ENGINEERed discharge nozzles shall be provided within the manufacturer's guidelines to distribute the FM-200 agent throughout the protected spaces. The nozzles shall be designed to provide proper agent quantity and distribution.

Nozzles shall be available in 3/8 in (10 mm) through 2 in (50 mm) pipe sizes. Each size shall be available in 90° Corner [Listed with a protection coverage area of 32' x 32' (9.753 m x 9.753 m)], 180° Sidewall [Listed with a protection coverage area of 64' x 32' (19.507 m x 9.753 m)], and 360° Center Room [Listed with a protection coverage area of 64' x 64' (19.507 m x 19.507 m)].

m)] distribution patterns.

Nozzles shall be of corrosion resistant construction and shall be designed specifically for FM-200 application.

Nozzles shall be permanently marked as to part number and orifice diameter.

Nozzles shall be listed at a maximum 16' (4.876 m) elevation and listed at a maximum 4' (1.219 m) distance below a ceiling while still achieving sufficient mixing.

Nozzles should be listed and/or approved to be used in the upright or pendant position.

Ceiling plates can be used with the nozzles to conceal pipe entry holes through ceiling tiles.

Distribution piping, and fittings, shall be installed in accordance with the manufacturer's requirements, NFPA 2001 and approved piping standards and guidelines. All distribution piping shall be installed by qualified individuals using accepted practices and quality procedures. All piping shall be adequately supported and anchored at all directional changes and nozzle locations. The piping shall be laid out to give maximum flow and to avoid possible mechanical, chemical or other damage. Installation shall follow drawings as closely as possible. System designer must be consulted for anything other than minor deviations in pipe routing.

Black or galvanized steel pipe shall be either ASTM A53 seamless or electric welded, Grade A or B or ASTM A-106, Grade A, B, or C. ASTM A-120, ordinary cast-iron pipe, aluminum pipe, or non-metallic pipe shall not be used. Stainless steel pipe shall be 304, 316, 304L, or 316L for threaded connections or 304L or 316L for welded connections.

Threaded fittings must comply with NFPA 2001 and be at a minimum class 300 malleable iron, class 300 ductile iron, or have a minimum rated working pressure of 416 psi (28.7 bar) at 70°F (21.1°C). Cast iron and Class 150 pound fittings shall not be used.

Grooved fittings and couplings must comply with NFPA 2001 and have a minimum rated working pressure of 416 psi (28.7 bar) at 70°F (21.1°C). Piping shall be rolled or cut grooved in accordance with the fitting or coupling manufacturer's guidelines.

Gaskets must be compatible with FM-200® agent (typically EPDM having a temperature range of -30°F to 230°F [-34°C to 110°C]). Gasket lubricant must be in accordance with manufacturer's specifications.

The minimum allowable working pressure at 70°F (21.1°C) for pipe and fittings in closed sections of pipe must be greater than or equal to the maximum operating pressure of the discharge pipe safety relief valve rated at 450 psi (31.02 bar).

All pipe and fittings shall be new and of recent manufacture.

Reductions in pipe sizes may be accomplished using threaded or grooved concentric reducing fittings, steel or stainless steel concentric swage fittings, or steel or stainless steel reducing

bushings. All such fittings must comply with NFPA 2001 and have a minimum rated working pressure of 416 psi (28.7 bar) at 70°F (21.1°C). Pipe reductions can be made using machined or forged steel hex bushings. Malleable and/or cast iron bushings are NOT to be used.

All piping shall be reamed, blown clear and swabbed with suitable solvents to remove burrs, mill varnish and cutting oils before assembly.

All screwed pipe shall be coated with Teflon tape or an appropriate pipe joint compound. When tape or pipe joint compound is used, coating of the threads must start at least two threads back from the pipe end. On small piping, care must be taken so as not to allow sealant to enter valves or controls.

All pipe must be thoroughly cleaned before installation. A wire flue brush should be pulled through the length several times, followed by clean cloth rags treated with a noncombustible metal cleaner designed for the purpose. All foreign matter and oil must be removed by this process.

All pipe and fittings installed out of doors or in corrosive areas must be galvanized or treated with a proper protective coating.

Piping shall be pneumatically tested in a closed circuit for a period of 10 minutes at 40 psi (2.76 bar) per the latest edition of NFPA 2001. At the end of 10 minutes, the pressure drop shall not exceed 20 percent of the test pressure. The pressure test shall be permitted to be omitted if the total piping contains no more than one change in direction fitting between the storage container and the discharge nozzle, and where all piping is physically tested for tightness.

Pressure Switches

The system shall include a normally open contact on a pressure switch actuated by the agent discharge to shut down equipment and sound alarm.

Switches shall be heavy duty, single pole, double throw.

Pressure switch shall require manual reset.

Pressure switch is only required when a manual valve actuator is supplied on the primary cylinder.

Pressure Operated Releases

The system shall include releases capable of holding maximum loads of 35 lbs (15.9 kg) to release self closing doors, dampers, windows, louvers, lids or valves upon FM-200 discharge

(Note : All devices to be closed must be self-closing and capable of being held open by a cable or chain hooked to the release.)

Piping to pressure releases shall be as specified above for discharge piping. All take-offs for

pressure release piping shall be from the top of the discharge piping.

DOCUMENTATION AND TESTING

SYSTEM INSPECTION AND CHECKOUT

After the system installation has been completed, the entire system shall be checked out, inspected and functionally tested by qualified, trained personnel, in accordance with the manufacturer's recommended procedures and NFPA standards.

- A. All containers and distribution piping shall be checked for proper mounting and installation.
- B. All electrical wiring shall be tested for proper connection, continuity and resistance to earth.
- C. The complete system shall be functionally tested, in the presence of the ENGINEER and all functions, including system and equipment interlocks, must be operational at least five (5) days prior to the final acceptance tests.
 - 1) Each detector shall be tested in accordance with the manufacturer's recommended procedures, and test values recorded.
 - 2) All system and equipment interlocks, such as door release devices, audible and visual devices, equipment shutdowns, local and remote alarms, etc. shall function as required and designed.
 - 3) Each control panel circuit shall be tested for trouble by inducing a trouble condition into the system.

TRAINING REQUIREMENTS

Prior to final acceptance, the installing contractor shall provide operational training to each shift of the ENGINEER's personnel. Each training session shall include control panel operation, manual and (optional) abort functions, trouble procedures, supervisory procedures, auxiliary functions and emergency procedures.

8.6.32 BATTERIES, CHARGERS AND DC DISTRIBUTION SWITCHGEAR

The following clauses describe the General Technical Requirements for Batteries, Chargers and DC distribution switchgear for use in substations for 110V DC power for switchgear operations, protection, control, alarms, indications and emergency lighting.

The equipment shall be supplied, installed and commissioned as per instruction and approval of the ENGINEERs.

REFERENCES

Any international standards referenced in the specifications and our outdated shall be replaced with the corresponding replacement.

IEC Standards

- IEC 60051 Direct acting indicating analogue electrical measuring instruments and their accessories.
- IEC 60146 Semiconductor converters
- IEC 60146-1-1Basic requirements of electrical power converters IEC 60146-1-3Transformers and reactors
- IEC 6060529 Degree of protection provided by enclosures
- IEC 60439 Low voltage switchgear and control gear assemblies (BS EN 60439) IEC 60623
Vented nickel cadmium prismatic rechargeable single cells

British Standards

- BS 88 Cartridge fuses for voltages up to and including 1000 VAC and 1500 V DC.
- BS 381C Specification for colours for identification coding and special purposes.
- BS 5634 Method of Test for Potassium Hydroxide.
- BS 6231 Specification for PVC insulated cables for switchgear and control gear wiring.

DESIGN REQUIREMENTS

Batteries shall be located in separate mechanically ventilated rooms, which will be provided with sinks and water supplies. Storage facilities will be provided for electrolyte, distilled water and maintenance equipment.

The voltage measured at the main distribution switchgear shall not vary by more than plus 10 percent or minus 20 percent of the nominal voltage under all charging conditions when operating in accordance with the requirements of this Section.

The complete equipment shall preferably be a manufacturer's standard but any departure from this Specification shall be subject to the approval of the ENGINEER.

BATTERIES

Type of Battery

The battery shall be of the high performance Nickel Cadmium pocket plate type complying with IEC 60623 and shall be designed for a life expectancy of 25 years.

Battery cases shall be of high impact translucent plastic or annealed glass and shall be indelibly marked with maximum and minimum electrolyte levels. The design of the battery shall permit the free discharge of the gases produced during the normal operating cycle, whilst excluding dust. Spray arresters shall be included.

The electrolyte shall be free from impurities and the Potassium Hydroxide used shall comply with BS 5634. Dilution of the alkaline electrolyte and topping up of cells shall be carried out using distilled water only.

A complete set of test and maintenance accessories, suitably boxed, shall be provided for each battery. A syringe hydrometer and a durable instruction card shall be included in each set.

Cells shall be numbered consecutively and terminal cells marked to indicate polarity.

Cells shall be permanently marked with the following information:

Manufacturer's reference number and code

Year and month of manufacture

Voltage and nominal capacity at the 5 hour discharge rate

The electrolyte capacity and general design of the cells shall be such that inspection and maintenance, including topping up of the electrolyte, shall be at intervals of not less than twelve months.

Initial Charge and Test Discharge

The initial charge, test discharge and subsequent re-charge of the battery must be carried out under continuous supervision. Resistors, instruments, leads, and the other apparatus will be necessary for the initial charge, test discharge and subsequent recharge of the battery.

Battery Duty

The battery shall have sufficient capacity to supply the following continuous and intermittent loads for the periods specified, with the chargers out of service.

Standing DC loading for protection, control, indications and alarms for 10 hours. This loading shall be determined from all equipment to be supplied on this Contract. In addition the future circuit requirements estimated on the same basis as the present requirements.

At the end of 5 hours the battery shall have sufficient capacity to complete the operations listed below, at the end of which duty the system voltage shall not have dropped below 90 percent of the nominal voltage with the standing loads, specified above, connected.

Two closing operations on all circuit breakers (including future) supplied by the battery.

Two tripping operations on all circuit breakers (including future) supplied by the battery. Where

busbar protection is provided, it shall be assumed that all circuit breakers in any one busbar protection zone trip simultaneously.

Charging of DC motor wound circuit breaker closing springs (where applicable) to enable the closing operations to be carried out.

At the end of these duties, the battery voltage shall not have dropped such that the voltage at the battery terminals falls below 90% of the nominal system voltage when supplying the standing load.

In addition, the voltages at the terminals of all components in the system (e.g. relays, trip and closing coils) shall not be outside of the individual voltage limits applying to them.

A margin of 10 % shall be allowed for derating of this battery over its life time.

All quantities derived in this manner shall be quoted in the Bid, but shall not be used for ordering materials until specifically approved by the ENGINEER. Detailed calculations, and loading characteristics on which these are based, shall be submitted to the ENGINEER at an early stage.

Location of Batteries

The batteries shall be housed in a ventilated battery room. The charging equipment and distribution switchboards shall be housed in a separate room.

The floor of the battery room shall be coated with a suitable electrolyte resistant protective coating. The floor shall be fitted with a drain and shall have sufficient slope to prevent any major electrolyte spillages from entering into other areas.

No ducts or any other items shall penetrate the floor or create a means whereby spillage can drain away apart from the drain provided for this purpose.

The ventilation fans and lamps in battery room shall be an explosion proof type.

Battery mounting connections and accessories

Batteries shall be placed on timber boards mounted in double tiers on steel stands of robust construction and treated with acid resisting enamel or gloss paint to BS 381C No.361. The cells shall be arranged so that each cell is readily accessible for inspection and maintenance and it shall be possible to remove any one cell without disturbing the remaining cells. The stands shall be mounted on insulators and be so dimensioned that the bottom of the lower tier is not less than 300mm above the floor.

Alternatively, batteries may be mounted in a similar manner on treated hard wood stands.

Batteries shall be supplied and erected complete with all necessary connections and cabling. Connections between tiers, between end cells and between porcelain wall bushings shall be by PVC cables arranged on suitable racking or supports. Before jointing, joint faces shall be bright

metal, free from dirt, and shall be protected by a coating of petroleum jelly. Terminal and intercell connections shall be of high conductivity corrosion free material.

Cartridge fuses shall be provided in both positive and negative leads, positioned as close to the battery as possible and shall be rated for at least three times the maximum battery discharge current at the highest operating voltage. The two fuses shall be mounted on opposite ends of the battery stand or rack in an approved manner. These fuse links shall comply with BS 88 Clause DC. 40 and shall be bolted in position without carriers.

Warning labels shall be fitted to warn personnel of the danger of removing or replacing a fuse whilst the load is connected and that fuses should not be removed immediately following boost charge due to the possible ignition of hydrogen gas.

Fuses between the battery and charger shall be located adjacent to the battery in a similar manner to that described above. A warning label shall be placed on the charging equipment indicating the location of these fuses and the fact that they should be removed to isolate the charger from the battery.

It shall not be possible to leave the battery disconnected (by means of switches or removal or operation of fuses) without some local and remote indication that such a state exists.

One set of miscellaneous equipment, including two syringe hydrometers, one cell-testing voltmeter, two cell-bridging connectors, two electrolyte-pouring funnels, two electrolyte thermometers, battery instruction card for wall mounting, electrolyte airtight containers, labels, tools and other items necessary for the erection and correct functioning and maintenance of the equipment, shall be provided for each station.

CONTROL AND CHARGING EQUIPMENT

Each battery charging equipment shall comply with the requirements of BS 4417 (IEC 146), shall be of the thyristor controlled automatic constant voltage type with current limit facilities and shall be suitable for supplying the normal constant load, at the same time maintaining the battery to which it is connected in a fully charged condition. All equipment shall be naturally ventilated.

All the equipment for each charger shall be contained in a separate ventilated steel cubicle. The charger cubicles shall normally be mounted immediately adjacent to the DC distribution panel to form a board and shall be of matching design colour and appearance.

Where their ratings permit, chargers shall preferably be designed for operation from a single-phase AC auxiliary supply with a nominal voltage of 230 V. Otherwise a three phase 400V supply may be utilised. Chargers shall maintain the float charge automatically for all DC loads between 0 and 100%, irrespective of variations in the voltage of the ac supply within the following limits:

Frequency variation : 47 to 51 Hz.

Voltage variation : $\pm 15\%$

The mains transformer shall be of a suitable rating and design. Clearly marked off-circuit tappings shall be provided on the primary windings and change of tapping shall be by means of easily accessible links. The transformer shall be of the natural air-cooled type capable of operating continuously at full load on any tapping with the maximum specified ambient temperature.

All rectifiers and semi-conducting devices employed in the charger shall be of the silicon type. They shall be adequately rated, with due regard to air temperature within the charger enclosure, for the maximum ambient temperature.

The rating of the charger on float charge shall be equal to the normal battery standing load plus the recommended finishing charge rate for the battery.

Each charger shall also incorporate a boost charge feature which shall, after having been started, provide an automatically controlled high charge rate sufficient to restore a fully discharged battery to the fully charged state within the shortest possible time without excessive gassing or any form of damage to the battery. The boost charge shall be initiated manually or automatically upon detection of a significant battery discharge. An adjustable timer shall be provided to automatically switch the charger to the float condition after the correct recharge period.

Should the AC supply fail while a battery is on boost charge, the switching arrangements shall automatically revert the charger to float charge status and then reconnect the battery to the distribution board.

The output voltage regulator shall be adjustable for both float and boost charge modes, within limits approved by the ENGINEER, by means of clearly marked controls located inside the cubicle.

Although it is not intended that the charger be operated with the battery disconnected, the design of the charger shall be such that with the battery disconnected the charger will maintain the system voltage without any damage to itself and with a ripple voltage no greater than 2.0% rms of the nominal output voltage.

The charger shall automatically adjust the charging current from a value not less than the battery capacity divided by 10 hours to a minimum value of not more than the battery capacity divided by 200 hours. The charging circuitry shall be so designed that the failure of any component will not give a situation which will cause permanent damage to the battery by over charging.

Each charger shall have a float charge maximum current rating sufficient to meet the total standing load current on the dc distribution board plus a battery charging current equal numerically to 7% of the battery capacity at the 10 hour rate.

Each charger shall be designed with a performance on float charge such that with the output voltage set at approximately 1.45 V per cell at 50% load and rated input voltage and frequency,

the output voltage shall not vary by more than plus 3% to minus 2% with any combination of input supply voltage and frequency variation as stipulated in this Specification and output current variation from 0-100% of rating.

Each charger shall be suitable for operating alone or in parallel with the other charger. When operating with both chargers, one charger shall be arranged to supply the standing load with the second charger in the quiescent standby mode.

Each charger shall also have a taper characteristic boost charging facility which shall be selectable by a float/boost charge selection switch and which will give boost charging of 1.60 - 1.75 volts per cell.

Each charger shall be designed with a performance on boost charge such that with rated input voltage and frequency the charger output shall not be less than its rating in Watts at 1.3 V and 1.65 V per cell, and also the output voltage shall be 1.60 -1.75 V per cell over an output range of 0 - 100% of rating.

The boost charging equipment shall be capable of recharging the battery within six hours following a one hour discharge period.

In the event of the battery becoming discharged during an AC supply failure, the rate at which recharging commences shall be as high as possible consistent with maintaining the automatic charging constant voltage feature and with the connections remaining undisturbed as for normal service.

The charger shall have an automatic boost/quick charge feature, which shall operate upon detection of a significant battery discharge. When, after a mains failure, the AC supply voltage returns and the battery have been significantly discharged, the charger will operate in current limit. If the current limit lasts for more than a specified time and the charging current does not fall back to float level, the automatic high rate charge shall be activated.

An override selector switch shall be provided inside the charger unit to enable a first conditioning charge to be made, in line with the battery manufacturer's recommendations, for batteries which are shipped dry and require forming at site.

A diode voltage regulator(DVR) unit shall be incorporated in the output circuit of each charger to limit the load voltage during charging of the battery. Should the stabilizer fail in the boost charging mode, the charger shall automatically revert to the float mode.

An anti-parallelling diode shall be provided in each positive feed to the DC distribution board to prevent faults on one supply affecting the other. These diodes shall be continuously rated to carry the maximum possible discharge current likely to occur in service and a safety factor of 4 shall be used to determine the repetitive peak reverse voltage rating. The I_{2t} rating of the diodes shall be such that in the event of a DC short circuit, no damage to the diodes shall result.

Each charger shall be capable of sustaining, without damage to itself, a continuous permanent

short circuit across its output terminals. The use of fuses, MCBs or other similar devices will not be acceptable in meeting this requirement.

Suitable relays shall be provided for each charger to detect failure of the incoming supply and failure of the DC output when in float charge mode. These relays shall operate appropriate LED on the respective charger front panel and shall have additional voltage free contacts for operating remote and supervisory alarms. These alarms shall be immune from normal supply fluctuations and shall not be initiated when any one charger is taken out of service.

The charger shall also be fitted with a device to de-energise the charger in the event of a DC output float over voltage.

Each charger shall be provided, as a minimum, with the following instrumentation, indication and alarm facilities:-

LED for the AC supply to the rectifier and DC supply from the rectifier.

LED for float and boost charging operations.

Voltmeter - Input voltage.

Voltmeter - Output voltage.

Ammeter - Output current.

Alarm - Charger failure.

Alarm - Mains failure.

The following battery alarms shall also be provided:

Battery fuse failure

Diode assembly failure

Battery circuit faulty

Low DC volts

High AC volts

Earth fault +ve

Earth fault -ve

Lamp test facilities shall be included.

A “charger faulty” alarm for each charger and a “battery faulty” alarm shall be provided in the substation control room and to the SCADA system where applicable.

Each battery charger shall be equipped with charge fail detection equipment to give local indication and remote alarm if the voltage from the charger falls below a preset level which will be lower than the nominal float charge voltage. Suitable blocking diodes shall be provided to prevent the battery voltage being supplied to the equipment and so prevent charge fail detection.

The device shall not operate on switching surges or transient loss of voltage due to faults on the AC system. The voltage at which the alarm operates shall be adjustable for operation over a range to be approved by the ENGINEER.

Each charger shall be equipped with a switch-fuse for the incoming AC supply and an off load isolator for the DC output.

Bidders shall include particulars with their bid on the method of adjustment included to compensate for ageing rectifier elements. The construction of the charger shall be such that access to all components is readily available for maintenance removal or replacement. Internal panels used for mounting equipment shall be on swing frames to allow for access to the charger interior.

A battery earth fault detecting relay, which will centre tap the system via a high resistance, shall be incorporated in the charger panel.

A low voltage detecting device for the system shall be incorporated in the charger panel. No-volt relays will not be accepted for these devices. The voltage setting shall be adjustable over an approved range.

In addition to any other requirements specified elsewhere, the battery earth fault detecting relays and low voltage devices shall each have three alarm contacts, one for local visual annunciation, one for the station control panel alarm indication and one for potential free contact for external supervisory alarms. A lamp test facility shall be provided.

DISTRIBUTION SWITCHBOARDS

The switchboard shall comply with the requirements of BS 5468 (IEC 60439)

The distribution switchboard shall be of the cubicle type or otherwise incorporated in the cubicles for battery chargers. Double pole switches and fuses or switch fuses (miniature circuit breakers to BS 4752 or IEC 60127 may only be used if it can be shown that there will be no discrimination problems with sub-circuits) shall be fitted to the DC switchboard as required by substation services but, as a minimum requirement, that set out in the Schedule A of Requirements.

Distribution panels shall be mounted adjacent to the charger control panel and shall be of the cubicle type complying with the general requirements of cubicle type control panels. No equipment associated with the chargers shall be installed in the distribution board.

Distribution panels shall incorporate double-pole switches and fuses for each of the outgoing DC circuits and double-pole isolators for the incoming DC supplies. The panel shall be provided

with a voltmeter and centre zero ammeter on each incoming circuit.

A double pole switch or contactor shall be provided for the purpose of sectionalizing the busbar.

Connections between the battery and the distribution cubicle shall be made in PVC insulated cable as required. Cable laid in runs where it may be subject to damage shall be protected by wire armouring, be sheathed overall and be cleated to walls as required.

Cable boxes or glands shall be provided as appropriate for all incoming and outgoing circuits of the distribution switchboard and associated battery chargers. Each circuit shall be suitably labelled at the front of the panel and at the cable termination where the terminals shall be additionally identified.

Charging and distribution switchboards shall be provided with an earthing bar of hard drawn high conductivity copper which shall be sized to carry the prospective earth fault current without damage or danger.

The cubicles for the chargers and distribution boards shall be of rigid, formed sheet metal construction, insect and vermin proof, having front facing doors allowing maximum access to the working parts, when open. The design of the cubicles for the chargers shall be such as to prevent the ingress of dust and minimize the spread of flames or ionised zones, shall be to IEC 60529 IP52, but at the same time shall provide all necessary ventilation and cooling. The design of the frames shall allow the clamping and holding of all chokes, transformers and similar sources of vibration, so that vibration will be minimized, satisfy relevant standards, and not limit the life of the equipment. The frame shall allow the fixing of lifting and so that the equipment remains properly mechanically supported whilst being transported, lifted and installed.

LABELLING

All relays, instruments and control devices, and each unit of the equipment, shall be provided with a label. All labels and lettering shall be of sufficient size to provide easy reading from the normal operating or maintenance positions and shall consist of black lettering on a white background. All warning and danger labels shall have white lettering on a red background. Labels shall be of the non- corrodible type and lettering shall be of motorway script or similar. If plastic labels are used, these shall be laminated to avoid warping.

SPECIAL TOOLS

The Contractor shall provide a complete set of all special tools and services necessary for the erection and maintenance of the complete equipment.

INSPECTION AND TESTING

Inspection and testing plan during manufacture and after installation on site shall be submitted by the Contractor for approval by the ENGINEER.

**SCHEDULE OF TECHNICAL
REQUIREMENTS OF Ni-CAD
BATTERY(110V DC System)**

SL. No. Description

1.	Installation	: Indoor
2.	Cell type	: Ni-cd
3.	Voltage (Normal)	: 1.2 volts per cell
4.	Float voltage	: 1.40-1.42 volt/cell
5.	Equalizing voltage	: 1.55 - 1.65 volt/cell
6.	Capacity in AH at 20°C Room)	: 460 AH @ 5 Hr (for 230/110kV Control

150 AH @ 5 Hr

7.	Ambient temperature	: 45°C
8.	Positive plate	: Tubular
9.	Negative plate	: Pasted
10.	Type of container	: Plastic polymer
11.	Discharge voltage	: 1.0 V/Cell
12.	Sp. gravity of electrolyte	: 1.19 ± 1%
13.	Sp. gravity of electrolyte (Charged)	: 1.23 ± .010 at 20°C
14.	Vent plug	: Anti-corrosive & fire proof
15.	Cell condition	: Pre-charged.
16.	Battery stand	: Steel frame of step type
17.	Standard	: IEC or equivalent

**SCHEDULE OF TECHNICAL
REQUIREMENTS OF 110 V DC BATTERY
CHARGER**

SL. No. Description

A) GENERAL	
1.	Installation
2.	Rectifier type
3.	Rated D.C. voltage
4.	Rated output current
	: 50 Amps (for 33kV control room)
5.	Charging mode

6.	High Voltage Insulation	: 1000 V AC for 1 minute between input to output and input to ground
7.	Insulation resistance	: 10 M Ω with 500 V DC for 1 minute
8.	Cooling system	: Self & natural air cooled.
9.	Relative humidity	: Up to 98%
10.	Ambient temperature	: 45°C (max.)
11.	Noise level	: 65 dB (max)
12.	Altitude	: 150 m
13.	Applicable Standard	: IEC or equivalent.

B) TECHNICAL DATA

A.C. INPUT

1.	Voltage	: 415 Volts
2.	Phase	: 3 Phase
3.	Frequency	: $50 \pm 5\%$ Hz
4.	Input AC voltage variation	: $\pm 5\%$
5.	Power factor (Full range)	: 0.8
6.	Efficiency (Full load)	: 85%
7.	Charge Characteristics	: Constant current /Constant voltage (During float charge)
8.	Current limitation	: 110%

D.C. OUTPUT

1.	Voltage	: $110 \pm 5\%$ volt
2.	Ripple Voltage (Full load)	: $\pm 3\%$
3.	Charge modes (3 level)	: Charge, Float charge & Boost charge
4.	Float Voltage (adjustable)	: 1.42 volt/cell
5.	Boost Voltage (adjustable)	: 1.53 volt/cell

8.6.33 LIGHTING AND SMALL POWER

This section of the Specification includes for the interior and exterior lighting and small power systems.

Whenever practicable, fixtures shall be sourced locally. All lamps, fittings, plugs, sockets and general accessories of the same size and types shall be similar and interchangeable throughout the installation.

The lighting and small power equipment and installation shall comply with other sections of this Specification as appropriate.

All civil works associated with this section of the works shall be deemed to be included as part

of the works in this section. No additional payments will be made for such requirements.

The requirements of this section of the works are subject to the Main Conditions and Specifications laid down in the specifications.

REFERENCES

Any international standards referenced in the specifications and our outdated shall be replaced with the corresponding replacement.

British Standards

- BS 7671 Code of Practice Regulations for Electrical Equipment in Buildings 15th Edition.
Institution of Electrical ENGINEERs.
- BS 6004 Specification for PVC insulated cables (non armoured) for electric power and lighting
- BS 6346:1989 Specification for PVC insulated cables for electricity supply BS 6500
Specification for insulated flexible cords and cables
- BS 6121 Mechanical cable glands
- BS EN 60947 Specification for control gear for voltages up to and including 1000V AC and 1200V DC
- BS 4533 Luminaries
- BS 3677 Specification for high pressure mercury vapour lamps
- BS 1363 Specification for 13A fuse plugs and switched and unswitched socket outlets
- BS 1362 Specification for general purpose fuse links for domestic and similar purposes (suitable for use in plugs)
- BS 4568 Specification for steel conduit and fittings with metric threads of 150 form for electrical installation
- BS 4066 Test on Electric cable under fire conditions.
- BS 4434 Specification for safety aspects in the design construction and installation of refrigerating appliances and systems.

Institution of Heating and Ventilation ENGINEERs Guide to current practice.

American Society of Heating, Refrigeration, and Air conditioning ENGINEERs

Recommendations

Heating and Ventilation Contractors Association of U.K. specification DW/ 121

- BS 5970 Code of Practice for thermal insulation of pipe-work and equipment
- BS 848 Fans for general purposes
- BS 6540 Method of test for atmospheric dust spot efficiency and synthetic dust weight arrestance
- BS 2871 Specification for copper and copper alloys: tubes
- BS 1470 Specification for wrought Aluminium and Aluminium alloys for general ENGINEERing purposes, plate, sheet and strip

DEFECTS LIABILITY PERIOD

The Contractor shall be responsible for the efficient and good working of the installations comprising this section of the Specification for the agreed period.

APPROVALS

The Contractor shall submit to the ENGINEER for approval copies of all his calculations forming the basis for the designs of the specified systems which shall be shown on the working drawings, which is also required to be submitted for approval.

Any approvals shall not, however, relieve the Contractor of his contractual responsibilities which include obtaining local authority approvals for electrical wiring installations.

LIGHTING REQUIREMENTS

The lighting installations shall be designed to give the standard service illuminations and shall incorporate emergency lighting where indicated. Control Rooms, Relay Rooms, Telecommunications Equipment rooms, offices and stores shall have the service illumination measured at 850 mm above finished floor level. All other areas shall have the service illumination measured at floor level.

The installations shall also meet the limiting glare index requirements as set out in the specified codes of practice. This section of work gives proposals for the types of lighting fittings to be used in the area, type of control to be employed, number of socket outlets and the types of mounting expected to be suitable for the respective areas. Where discharge and fluorescent light sources are to be used in areas containing rotating or reciprocating machinery, the fittings shall be allocated between the 3 phase and neutral in such a manner as to avoid stroboscopic effects.

When 3 phase lighting installations are to be used, contactor switching controlled by pushbuttons located in the area to be illuminated is preferred.

In all rooms and corridors having two entrances the lighting installation shall have two way switching, the switches being located in appropriate positions adjacent to the entrances.

Emergency lighting shall be connected to a Central Battery System and shall be arranged to illuminate all stairways, exits and entrances and provide some illumination in offices and operational areas within the Administration Building, GIS Switchgear Building, Control Building, Sea Water Intake Facility, Pre-Treatment Facility, RO Facility, Post Treatment Facility, Electrical Rooms, Transformer Bays, and Gantry Area. Central Battery System shall be connected to a Three Phase Normal Power Supply coupled with a Standby Generator

Security lighting shall be installed around the perimeter walls illuminating the external area and shall be controlled from the gatehouse. The level of illumination for security lighting shall be measured at a distance of 3 metres outside the boundary wall.

SCHEDULE OF DESIGN REQUIREMENTS

The lighting system shall include provision for ease of erection, maintenance, cleaning, lamp replacement and future extension. Lamp replacement and maintenance should, unless otherwise approved, be possible without necessitating outages on main plant items.

Lighting apparatus shall be of top quality, designed to ensure satisfactory operation and service life under all variations of load, frequency and temperature. Sodium discharge lighting shall be used for road and security lighting. GIS Substation, Electrical Substations, & Gantry Area floodlighting shall use 500W Halogen lamps unless otherwise specified. Streetlighting Illumination Calculation and Area Lighting Calculation shall be submitted to the ENGINEER for approval.

Key to Abbreviations:

L Local switches

S1, S2 etc. Socket outlets or fused spur circuits

P.B Pushbutton for remote control

T.S Time switch control

C Ceiling mounted

W Wall mounted

P Pole or earth mast mounted

M Recessed modular mounting

- D Suspended
- F Flush installation
- S Surface installation
- A Automatic on mains failure
- BH Behind ceiling diffuser.

CODING SYSTEMS

The Contractor shall, when preparing drawings showing the respective designs, use a code to identify each lighting fitting and socket outlet.

The code shall comprise letters and figures so compiled that the following information can be readily identified:

The lighting distribution board to which the fitting or socket outlet is connected.

If connected to the normal supplies or to the emergency DC supplies.

The circuit number and phase of the distribution board to which the fitting is connected.

The sequence of the fitting in a particular circuit.

SWITCHES AND PUSHBUTTONS

Switches shall be rated for 15 amps, shall be single pole types and be provided with an earth terminal.

Switches shall be one way, two-way or intermediate as required and, where mounted together, they shall be fitted in a common box.

Switches for use in areas designated for surface installation shall be quick-make-quick-break fixed grid industrial types mounted in galvanised malleable iron boxes with protected dolly and arranged where necessary for multigang switching.

Switches for use in areas designated for flush installation shall be micro-break types fixed to white plastic cover plates and mounted in galvanised steel flush type boxes.

Switch-boxes shall be galvanised and fitted with screwed stainless steel front plates having a 6 mm overlap minimum for flush installations. They shall be suitably barriered and labelled where two phases are connected in the same box.

Switches mounted externally shall be of weatherproof pattern to IP55 level fitted with machined

box and cover joint, brass operating handles, neoprene weather tight seals and external fixing feet.

Where DC emergency lighting circuits are to be switched, double-pole quick make, quick break switches with pillar type terminals and earthing straps shall be provided.

Switches shall be mounted 1.4 m above finished floor level.

Pushbutton switches shall either be flush or surface types contained in galvanised steel boxes and be single pole rated for 5 Amps. Pushbuttons shall be made of non-hygroscopic material, be non-swelling and so fitted as to avoid any possibility of sticking.

The terminals for all switches shall be adequate to accommodate 2 conductors, each a minimum of 1.5 mm² in area.

LIGHTING FITTINGS

Illustrations and/or samples of all lighting fittings which the Contractor proposes to purchase shall be submitted to the ENGINEER for approval before issuing any sub-orders.

Lighting fittings for interior and exterior use are to be manufactured and tested in accordance with the appropriate sections of BS 4533, IEC 60162 or equivalent and together with all components are to be suitable for service and operation in the tropical climate stated.

Each fitting is to be complete with all lamp holders, control gear, internal wiring, fused terminal block, earth terminal and reflectors or diffusers as specified. The design of each fitting is to be such as to minimise the effect of glare and such that the ingress of dust, flies and insects is prevented, where open type fittings are used it is to be impossible for insects to become lodged therein.

The control gear for use with fluorescent lamps is to be quick or resonant start type without starters. Chokes are to be impregnated and solidly filled with polyester resin, or other approved high melting compound, are to be manufactured to restrict the third harmonic content to less than 17% of the uncorrected current value, and are to be silent in operation.

The built-in ballast units shall comply with IEC 60082 and shall include radio interference suppressors and capacitors to correct the fitting power factor to a minimum of 0.85 lagging. Control gear noise levels shall be minimal.

Fittings shall be supplied complete with closed end vitreous enameled metal reflectors or totally enclosed opal plastic diffusers, which shall be fully interchangeable.

Dispersive reflector fittings suitable for mercury bulb fluorescent or tungsten filament lamps shall be of heavy gauge sheet steel finished vitreous enamel. They shall be fitted with anti-vibrators and arranged for conduit box mounting, direct or pendant, on galvanised ball and socket dome type lids.

Bulkhead fittings shall have cast bases tapped for conduit entry, hinged bezels, heat resisting prismatic glasses fitted with neoprene gaskets and porcelain lamp holders. Circuit cable shall not be connected direct to bulkhead fittings but shall terminate in a fixed base connector mounted in a conduit box adjacent to the fitting. Final connections to each fitting shall be carried out with silicone rubber covered cable. All bulkhead fittings shall be watertight pattern.

LED flood light fittings shall be explosion-proof, featured with high strength, impact resistance anticorrosion with performances of strong waterproof and dustproof, body material shall be Aluminium alloy.

Internal connections are to comprise stranded conductors not less than 0.75 MM² covered with heat resistant insulation to the requirements of BS 6500 or equivalent.

All internal wiring is to be adequately cleated to the fitting casing with an approved form of cleat. The finish of fittings for interior use is to be impervious to deterioration by atmospheric reaction. Fittings for exterior use shall have a vitreous enamel, natural Aluminium or galvanised finish according to the manufacturer's standard product.

Lamp holders for tungsten lamps up to 150 watts shall be brass or porcelain BC type and for higher ratings shall be ES or GES type according to size. Fittings for housing tungsten lamps exceeding 150 watts rating are to be provided with an approved method of dissipating heat from the lamp cap and terminal housing.

Lamp holders as applicable are to be suitable for the lamp specified.

Lighting fittings are to be of the type description as generally set out in the schedule appended to this section of the Specification. The type references used are to be repeated in the Schedules and on the drawings.

LAMPS

The Contract includes the supply and erection of all lamps and tubes necessary to complete the installation.

Fluorescent lamps shall be manufactured and tested in accordance with BS1853, IEC 60081 or equivalent, shall be bi-pin types and shall have colour rendering values of X = 0.335 and Y=0.342 (i.e., Colour 2) on the CIE chromaticity scale.

Tungsten lamps shall be manufactured and tested in accordance with BS 161 or equivalent and shall be bayonet cap for lamps up to and including 100 watts. Lamps rated for 150 watts and higher shall have edison screw caps. Low wattage lamps used in exit signs and emergency lighting units may be small or miniature edison screw.

Discharge lamps shall be manufactured and tested in accordance with BS 3677 or equivalent. Mercury vapour lamps shall be fluorescent types having a 10% red ratio colour correction, whenever used.

LED flood light shall be rain/fog penetrable and tested in accordance with IEC/EN 62471 or equivalent.

SOCKET OUTLETS AND FUSED SPUR OUTLETS

Each socket outlet shall comply with the requirements of the BS 1363 or equivalent and shall be the interlocked shuttered and switched types arranged for surface or flush mounting in single or multi-gang units as appropriate.

Each fused spur outlet shall be equipped with double pole isolator, a fuse to BS 1362 or equivalent and where required front entry for flexible connection.

Each socket outlet and fused spur outlet shall be equipped with a galvanised metal box with earth terminal.

Each group of five socket outlets is to be provided with a matching fused plug top.

All socket outlets for exterior use shall be corrosion proof / water proof and be equipped with screwed dust proofed cap attached to the socket by means of a chain.

13A, 32A, 63A, 100A TPN+E Switched Socket outlets shall be provided inside and outside the 230kV/110kV/11 kV GIS Substation, Transformer Bays, and Electrical Rooms that will be used for testing and commissioning, operation and maintenance.

TIME SWITCHES

Time switches for use with lighting systems shall be the synchronous motor wound types protected by a suitably rated fuse for 230 volts operation with a nine hour reserve spring and are to be fitted with a twenty-four hour hand set dial, two "off" and two "on" levers and manual operation pushbutton. The main contacts shall be rated for 20 Amps on a 230 Volt 50 Hz AC supply.

Time switches shall be suitable for mounting in the distribution boards supplying the circuits to be controlled.

LIGHTING POLES

Lighting poles shall be tapered, of hot dip galvanised steel with bituminous preservative inside and outside at the base and shall be approved by the ENGINEER.

Each pole shall be equipped with a base section compartment of 470 mm by 150 mm to house an inspection trap, lockable door, fused cutout, cable entry and terminations for both the incoming and outgoing power cables and secondary cables feeding the light sources.

Poles for substation lighting shall support the floodlights at 15m above ground level and poles for access roadway lights shall support the lanterns at 12 m above ground level.

The Contractor shall ensure each pole is provided with foundations suitable for the ground

conditions occurring at each Site.

INTERIOR INSTALLATIONS

Wiring for the lighting and socket outlet installations shall comprise PVC cables drawn into conduits attached to walls or ceilings as appropriate.

Surface and flush type installations are required according to the particular area as indicated in the schedule appended to this section.

In areas where flush type installations are indicated the wiring shall be drawn into conduits buried under wall finishes or concealed above ceilings as appropriate.

All fixings shall be of a type approved by the ENGINEER and all metalwork used shall be galvanised. Fixings to structural steelwork shall be with purpose made brackets or clamps; the drilling of structural steelwork will not be permitted.

Cleats with two screw fixings shall be used for supporting conduits at not greater than 2m intervals.

All switchboxes, socket outlet boxes and items of a similar type shall be fixed with two screws or bolts.

Switches and pushbuttons for lighting circuits shall be mounted at 1400 mm above finished floor level. Socket outlets shall be mounted 500 m above finished floor level but those for use with workshop benches shall be mounted 150 mm clear of the bench working surface.

Lighting fittings shall be attached to ceilings, walls, trunking or roof steelwork or suspended there from as appropriate.

Where fittings are to be suspended, rod type suspension units shall be employed.

Final connections to all suspended lighting fittings shall be with heat resistant flexible cable terminated in porcelain clad connectors in the ceiling or junction box which shall also terminate the main circuit cable. The cable length shall be such that the suspension unit supports the full weight of the lighting fittings.

Where recessed type lighting fittings are to be installed suspension units shall be used to prevent the weight of the fittings being applied to the suspended ceiling. It shall be possible to carry out maintenance from the underside of the fitting without disturbing the false ceiling. To facilitate this need the final connection to each fitting shall be with heat resistant flexible cable from a plug in type ceiling rose mounted above the false ceiling.

All cables not contained within conduit for their whole route shall be terminated with a cable gland.

Where lighting fittings are mounted direct on walls or ceilings, the main circuit cables may be

connected into the fitting terminal block. Where terminal blocks do not exist within the lighting fitting, flexible heat resistant cable shall be used connected to a separate junction box.

Earth continuity shall be maintained throughout the entire wiring installation with separate insulated earth continuity conductors of adequate cross-section ultimately connected to a common earth terminal at the respective distribution board.

Within the interior installation adequate provision shall be made for connection to small ventilating fans, which are not energised from the central air conditioning control and starter panel.

Each and every trunking route shall be bonded across all joints with external copper bonding links supplied for the purpose.

EXTERIOR INSTALLATION

Exterior substation lighting fittings shall be attached to substation walls at high level or pole mounted as appropriate. Security lighting round the perimeter wall/fence is to be provided.

When locating the floodlights for the switchyard lighting, the Contractor shall ensure that all floodlights are outside safety clearance for the high voltage lines at the Gantry Area.

Cables to exterior lighting shall be laid in uPVC ducts, laid in concrete trenches or cleated to buildings structures as appropriate to the route requirement. The cables shall be terminated at a cut-out located at the base of each support. Wiring between the cut-out and the control gear or lantern shall be with multicore cable run within poles or with cable drawn into galvanised steel conduit attached to the supporting structure.

EMERGENCY LIGHTING

Emergency lighting shall comprise lighting fittings of the types indicated in the schedule appended to this section of the Specification.

The system shall be so arranged that on failure of the normal a.c. supplies to the lighting installation the emergency lighting system will automatically be switched on. Other than those of the "on demand" type, all emergency lighting shall be switched "off" 5 minutes after restoration of normal supplies. Each emergency lighting unit shall have a minimum 3 hour rating.

Sufficient fittings of Type E3 shall be provided in each room to enable the rooms and building to be evacuated safely.

In addition, in designated working areas emergency manually switched lighting, to give not less than 30 lux, shall be provided utilising type E4 fittings. Switches shall be labelled to the approval of the ENGINEER.

The security lighting scheme shall illuminate the area to 6 metres inside the perimeter wall to

the lighting level specified.

SCHEDULE OF LIGHTING REQUIREMENTS

Control Building

Location	Service	Glare Illuminance (Lux)	Index
Control Relay Room		500	25
Behind panels		100	-
Office		500	20
Battery Room		300	-
Toilet		100	-
Corridors, Stairs		100	20
Outdoor Areas			
GIS Substation Flood lighting		300	-
230/110kV GIS Room		500	-
11kV Switchgear Room		500	-
Transformer Compounds		300	-
Roadway Lighting		150	-
Perimeter Wall Security		150	-
Control Building Exterior		300	-
Electrical Rooms		500	-

8.6.34 AIR CONDITIONING AND VENTILATION

This Section of the works covers the design, supply, delivery, installation, commissioning and setting to work of the heating and ventilating systems for the 230/110kV GIS Substation Building and CP1 Facilities.

All heating and ventilating systems shall be fully automatic in operation and shall be capable of maintaining internal conditions within the bands of temperature and humidity specified hereafter. the substations are normally manned and allowance shall be made for at least four persons on site in the design.

Heating

Electrical heating shall be provided for each room of the building. Except for the battery room, the heating shall comprise of 1500mm long tubular heaters with a load of 60 watts/foot (300mm) which shall be mounted in double tier banks. Electric heaters shall be fitted with bright plate safety guards affording full protection to the heating tubes. The Contractor shall assess the thermal performance of the building and ensure that the sizes of units are adequate to maintain internal temperatures of 5° C when the external temperature is -3°C, measured 1200mm above finished floor level out of an air stream.

The heaters in each room shall be controlled by contactors which have thermostats connected into the coil circuit. Thermostats shall be located in each room and have a maximum cut-off temperature of 17° C.

Each heater bank shall be equipped with a local isolator. The lower tubular heater shall be mounted at 500mm above finished floor level.

Air Conditioning

The following areas shall be air conditioned :

Administration Building

Gas Insulated Switchgear Room

11kV Switchgear Room

Low Voltage Switchgear Room

Motor Control Center Room

Electrical Rooms

Control / Relay room

Tel/LAN / SCADA / PLC room

Offices / Record Room

Laboratory Room

Canteen / Kitchen

Air conditioning shall be provided in the form of Air Cooled Split System Air Handling Units. The systems shall handle predominantly recirculated air with a controlled quantity of fresh air introduced either at each unit or independently via a separate supply and extract system. Supply air distribution ducts for the Control/Relay room shall be located in the false ceiling serving supply diffusers. Return (recirculated) air shall be drawn in through the front of each unit.

The cooling medium for the split System Air Handling Units shall be direct expansion provided by air cooled refrigeration condensing units located on the roof of the building or wall mounted on building exterior, and interconnected by refrigerant pipe-work to multi circuit direct expansion cooling coils.

Air conditioning system shall be thermostatically controlled to maintain internal conditions under continuous operation within the limits stated. Plant shall be arranged to facilitate maintenance and future replacement of equipment.

Mechanical Ventilation

Supply and extract ventilation shall be provided to serve the following areas:

1. Switchgear room
2. Battery Rooms
3. Toilets (Extract only)
4. Cable basement

Supply air handling plants shall consist of a sand trap fresh air intake louvre, insect screen, pre-filter, bag filter, electric air heater battery, fan and distribution ductwork.

The air intake shall not face the prevailing wind.

Extract ventilation shall be provided by means of wall mounting fans, roof extract units or ducted systems with louvered discharges to atmosphere. Individual extract fans shall be provided for Battery room and toilets.

Extract fans for battery room shall be corrosion resistant throughout, with a 4 mm PVC lining.

Basis for Design

External Design Conditions

The external conditions for the calculation of duties for the mechanical services shall be with mean monthly, maximum and minimum values as below:

Maximum ambient shade temperature 45 deg C

Minimum ambient shade temperature 4 deg C

Maximum daily average temperature 35 deg. C

Maximum annual temperature 25 deg. C

Relative humidity	- maximum	100%
	- minimum	80%
Solar radiation	100mW/sq.m	

All plant and equipment installed externally, or which can be affected by external condition shall be capable of withstanding without damage or deterioration the effects of solar radiation, rain, wind, dust, sand storms or other weather phenomena prevalent in the area in which particular building is located.

Internal Design Conditions

Air conditioning systems shall be capable of maintaining internal conditions in all air conditioned areas within the following bands or, if necessary for the satisfactory operation of the equipment housed, more stringent requirements:

For substations	22+4 °C DB
	40 to 70% R.H.

The following air change rates/hour shall be provided in mechanically ventilated area:

Switch gear Rooms	10
Battery Rooms	10
Toilets 12 (Extract only) Cable basement	6
Other general areas	4

All air conditioning and ventilating systems shall be designed for continuous operation. Plant shall be arranged to facilitate maintenance and future replacement of equipment.

The Contractor shall calculate heat gains and losses under the specified conditions for each part of each building, taking into account solar radiation, thermal transmittance through roofs, walls, floors and windows, fresh air requirements, heat emission from installed electrical equipment and lighting, personnel, infiltration and any other sources. The Contractor shall be responsible for determining the heat transfer coefficients for all materials used in building construction. In the event of any change in materials, design or method of building construction, the Contractor shall at all times be responsible for rechecking the design of all systems to ensure that they are capable of meeting the specified design requirements.

Air Cooled Condensing Units

The cooling medium for the air conditioning shall be direct expansion refrigeration provided by air cooled condensing units located externally.

The condensing units shall be of the fully packaged type requiring only site connection of refrigeration pipe-work, isolated electrical supply and input from the control system.

The individual item of refrigerant equipment shall be matched such that the required performance of the evaporator is achieved concurrently with the satisfactory operation of the compressor and adequate heat rejection at the condenser. Each system as a whole shall maintain the correct duty at the design ambient and operate at the maximum ambient conditions stated without exceeding the safe operational limits of any individual item of equipment and without causing any safety device to operate.

All electrical equipment, control, magnetic coils and solenoids shall be manufactured specifically for operation at the electrical characteristics specified herein and such items designed for any other characteristics shall not be used.

Air cooled condensing units and air handling units that are inter-connected on site with refrigerant piping shall all be supplied by the same manufacturer.

The casings of the condensing unit shall be weatherproof and shall incorporate adequate access and inspection panels secured in place by rustproof fasteners.

The whole of the casing shall be treated for corrosion and weather resistance and ungalvanized mild steel shall not be used (even if painted). The unit shall be finished in not less than two coats of weather resistant finish, such as baked enamel of a light reflective colour.

The access panels shall be adequately sized for the service and removal of all working parts of the unit. All panels shall be stiffened and supported to prevent flexing and drumming.

Electrical equipment shall be contained in a fully weatherproofed enclosure with internal division between the power connections and equipment and the control connections and equipment.

Refrigeration Systems

(a) Liquid lines shall be insulated where they are in direct sunlight or where they pass through non-air conditioned areas.

Suction lines shall be insulated over their entire length.

All insulation to refrigeration pipe-work shall be flexible closed cell 1 foam phenolic rubber type with a temperature range of -40°C to +105°C and having a thermal conductivity of 0.0375 w/m °C at 21 °C and a water vapour transmission of less than 6.0 ng/Ns.

The thickness of insulation shall be in accordance with the following tables:

Suction Lines

Location	Insulation thickness for O.D.	Pipe Sizes Range
	6-10mm	12-22mm
Exposed to weather	13mm	19mm
In air conditioned spaces	9mm	19mm
In non-air conditioned spaces	9mm	9mm
Liquid Lines		
Exposed to weather and in non-air conditioned spaces	9mm	9mm

(b) The refrigerant used shall conform to BS 4334 Group 1 or equivalent and shall be non explosive, non-combustive, non-toxic and non-irritating.

Packaged air conditioning plant items requiring interconnection with refrigeration piping on site shall be leak tested by the manufacturers and delivered to site with a holding charge of refrigerant.

Console Air Conditioning Units

Console model room air conditioners shall be of the slim-line pattern and complete with 4-way adjustable grilles, heavy gauge zinc coated stove enamelled sheet steel casing with single or two colour decorative finish. Electrical-heaters shall not be fitted.

The casing and position shall be such as to protrude not more than 250 mm into the air-conditioned space and no external projection beyond the building line will be permitted other than the fixing of the condenser cooling air grille.

The units shall be extremely quiet in operation, the noise level not being higher than 30 dB. All sections of the casing shall be acoustically and thermally insulated.

Compressors shall be of the fully hermetic type, fitted with resilient mountings and complete with thermal overload protection and starting relays.

Evaporators shall be manufactured of copper tube with copper or aluminum fins mechanically bonded. The evaporator fan shall be of double inlet, double width type and complete with continuously rated totally enclosed electric motor.

Filters shall be of the washable type, suitably positioned for easy access for cleaning.

Automatic control by means of an integral thermostat shall be provided, together with the safety control to prevent excessive cooling.

Motors shall be air cooled and units shall be complete with internally mounted condenser cooling fans with totally enclosed motors.

Fresh air shall be introduced separately by means of a central fresh air plant, where these units are proposed to serve individual offices in a building.

Units shall be supplied as a whole and be suitable for easy removal and re-positioning should this be desired at a later date.

Ductwork

All sheet metal ducting shall be manufactured and installed in accordance with the Institution of Heating and Ventilation ENGINEERs Guide to Current Practice Section B 16, the American Society of Heating, Refrigeration and Air Conditioning ENGINEERs, or the Heating and Ventilating Contractors Association of United Kingdom Specification DW/142 or equivalent international standards for sheet metal ductwork for low velocity low pressure air system with air velocity of up to 10 m/s.

All ductwork and fittings serving hazardous areas, such as battery rooms where corrosive fumes are expected, shall be of rigid PVC materials.

Condensate Drains

Provision shall be made for condensate to be passed into the rainwater drainage system. Condensate drains must be routed directly into the drainage system or individual soakaways. Pipes discharging onto substation or building brick paving will not be permitted.

Extract Ventilation Units

This clause covers fan powered extract ventilation units for mounting in walls and windows, on roofs and in plant rooms.

Extract units shall incorporate propeller, aerofoil, axial, centrifugal or hybrid type fans which shall be constructed in accordance with the relevant sections of this Specification.

Roof units shall comprise a galvanised sheet steel base suitable for use as a weathering skirt, a mild steel fan/motor mounting frame and a spun Aluminium cowl. The sheet steel base shall be constructed to support the fan/motor without distortion and where the fan is belt driven shall incorporate a rigid subframe for motor mounting. Fans shall be diaphragm mounted or fitted with a cylindrical casing designed for removal from the unit from inside or outside the building without disturbing the weathering skirt or cowl fixings. The cowl shall be weatherproofed and shall be hinge mounted to provide complete access to the fan/motor.

Lubricating points shall be extended to a convenient access point.

Stainless steel nuts, bolts and washers shall be used for all fixings exposed to the weather.

Air Filters

All filter media shall be properly bonded and protected against filter fibre or particle migration. The direction of air flow shall be clearly marked on all filter panels and on installation frames.

Access to filters shall be through removal panels fitted with quick release fasteners and rubber sealing gaskets.

Each disposable panel filter system shall be provided with 4 complete spare sets for use during the commissioning period. These sets shall be in addition to any filter cells supplied as spares in accordance with the general clauses of this specifications.

Filter performance shall, unless otherwise noted, be taken to mean the Overall Gravometric Efficiency against BS 6540:Part I Duct Test or equivalent.

Filter media of all types and sizes shall be supported in rigid peripheral frames with internal or external wire support of the media to ensure that the media shall not collapse under air flow. The holding frames shall incorporate accurately sized channel sections to provide a good fitting for the filters.

The type of washable and/or disposal panel filters shall be subject to the ENGINEER's approval.

Grilles and Louvres

Grilles shall be of aluminum construction and shall be fixed by means of subframe with spring clips or screw fixings.

The corners of front flanges of grilles and subframes shall be mitred and jointed to produce a clean unbroken appearance and visible aluminum sections shall be free from extrusion marks.

Front flanges shall be at least 30mm wide and shall incorporate a lip of at least 4.5 mm and a felt gasket. Blades shall be fixed at even centers with intermediate mullions giving support for blades of more than 550 mm long. Grille finish shall be anodised natural Aluminium colour except where otherwise indicated.

All grilles shall be fitted with an opened blade damper for regulation purposes and shall be fitted with acoustically lined inlet plenums where necessary in order to comply with the acoustic limits of this Specification.

Outdoor air louvers shall be of all extruded Aluminium construction fitted with opposed blade dampers in the connected ducting where necessary for air flow regulation, Movable blade louvres shall not be used.

Louvres shall be weatherproof and shall incorporate an Aluminium wire mesh screen on the

inside surface.

The dimensions of louvers for mounting in the building structure shall suit the concrete block or brick modules and shall be fixed to a hardwood frame.

Control Equipment

Each item of shall be provided with local isolation and/or emergency stop buttons to facilitate maintenance, inspection and emergency operation.

The control system shall be of the electronic type, capable of providing the degree of thermostatic control specified. The Contractor shall provide full wiring diagram of all control circuits giving terminal connection reference.

The control system shall incorporate all necessary safety interlocks for the successful operation of the mechanical plant and system. All of the individual control elements shall be provided by the same manufacturer.

Temperature sensors shall be of the resistance type using nickel based elements and shall be accurate to + 1oCover the range of 0 °C to 30 °C. The sensor resistance shall be compatible with the measuring bridge of the matching control box.

Electrical Connections

All electrical power control cables and wiring associated with the air conditioning and ventilation systems, including all connections between control panels, valves, thermostats, sensing probes and other like items shall be supplied, installed and connected up as part of this Contract.

The cabling and wiring system shall comply with the requirements of the relevant clauses of this Specification and be either surface or flush installation as appropriate.

Cables and wiring shall comprise either PVC/WPVC laid in cleats or trenches, or PVC drawn into galvanised conduits and trunking.

Final connections to electric motors and all other items of plant subject to movement and vibration shall comprise flexible cable in flexible conduit.

Manufacturers

Wherever possible all air conditioning and ventilating plant shall be selected from a single manufacturer's product range and origin. Where this is not possible, because of practical or technical constraints. then the number of different sources of origin shall. be kept to a minimum. Local service facilities shall be available for the equipment proposed.

The Contractor shall provide, with his submission, illustrated technical literature covering all plant and equipment offered.

Standards

All air conditioning and ventilation equipment shall conform to British Standards, Chartered Institution of Building Services or ASHRAE recommendations or other recognised International Standards.

Approval

The Contractor shall submit to the ENGINEER for approval copies of all his calculations forming the basis for the selection of all air conditioning and ventilating plant, plant selection details and full working drawings. Such approval shall not relieve the Contractor of his contractual responsibilities.

Maintenance

The Contractor shall be responsible for the maintenance of all installations covered by this section of the Specifications for the period stated elsewhere in the Specification.

EARTHING AND BONDING

All equipment being supplied under this Section shall be effectively bonded to ensure earth continuity throughout the system. Continuity may be provided by means of cable armouring but a separate earth continuity conductor shall be included with all wiring in conduits. No reliance shall be placed on metal to metal joints in conduits for earth continuity. The earth continuity conductors shall as far as possible be in one continuous length to the furthest part of the installation from the controlling switchboard. The earth conductor shall connect all metal cases housing electrical equipment. The branches shall be connected to the main conductor by permanently soldered on mechanically clamped joints.

8.6.35 TELEPHONE / LAN SYSTEM

Contractor shall Design, Supply, Deliver, Test and Commission a complete TEL/LAN System as per ANSI/TIA/EIA 568-B in 230/110/11kV Gas Insulated Substation, CP1 Facilities and Administration Building. Complete conduit/ductbank system shall be provided throughout the GIS buildings, Administration Building and CP1 Plant facilities to enable the telephone / LAN cables to be run to the proposed extension points. This includes telephone wiring to operators' desks, office in the GIS Control Building and Administration Building.

Telephone instruments, the PABX and connections to PTT exchange lines shall be carried out by the approved Telecommunication / LAN Contractor.

8.6.36 CCTV SYSTEM

At least 12 (twelve) IP based CCTV Camera with complete necessary hardware & software for video recording, monitoring and storage, switch etc. shall be supplied, installed and commissioned inside and outside of 230/110/11kV GIS building for security purpose. The suitable location of the camera shall be finalized during contract execution and shall be

submitted to the ENGINEER for approval. Data connection for individual camera shall be through well protected fiber optic cable.

CCTV Camera specifications shall be as follows:

PTZ type camera

Signal Format : NTSC

Input Voltage : 12/24V

Panning range : 0-360 degrees

Tilt Range : 0-90 degrees Horizontal resolution : 480TV lines

Fixed Type camera

Signal Format : NTSC

Input Voltage : 12/24V Horizontal resolution : 550TV lines

Digital Video Recorder

Recording mode : Continuous Camera display : 16 channel

Signal cable Type : Fiber Optic Type

CCTV camera system shall have to be integrated with substations Fiber Optic Multiplexer equipment for remote monitoring.

CCTV camera system for the Administration Building and the whole CP1 Plant shall be designed by the Contractor and shall submit the drawings to the ENGINEER for approval.

TESTING AND COMMISSIONING

The Contractor shall be required to prove that the installed system meets the design requirements and Specification to the satisfaction of the ENGINEER.

8.6.37 BUILDING AND CIVIL ENGINEERING WORKS

GENERAL

Under this Section the Contractor will be responsible for the design and construction of all civil ENGINEERING and building works and services for new 230/110/33 kV indoor GIS substation at CP1.

Scope of Work

The Bid must cover all requirements of the bid documents and any other items not specifically mentioned but which are necessary for the satisfactory design, construction, operation and maintenance of all equipment to the satisfaction of the Employer. No additional costs will be considered for any items which have been overlooked but which are essential for the proper completion of the project in every respect.

The work shall include but not be limited to:

- a) Site survey and subsoil investigation.
- b) Site preparation, cutting or filling up to the level specified in 10.1.4 and leveling.
- c) Roadways, car ports, paths and surfacing.
- d) Foundations for all equipment to be installed in outdoor switchyards, control building, indoor switchgear and any other building required for the project.
- e) GIS and control building (complete building consisting of structural reinforced concrete frames, brick walls, concrete roof and floor slabs) with cable basement.
- f) Motorized roller shutter door for GIS entrance.
- g) Floor finishing: screed for cable basement and GIS room, Nitocote epoxy resin coating in battery room, raised floor for control room and homogeneous tile for other floors.
- h) Cable trenches, cable tunnels, cable ducts and pipe ducts.
- i) Water supply and plumbing installations
- j) Surface water and foul drainage.
- k) Guard house and fences.
- l) Air conditioning and ventilation.
- m) Lighting, small power, external floodlighting, emergency lighting and fire protection.

For all substations and for individual rooms in substations suitable nameplates, signs and labels shall be provided to ensure identification, safe operation of plant and warning of danger. The text, which shall be both in Tamil and English, shall be approved by the ENGINEER. The substation sign board(s) shall be 3 mm, Aluminium sheet powder coated and the text (Tamil & English) shall be UV resistant, CMWSSB logo on a separate circular plate to be fixed at the centre of sign board. The inscriptions shall be engraved with colored lettering. All nameplates, signs and labels shall be non-deteriorating and non-warping under aggressive weather conditions and shall be guaranteed for a minimum period of 10 years.

Plates, etc., will be securely attached using bolts and nuts or screws; adhesive will not be permitted.

Included in the scope of work is the detailing, construction and maintenance of the following items which shall generally be constructed to the Employer's standards, but full working drawings shall be prepared by the Contractor:

- a) Septic tank and soak away
- b) Underground water storage tank

Drawing and design of septic tank and soakaway shall be prepared by the contractor and shall be finalized during detailed Engineering.

The Bidder shall state which approved local building contractor(s) he proposes to employ to carry out the work.

Contractor to satisfy himself as to all conditions

The Contractor shall assess:

- n) access conditions at all sites, plus ground conditions and ground bearing capacity
- o) transport costs, materials costs and restrictions of availability of supply of materials locally
- p) importation restrictions and delay due to customs controls
- q) restrictions imposed by existing equipment on sequence of construction, access, etc.
- r) restrictions caused by cable laying, equipment and line contractors
- s) ground conditions and temporary works required to provide support during excavation.

8.6.38 Standby Diesel Generator Set

Contractor shall Design, Supply, Deliver, Test and Commission the KVA rating of the Generator Sets to supply the Critical Loads on the following CPI Facilities :

1. 230/110/11kV GIS Substation / Control Room
2. Administration Building
3. Sea Water Intake Building
4. Pre Treatment Building
5. RO Building 1
6. RO Building 2
7. Post Treatment Building
8. Water Storage Building

The Diesel Generator set shall be locally supported and shall preferably be as per IEC, British Standards and NEMA Standards.

The generator supplier shall have the capability to conduct on-site load bank tests

Generator set rating shall not be less than all the available electrical loads. These ratings as a minimum should be acceptable for site conditions of altitude up to 305 M (1000 FT) and temperatures up to 50° C (122° F).

Technical Specifications

Shall be equipped with a 4 stroke-cycle diesel engine generator set, not to exceed 1800 revolution per minute, manufactured in accordance with B.S. 5514 or ISO 3046 and generally to such International standards as D.I.N., E.I.C., N.E.M.A. The engine shall be capable of providing a 10% overload for a maximum of one hour in any twelve-hour period over its prime output. The governor shall be electromechanical type and complies with BS85514 Class A1.

The diesel engine shall comply with the emission standards of the Clean Air Act of the local environmental authority

The maximum sound level of the generator set shall be 85dBA measured one meter away from the equipment. The option to provide sound proofing if the equipment does not meet this requirement shall be approved by the ENGINEER.

The engine shall be diesel, radiator and fan cooled. A governor shall provide automatic frequency regulations adjustable to 5% drop. The governor shall have provision for paralleling with the addition of load sharing controls. The engine shall be cooled by a mounted closed loop radiator system rated for full load operation in 50 degrees C (122 degrees F) ambient as measured at the generator air inlet. Radiators shall be provided with a duct adaptor flange. The cooling system shall be filled with 50/50 ethylene glycol/water mixture by the equipment supplier. Rotating parts shall be guarded against accidental contact and meet all OSHA requirements.

The engine-generator set shall include the engine accessories as follows: A DC electric starter capable of three complete cranking cycles without overheating, before over crank shutdown (75 seconds). Positive displacement, mechanical, full pressure, lubrication oil pump. Full flow lubrication oil filters with replaceable spin-on canister elements and dipstick oil level indicator. An engine driven, mechanical, positive displacement fuel pump. Fuel filter with replaceable spin-on canister element. Replaceable dry element air cleaner with restriction indicator. Flexible supply and return fuel lines. Engine mounted battery charging alternator, 45 ampere minimum, and solid-state voltage regulator.

The AC generator shall be brushless design screen protected, fan ventilated, drip-proof, self-exciting in accordance with IP23 (NEMA 1) Protection and directly connected to the engine with flexible drive disc(s). It shall be fitted with heavy-duty long life bearings, lubricant packed for 40000 hours operation. The genset shall be constructed in accordance with BSEN 60034 and relevant section of other international standards such as BSS 5000, UDE 0530, NEMA MG1-22 and IEC4.

Temperature rise measured by resistance method at full load shall not exceed 110 degrees Centigrade.

The genset output voltage shall be 240/415volts AC, 50 Hz 3phase and Neutral. The voltage regulator shall be immune from disoperation due to load-induced voltage waveform distortion.

The voltage regulator shall be equipped with three-phase voltage sensing (3 phase RMS sensing automatic voltage regulator and set mounted control panel). The regulators shall control buildup of the AC generator voltage to provide a linear rise and to limit overshoot. The regulator shall include torque-matching characteristics, which shall reduce output voltage in proportion to frequency below a threshold of (48-50) HZ. The voltage regulator shall include adjustments for gain, damping, and Frequency roll- off.

The set control shall have automatic remote start capability from a panel- mounted 3-position (Stop, Run, Remote) switch. The unit shall provide cycle cranking of 15 SEC (ON)/15 SEC (OFF) for three attempts (75 EC). If engine fails to start a lockout of the engine shall be in place and indicate over crank on alarm status panel. The control shall shut down and lock out upon: failing to start (over crank), overspeed, low lubricating oil pressure, high engine temperature, or operation of a remote manual stop station. A panel mounted switch shall reset the engine monitor and test all the lamps. Local and remote panel shall have emergency stop button.

Local panel shall have a common digital instrument with LCD display. The following parameters shall be displayed as a minimum:

Phase Voltage

Line Current

Load in kW

Engine Speed in rpm

Frequency

Engine Temperature, in deg C

Oil pressure in psi

Running hours meter

Lamp indications on the control panel shall be provided as follows: Over crank shutdown – red

Over speed shutdown – red Low oil pressure shutdown – red

High engine temperature shutdown – red High engine temperature prealarm – yellow Low engine oil pressure prealarm – yellow Low coolant level – yellow

Low fuel level – yellow Overload alarm – red Run – green

Not in automatic start - flashing red

Auxiliary (2 each) - red (Customer identified)

The NEMA 1 enclosed control panels shall be mounted on the generator set within the weather protective housing with vibration isolators. Control panel mounted indicating meters and devices shall include: Engine Oil Pressure Gauge, Coolant Temperature Gauge, DC Voltmeter, Running Time Meter (hours), Voltage adjusting rheostat, locking screwdriver type, to adjust voltage +/- 5% from rated value; Analog AC Voltmeter, dual range, 90 degree scale, 2% accuracy; Analog AC Ammeter, dual range, 90 degree scale, frequency meter, +/- 0.6 Hz accuracy; Seven position phase selector switch with OFF position to allow meter display of current and voltage in each phase. When supplied with re connectable generators, the meter panel shall be re connectable for the voltage specified.

Voltage regulation is maintained within the limits of + or - 1 to 2% from no load to full load including cold to hot variations at any power factor between

0.8 lagging and unity and inclusive of a speed variation of 4.5% nominal voltage is set.

Stator and rotor insulation shall be Class "H" standard.

Radio and television suppression shall be provided and shall comply with

B.S.S. 800/1983.

The complete generating set shall be mounted as a whole on a heavy-duty steel base frame to maintain alignment between components. The base shall incorporate a battery tray with hold down clamps within the rails.

Back-up starting batteries shall be provided connected through a double- throw switch (100 ampere rating minimum) for easy transfer in case of battery failure. This shall be in addition to the standard starting battery normally provided by generator suppliers.

Inspection and Testing

Factory Acceptance Tests shall be conducted for all generator sets prior to shipment. For new generator brands never been used, the ENGINEER shall witness the FAT. Tests shall include but not limited to running at full load, maximum power, voltage regulation tests, transient and steady-state governing, single step load pick- up, emission tests and safety shutdowns. Tests not witnessed by the ENGINEER shall be documented and submitted to ENGINEER for approval.

On-site acceptance tests shall be conducted for all generator set brands regardless if they are already in use. All gensets that have been tested at the factory shall also undergo on-site acceptance tests. The ENGINEER standard testing procedure shall be followed which shall include a 5-minute cold start test, load tests for 15 minutes at 25% load, 50% load and 75% load. At 100% load, the genset shall be tested for 30 minutes. At 105% load, it shall be conducted for 5 minutes.

The contractor/supplier shall provide a resistive load bank, cables, connectors, tools, instruments

and shall make the necessary connections for such an on-site load test. On-site acceptance tests shall not utilize the existing and actual load of any facility.

On-site tests shall conform to NFPA 110 par 5-13.2.3, including strip chart documentation to verify voltage and frequency.

The following parameters at the minimum, shall be logged/recorded during the test: kW load, phase voltages, line currents, frequency, speed in rpm, water jacket temperature and pressure and oil pressure. These shall be monitored before and during changes of generator set load.

8.6.39 UPS SYSTEM AND ITS BATTERIES

Introduction : Contractor shall Design, Supply, Deliver, Test and Commission a fully functional Dual Redundant UPS System for the following CP1 facilities :

1. *230/110/11kV GIS Substation / Control Room*
2. *Administration Building*
3. *Sea Water Intake Building*
4. *Pre Treatment Building*
5. *RO Building 1*
6. *RO Building 2*
7. *Post Treatment Building*
8. *Water Storage Building*

ELECTRICAL SYSTEM DETAILS

Design Temp. - 500 C.

Power Supply Input for UPS : 3 Phases – 415V AC, +/- 10%, 1 Phase – 240VAC,
+/- 10%, 50Hz+/- 3% (Emergency Power Supply
connected to a Standby Diesel Generator Set.)

STANDARDS

In general the Equipment shall be in line with latest edition of relevant IS / BS / IEE / IEC / IS.

Some of relevant Indian Standards are listed below:

- | | | |
|----------|---|--|
| IS: 3700 | - | Essential ratings and characteristics of semi-conductor devices. |
| IS: 3715 | - | Letter symbols for semi-conductor devices. |
| IS: 4411 | - | Code of designation of semi-conductor devices. |

IS: 5001 - Guide for preparation of drawings for semi-conductor devices.

IS: 5469 - Code of practice for the use of semi-conductor junction devices.

IEC 62040-3 (International Electrotechnical Commission) – Uninterruptible Power Systems (UPS) – Part 3: Method of specifying the performance and test requirements.

IEEE 587 (ANSI C62.41) Category A & B (International Electrical and Electronics Engineers) – Recommended practices on surge voltages in low voltage power circuits.

CISPR 22: FCC Rules and Regulations 47, Part 15, Class A (Federal Communications Commission) – Radio Frequency Devices (prior to Feb 16, 2006).

MIL-HDBK-217E (Military Handbook) – Reliability prediction of electronics equipment

ISO 9001, "Quality Management Systems - Requirements." or

ISO 14001, "Environmental Management Systems - Requirements with Guidance for Use."

UPS should be certified for LEED credits and/or for sustainable/GREEN product certification

DESCRIPTION & SYSTEM OPERATION

The UPS shall consist of a **Dual Redundant System** to continue to support the critical load should one or more UPS modules fail which consist of Rectifier / Charger, Battery, Inverter, Static Transfer Switch, Maintenance Bypass Switch, Synchronizing Equipment, Protective Device and other Accessories.

The UPS shall provide continuous electric power within specified tolerance, without interruption, to the critical loads.

Normal power supply of 415V, 50 Hz TP, shall be supplied to UPS System.

The solid-state rectifier / charger shall convert incoming AC power to DC power. The rectifier / charger output shall be fed to solid-state inverter. The inverter shall convert the DC power into AC power, which shall supply the load. Upon failure of AC power, input power for inverter shall automatically be supplied from the battery with no interruption / disturbance in inverter output in excess of limits specified herein (in these specifications). At the same time, UPS shall energize an alarm circuit.

The duration for which Battery shall supply A/C power to critical loads shall be minimum 15 minutes.

When A/C power is restored, the input power for the inverter and for recharging the battery shall automatically be supplied from rectifier / charger output without interruption/ disturbance in inverter output in excess of limits specified herein (in these specifications).

The solid-state circuitry used for both Rectifier & Inverter shall be IGBT technology.

Intelligent RS-232 Communication shall be possible which will Provide UPS status indications, electrical parameters such as Input & Output Voltage, Load levels etc and unattended shutdown.

User-friendly LCD Display to indicate all important UPS parameters such as Input Voltage, Output Voltage, Battery Level and Load Level shall be provided.

The UPS system shall consist of the following modular architecture

ARCHITECTURE

Scalable array Infrastructure:

The system power train shall be comprised of 500 kVA power modules and shall be capable of being configured for N+X redundant operation at the rated i.e. 500KVA system load. This 500kVA systems shall be capable of paralleling with similar rating system to form a bus of 1.5 MW. This 1.5MW system should be load bus synchronous to a similar rating bus. These 2 nos. 1.5 MW bus shall form 2 sources (A & B) required. The architecture should have the flexibility of adding this 500KVA power modules without the need of any external cabling of addition of panels.

B. Module Management:

The modular UPS shall offer the ability to scale its capacity and/or redundancy by automatically shifting load to fewer power modules. The UPS shall provide an Module Management System, which will control the UPS to selectively place unnecessary modules in the “mode” based on the sensed output load level. This is in order to drive the load higher on the remaining modules. Therefore, with multiple modules, a UPS shall achieve 2-3% higher efficiencies than conventional operation when loaded less than 50% of system rating.

In case of instantaneous addition of full load on the bus this modules should assume load without any interruption to the total load.

C. EcoMode:

In bypass operation, an even higher operating efficiency may be achieved without sacrificing protection when there are good power conditions. Depending on configuration, efficiency can exceed 99%.The load remains in bypass mode until the input voltage exceeds tolerance levels, and then enters full protection mode. This setting is disabled by default and can be configured using the display. UPS should be capable of operating in ECOMODE even when they are paralleled to form 1MW bus.

E. Concurrent maintenance:

Any redundant internal module can be concurrently isolated and serviced (by factory-trained service engineers) while the other internal module/s continues to provide protected power to the load.

F. Load Test at Site:

UPS should have the ability to perform a full load test in double conversion mode without the connection of a load bank.

5. MODES OF OPERATION :

Each UPS shall have a rating of ____KVA (Rating to be Designed by Contractor) for all the facilities mentioned above and shall be **DUAL REDUNDANT** and shall be made up of the following components, described in detail in this specification:

1. rectifier
2. battery charger
3. inverter
4. battery
5. automatic bypass (via a static switch)
6. user and communications interface
7. Individual battery management system.
8. any and all other devices required for safe operation and maintenance, including circuit breakers, switches, etc.

Battery:

Upon failure of the commercial AC power, the critical load shall continue to be supplied by the Inverter, which shall obtain power from the batteries without any operator intervention.

There shall be no interruption to the critical load upon failure or restoration of the commercial AC source. Each module or system of 500kVA shall have its own Batteries to meet the autonomy time requirement.

Recharge:

Upon restoration of the AC source, the Charger shall recharge the batteries and simultaneously the Rectifier shall provide power to the Inverter. This shall be an automatic function and shall cause no interruption to the critical load.

Bypass:

If the module must be taken out of the standard double conversion mode for overload, load fault, or internal failures, the static bypass switch shall automatically transfer the critical load to the commercial AC power. Return from Bypass mode to Normal mode of operation shall be automatic. No-break transfer to and from Bypass mode shall be capable of being initiated manually from the front panel.

Input Current Total Harmonic Distortion:

The input current THDI shall be held to less than 5 percent at system load greater than 50 percent while providing conditioned power to the critical load bus, and charging the batteries under steady-state operating conditions. This shall be true while supporting both a linear or non-linear load. This shall be accomplished without the requirement for additional or optional filters, magnetic devices, or other components.

Soft-Start Operation:

As a standard feature, the UPS shall contain soft-start functionality, capable of limiting the input current from 0 percent to 100 percent of the nominal input over a default 10 second period, when returning to the AC utility source from battery operation. The change in current over the change in time shall take place in a linear manner throughout the entire operation.

Magnetization Inrush Current:

The UPS shall exhibit zero inrush current.

SYSTEM CHARACTERISTICS:

A. UPS output in standard double conversion mode

1. 415V, 3-phase, 4 wire plus ground. Output wiring configuration is based upon input wiring configuration for systems without internal transformers.
2. Steady-state voltage regulation (in inverter) shall be within +/- 1% average from nominal output voltage.
3. Transient voltage response shall be < +/- 5% from nominal voltage for load step from 10% to 100%.
4. Linear load harmonic distortion capability: Output voltage THD of less than 2% for 100% linear load.
5. Non-linear load harmonic distortion capability: Output voltage THD of less than 5% for 100% non-linear load when tested using the non-linear load described in IEC 62040-3.
6. Manual output voltage adjustment shall be +/- 3% from nominal.
7. Line synchronization range shall be +/- 3Hz, adjustable to +/- 0.5Hz.
8. Frequency regulation shall be +/- 0.1Hz free running.
9. Frequency slew rate shall be adjustable up to 0.7 Hz/second maximum.
10. Phase angle control:
 - a) Balanced linear load shall be +/- 1 degree from nominal 120 degrees
 - b) Unbalanced linear loads shall be less than +/- 3 degrees from average phase voltage for 100% load unbalance.
11. Phase voltage control:
 - a) Balanced linear loads shall be +/- 1% from average phase voltage

b) Unbalanced linear loads shall be less than +/- 5% for 100% load unbalanced

12. Overload current capability (with nominal line and fully charged battery): The unit shall operate with up to 110% of resistive/inductive load for 10 minutes, up to 125% for 30 seconds, and up to 150% for 10 seconds.

13. Fault clearing current capability: 1000% RMS for 20ms., 600% for 50 ms. With bypass intervention. Inverter 200% phase-to-phase for 10 cycles;

14. Static transfer time: No break, completed in less than 4ms.

15. Acoustical noise: Noise generated by the UPS under normal operation shall not exceed 85dB(A) at one meter from any operator surface, measured at 25 degrees C (77 degrees F) and full load, per ISO7779 standard..

16. EMC Suppression: The UPS shall meet IEC 62040-2, Category C3.

17. Electrostatic discharge (ESD): The UPS shall meet EN61000-4-2 level 3.

18. Efficiency: The UPS efficiency shall be up to 94,5%. If UPS requires input filters for controlling input THD, manufacturer shall state efficiency of UPS with input filters connected.

Battery management system:

The UPS shall contain a battery management system which has the following features:

1. The battery management system shall provide battery time remaining while operating in normal mode and battery mode. Battery time available information shall be displayed real-time, even under changing load conditions. Upon commissioning, battery runtime information shall be available.

2. The battery management system shall automatically test the battery string(s) to ensure that the battery is capable of providing greater than 80% of its rated capacity. Testing the batteries shall not jeopardize the operation of the critical load. Upon detection of the battery string(s) not capable of providing 80%, the UPS system will alarm that the battery needs attention/replacement. The battery test shall be able to detect the following:

a. Open battery string

b. Shorted battery string

c. Battery capacity (runtime) less than 80% of "new" battery capacity

3. The UPS shall communicate battery test and monitoring data to the UPS

manufacturer's remote monitoring site. Battery life remaining, capacity, and number of on-battery events shall be provided in a monthly report.

4. An optional temperature sensor shall be available to monitor the ambient temperature internal to the battery cabinet. If the ambient temperature increases, the UPS system charger shall automatically reduce the charging voltage to a level recommended by the battery manufacturer. If the ambient temperature is decreased the UPS shall automatically increase the battery charge voltage to that recommended by the battery manufacturer.**UPS MODULE CABINET**

The UPS Module Cabinet shall consist of a rectifier / charger, a three-phase inverter, static transfer switch, maintenance bypass switch , logic, synchronizing equipment, protective devices, and accessories as required for proper operation.

RECTIFIER / CHARGER UNIT

- a) The rectifier / charger unit shall be solid state and shall provide direct current to the inverter unit and for battery charging.
- b) An input AC filter shall be incorporated into the rectifier / charger unit. The filter is not to be add-on in front of the rectifier / charger. This filter is to reduce the current harmonics feedback into the input AC line to no more than 10%. The filter is to also improve the input power factor so that it is no more lagging than 0.95.
- c) The rectifier / charger unit shall provide for input current limiting whereby the maximum input current shall be limited to 125% of the full input current rating. This current limit shall be in effect, no matter whether the load is connected to the UPS module or the static transfer switch. That is, if the static transfer switch is supplying full rated load, then the rectifier / charger must limit the battery recharging to 25%. Further more, if the load is connected to the maintenance bypass line, the rectifier / charger input current must automatically reduce to 25%.
- d) The rectifier / charger unit shall provide features whereby when the AC power is returned after the UPS has been operating on battery power or has been de- energized, the total initial power requirement at the input terminals will not exceed 20% of rated load, and the power will gradually increase to 100% of full rating over the 15 second time interval. The unit shall be provided with an internal switch so that walk-in time can be changed from 2 seconds to 15 seconds.
- e) IGBTs in the rectifier / charger shall be fused with fast acting fuses, so that loss of any one power semiconductor will not cause cascading failures. All fuses shall be provided with a blown fuse indicator with an alarm indicator on the control panel.
- f) The rectifier / charger unit shall have an output filter to minimize ripple voltage into the battery. Under no conditions shall ripple voltage into the battery exceed 2% RMS. The filter shall be adequate to insure that the DC output of the rectifier/ charger will meet the input requirements of the inverter.
- g) The rectifier unit shall be designed to boost charge the completely discharged batteries in 10 to 14 hours. The changeover between boost charger mode and float charge mode shall be affected manually/automatically.. Necessary alarms to indicate battery discharged and D.C. over voltage conditions shall be provided. Selector switch shall be provided for selecting the float charge or boost charge mode.
- h) There shall be DC overvoltage protection so that if the DC voltage rises to the pre- set limit, the UPS module is to shut down automatically and the load is to be transferred to the static bypass line uninterrupted.
- i) To prevent battery damage from over-discharging at light load, the rectifier / charger is to automatically raise the shutdown voltage set point as the load is reduced. The shutdown set point

is to increase linearly from minimum to 1.75 volts per cell as the discharge time increases from 15 minutes to one hour.

j) The output voltage of the rectifier / charger unit shall be as follows:

Float mode : Variable 115 - 130V DC or 230 - 260V DC Boost mode : Variable 125 - 145V DC or 250 - 290V DC

INVERTER UNIT

a) Advanced PWM Inverter with Precision Control Circuitry using High Performance IGBT Power Stage. The output shall be Pure Sine-wave output with less than 3% THD. Exceptional reliability, superior performance, Quite operation with very high reliability and efficiency shall be the key characteristics.

b) The inverter unit shall be a solid state device capable of accepting the output of the rectifier / charger or the unregulated voltage of the battery and provide regulated rated AC output within specified limits.

c) The output frequency of the inverter shall be controlled by an oscillator. The oscillator shall be temperature compensated and be adjustable +5% of rated frequency. The oscillator shall hold the inverter output frequency to +0.1% for both steady state and transient conditions. Drift shall not exceed +0.1% during a 24 hour period. Total frequency deviation, including short time fluctuations and drift, shall not exceed +0.1% from the rated frequency.

d) The inverter output shall stay synchronized with the static bypass line provided the static bypass line remains within +3 Hz of the nominal frequency. If the line frequency goes outside these limits, the inverter is to break sync with the line and run on its internal frequency. When the line frequency returns, within limits, the inverter output is to automatically re-synchronize with the line. The rate of change of frequency is not to exceed 0.1 Hz per second. The unit shall be provided with an internal switch so that the synchronizing frequency range can be changed from +3 Hz to +1 Hz or to +0.5 Hz.

e) The inverter shall be able to sustain an overload across its output terminals up to 150% load, while supplying any load within its rating, without reducing the output voltage. Loads greater than 150% shall be transferred to the static bypass line.

f) The inverter, with the static bypass line disabled, shall current limit at 150% rated current at reduced voltage for any loading over 150% rate load. The inverter shall be capable of at least 300% current for short circuit conditions. If the short circuit is sustained, the inverter shall shut down and disconnect automatically from the critical load bus.

g) The inverter unit shall be designed to operate from the rectifier output without use of battery smoothing effect. With the battery connected to the UPS system, a filter shall be provided at the input of inverter unit to reduce the A.C. Feedback from the inverter to the battery to a maximum of 2% of the battery AH capacity.

h) The inverter unit shall be designed to operate with 93V to 145V DC or 186V to 290V DC at the terminals of inverter input filter. The output inverter voltage shall be stabilised to within +2% of the nominal output voltage with a load variation of 0 - 100% at 0.6 power factor (lagging).

During step loading of 100%. The system voltage dip shall not exceed 15% and output voltage shall recover to within + 3% of the nominal output voltage within 10 cycles (200 m sec.)

- i) The inverter voltage regulator is to regulate each phase so that an unbalance loading will not cause the output voltage to go outside the specified voltage unbalance or phase displacement.
- j) An output AC filter shall be incorporated in the inverter unit. The filter shall reduce the inverter output voltage harmonics to 5% RMS total and single harmonics to 3% RMS for linear loads.
- k) Power semi-conductors in the inverter unit shall be fused with fast acting fuses, so that loss of any one power semiconductor will not cause cascading failures. All fuses shall be provided with a blown fuse indicator with an alarm indicator on the control panel.

STATIC TRANSFER SWITCH

- a) The Static Transfer Switch, using solid state devices, shall be provided to transfer the load between the UPS module and the static bypass line uninterrupted. Automatic static load transfers are to be initiated when a system overload is greater than specified here, a branch load circuit faults or a fault within the UPS module occurs.
- b) For Auto or Manual operation of Static transfer Switch Load should not suffer.
- c) If the static transfer was caused by an overload or branch fault and this condition was rectified, then the static transfer switch is to automatically re-transfer the load to the UPS module.
- d) The static transfer switch shall be sized to provide 125% rated load continuously. The switch shall also have an overload rating of 2000% rated load for two cycles.
- e) Any time the load is on the static bypass line, the control panel shall indicate so. The audible alarm is to sound only after a ten-second delay. If the transfer was due to a momentary overload and automatically re-transferred back to the UPS module after the overload was removed, the alarm and indicator are to automatically reset.
- f) This Static Bypass Operation in any Case should not cause any interruption to the load.

MAINTENANCE BYPASS SWITCH

- a) A manually operated maintenance bypass switch is to be incorporated into the UPS module cabinet that will connect the load to the input AC power source bypassing the rectifier / charger, inverter, and static transfer switch.
- b) All energized terminals shall be shielded to ensure that maintenance personnel do not inadvertently come in contact with energized parts or terminals. A means to de- energize the static switch shall be provided when the UPS is in the maintenance bypass mode of operation.

- c) While the load is on the maintenance bypass line, it shall be possible to check out the operation of the rectifier / charger, inverter, and static transfer switch. It shall also be possible to check the battery operation.

BATTERY

A Battery system shall be furnished for the UPS with sufficient capacity to maintain UPS output at the specified load for a duration of minimum 15 minutes. The type of battery shall Maintenance-free, Valve-regulated type. A minimum of 10 years warranty for performance of declared parameters within permissible limits shall be provided.

CONTROLS AND INDICATORS

- A. Microprocessor controlled circuitry: The UPS controls shall have the following design and operating characteristics:

1.Fully automatic operation of the UPS shall be provided through the use of microprocessor controlled Digital Signal Processing. DSP shall eliminate variances from component tolerance or drift, and provide consistent operational responses.

2.All operating and protection parameters shall be firmware controlled, thus eliminating a need for manual adjustments. The logic shall include system test capability to facilitate maintenance and troubleshooting. Printed circuit board replacement shall be possible without requiring calibration.

3.Start-up and transfers shall be automatic functions.

- B. Digital Front Panel Display: The UPS control panel shall be a digital front panel display that features an 8x40 (8 lines, each with 40 characters) backlit LCD display. The LCD shall display UPS status, metering, battery status, alarm/event queue, active alarms and UPS configurations. The front panel display shall show a system mimic diagram with an outlined power path, current operating mode and event logs.

- C. Control Panel Indicators: The UPS control panel shall provide the following monitoring functions with indicator LED's:

NORMAL: This shall indicate that the commercial AC utility or generator source is supplying power to the rectifier and the inverter is supporting the critical load. A text message shall indicate if the bypass line is not within tolerance.

BYPASS: This shall indicate that the UPS has transferred the load to the bypass circuit.

BATTERY: This shall indicate that the commercial AC utility or generator source has failed and the battery is supplying power to the inverter, which is supporting the load. A text message shall indicate if the battery charge is low or if the battery is installed but disconnected.

ALARM: This shall indicate that the UPS detects an alarm condition, outlined in detail in the operator's manual.

- D. Control Panel Controls: The UPS control panel shall provide the following functions from front panel push buttons:
- E. EVENTS: Displays the list of Active System Events and a historical log of system events. Historical logs shall include a detailed time stamped list of the latest 128 events.
- F. METERS: Displays performance meters for the system or critical load. When selected, the front display shall show individual screens of input parameters, output parameters or bypass parameters including; voltage, current and frequency. In addition, the battery display shall show runtime remaining.
- G. CONTROLS: Displays a System Controls screen. Allows selection of operating mode, normal, bypass, charger on/off and Power Module on/off.
- H. SETUP: Allows display contrast, date and time information serial communication port configuration and display of firmware revision numbers.
- I. RETURN: Confirms selection or returns to previous screen.

Interface panel: The UPS shall be equipped with an interface panel, located behind a protective cover, which provides the following signals and communication features in a Class 2 environment:

Alarm contact: A dry contact for annunciating a summary alarm shall be provided for customer use. This contact shall be Form "C" capable of supplying both N/O and N/C contacts. Contact ratings shall be 5A max at a voltage not to exceed 28VDC or 30VAC.

RS232 (EIA / TIA-232) communications interface: Circuitry shall be provided for one RS232 (EIA / TIA-232) communication port for connection to automated service department diagnostic tools. This port may be used with simple ("dumb") terminals to gain remote access to all unit operation information.

Building alarms: Two inputs shall be provided for monitoring the status of external dry contacts. Building alarms shall be set up through the UPS configuration mode function on the RS232 (EIA / TIA-232) port.

External EPO contacts: Shall be provided to connect an external remote emergency power off switch to shutdown the UPS and de-energize the critical load.

Battery control contacts: Contacts shall be provided to connect the battery shunt trip and auxiliary signals from a battery breaker or battery disconnect switch.

External bypass indicator connection: A connection point shall be provided to acknowledge that an external maintenance bypass has been closed around the UPS, placing the critical load on utility power.

The system shall have options to add four (4) additional building alarms, 384 logged events, 4 additional languages, Mandarin or Russian as a primary language.

CABINET

All the cells making up the Battery shall be installed in a free-standing cabinet, that is, of the same constructions as the UPS module cabinet. The cabinets shall be of the same height and depth.

Each cell is to be held in place to prevent movement during seismic motion.

Connectors are to be used so that the battery can be disconnected in no more than 42 volt sections.

BATTERY DISCONNECT CIRCUIT BREAKER

The UPS Module shall have a Battery Circuit Breaker. This circuit breaker is to be mounted in the battery cabinet. When open, there shall be no battery voltage present in the UPS

module cabinet. The UPS module shall be automatically disconnected when the battery reaches the minimum discharge voltage level or when signalled by other control functions.

MIMIC PANEL

The Mimic Panel is to depict a single line diagram of the UPS. Indicating Lights shall be integrated with the single line diagram to illustrate the status of the UPS power paths. The functions whose status are to be displayed shall include, but not be limited to, the following:

- a) Input power available
- b) Output power available
- c) Normal operation
- d) Bypass operation

COMMUNICATIONS

A. Communications Bay: The UPS shall be equipped with field configurable communications bays that will accommodate four (4) communication devices.

B. Remote Monitoring:

1. Optional WEB/SNMP communication capabilities will be available for all systems.
2. The UPS shall be able to be monitored remotely via communications devices. UPS manufacturer shall provide optional communications devices capable of communicating via various industry standard protocols such as RS232 and ModBus. Monitoring of UPS status may also be performed through isolated dry contact Form C relays.
3. Remote monitoring of the UPS shall also be possible through status indicators elsewhere in the same facility through a device that replicates these indicators.

The UPS communication capability should be able to integrate into any industry standard Building Management System (BMS) and/or Network Management System (NMS). The UPS must also be able to be monitored via any standard Internet browser (i.e. Internet Explorer and Netscape).

All optional hardware interfaces shall be “Hot-swappable” (UPS maintains power to critical applications while changing interfaces).

Shutdown:

1. There shall be a mechanism that provides graceful, orderly, unattended, sequential shutdown of one or multiple computers powered by one UPS. This shutdown shall be performed via in-network or out-of-network means. The order of shutdown shall be user-defined, allowing the maximization of runtime on battery for more critical systems.
2. Shutdown of AS/400 computers shall be possible through open-collector relay contacts or isolated, dry contact, Form-C relays.
3. The UPS shall also be capable of interfacing with an operating system’s built-in shutdown routine, e.g. Windows NT. This shall be done through a cable connection to the optional serial port on the UPS.

Notification:

1. There shall be a mechanism to send alerts to key personnel via email or SNMP traps. An alarm notification may also be sent by a network message.
2. Dial-out to a computer for alarm notification may be performed. The user may respond by dialing-in to retrieve alarm history and a summary of current meter status.
3. Management: A remote battery test may be performed via an Ethernet network. The UPS shall be tested through invoking a single command.

INSTRUMENT, INDICATIONS AND ANNUNCIATIONS

Following along with described above shall be provided on the system

Charger Panel

AC Line Voltage (with a selector switch) AC Line Current (with a selector switch) Charger Output Voltage (each)

Charger Output Current

Battery Current (charging / discharging current) BB Inverter Panel

DC Input Current

Standby Transformer Secondary Voltage UPS Output Voltage

UPS Current

Power Factor Meter Frequency Meter

Following indications lamps shall be provided

Charger Panel AC mains ON (3 Lamps) Battery on Float

Battery on Boost

Inverter Panel Battery Output ON Inverter - I Feeding

Inverter - II Feeding (Only for redundant system) Standby Supply ON

Load on Bypass Mains Synchronised

Audio-Visual Alarm shall be provided for the following complete with 'ACCEPT', 'RESET' and 'TEST' facilities.

Charger Panel

- a) Mains Undervoltage / Single Phasing
 - b) Charger Failure / SCR Fuse Failure
 - c) Reverse Polarity on DC Bus
 - d) Cooling Fan Tripped (common for all fans)
 - e) Battery Discharged
 - f) DC Over-Voltage
 - g) Battery Earth Fault BB) Inverter Panel
- a) DC Input Failure
 - b) Inverter - I Output Trouble

CONSTRUCTION

- a) Rectifier / Charger and Inverter sections shall be housed in separate panels and shall be complete with all interconnections. The panels shall be fabricated with 1.6/2 mm thick cold rolled sheet steel and structural steel. The panels shall be free-standing. Verminproof fitted with suitable louvers for ventilation and cooling fan. Hinged doors shall be provided at the front and back where required, with dust tight gaskets. Interpanel sheet steel barriers shall be used. The enclosure shall be IP-51 (NEMA- IA).
- b) Power cables shall be with aluminium / copper conductor as specified in SLD. Control cables shall be with copper conductors. All Cable connections shall be from bottom and from the front of the panel. At the bottom of the panels, a removable bolted gland plate shall be provided with double compression type cable glands fitted to it for external cable connections. Clamp type terminals shall be used for connection of all wires upto 10 mm² and terminals for larger size shall be bolted type suitable for cable lugs.
- c) Busbars shall be colour coded and live parts shall be properly shrouded to ensure complete safety to personnel intending routine inspection by opening the panel doors. All equipment inside the panel and on door shall have suitable nameplates and device number as per the schematic diagram.
- d) All fuses shall be link type with HRC links and mounted inside the panel. All power and control switches shall be mounted on the door operable externally and shall be rotary type. Space heaters and 100W incandescent lamps shall be provided in each panel. All instruments shall be switchboard type, back connected, 96 x 96 mm square of own manufacturers make. Scale shall have a red mark indicating maximum permissible

operating rating. Test terminals shall be provided on a separate rail for measuring and testing of equipment to check the performance.

- e) A suitably sized earth bus shall be provided at the bottom of the panels with provision for earth connection at both ends to IITM's main earth grid. Suitable earthing of potential-free metallic parts of various equipment shall be done to ensure safety.
- f) All metal parts shall be treated so as to ensure efficient anti-corrosive protection. Hardware shall be zinc passivated or electro galvanised. Panel enclosure and structure supports shall be thoroughly cleaned and degreased to remove mill scale and rust, etc. External surface shall be prepared for final painting with Manufacturer's standard colour code.

MECHANICAL DESIGN

- A. Ventilation: The UPS shall be designed for forced-air cooling. Air inlets shall be on the front of the unit. Air outlets shall be on the top. Eighteen inches of clearance over the UPS outlets shall be required for proper air circulation. .
- B. No back or side clearance or access shall be required for the system. The back and side enclosure covers shall be capable of being located directly adjacent to a wall.
- C. Cable entry: Standard cable entry for the UPS cabinet shall be through either the enclosure bottom or top. A dedicated wireway shall be provided within the UPS cabinet for routing user input and output wiring.
- D. Front access: All serviceable sub assemblies shall be modular and capable of being replaced from the front of the UPS (front access only required). Side or rear access for installation, service, repair or maintenance of the UPS system shall not be required.
- E. Service area requirements: The system shall require no more than 915 mm of front service access room and shall not require side or rear access for service or installation.

EQUIPMENT DETAILS

All materials and parts comprising the UPS shall be new, of current manufacture, of a high grade and free from all defects and imperfections and shall not have been in prior service, except as required during factory testing.

All active electronic devices shall be solid state. All semiconductor devices shall be hermetically sealed. All relays shall be dust tight.

The maximum working voltage, current and di/dt of all solid state power components and electronic devices, shall not exceed 75% of the ratings established by their manufacturer. The operating temperature of solid state component cases shall not be greater than 75% of their ratings. Electrolytic capacitors shall be computer grade and be operated at no more than 90% of their voltage rating.

WIRING

- a) Access holes with cover plates are to be provided on top and bottom of the UPS and battery cabinets for inter-cabinet wiring and customer installation wiring.
- b) Wiring practices, materials and coding shall be in accordance with the requirements of the National Electrical Code, OSHA and applicable local codes and standards.
- c) All bolted connections of bus bars, lugs and cables shall be in accordance with requirements of the National Electric Code and other applicable standards. All electrical power connections are to be torqued to the required value and marked.

VENTILATION

Adequate ventilation shall be provided to insure that all components are operated within their environmental ratings. All fans are to be equipped with wind vane sensors connected to an alarm on the module control panel.

Temperature sensors shall be provided to monitor temperature of critical components. Upon detection of temperatures in excess of component manufacturer's recommended ambient working temperature, the sensors shall cause audible and visual alarms to be sounded on the module control panel.

Forced ventilation if provided by means of fans shall have 100% redundancy.

If redundancy is not provided then it shall be possible to run the system at rated load for half hour and at reduced load (about 75%) continuously without any damage to the system.

ENVIRONMENTAL REQUIREMENTS

- A. The UPS shall withstand any combination of the following external environmental conditions without operational degradation.
 - 1. Operating Temperature: 0 degrees C to + 40 degrees C (32 degrees F to 104 degrees F) no derating is required within this range (excluding batteries).
 - 2. Storage Temperature: - 25 degrees C to + 60 degrees C (-13 degrees F to 140 degrees F). Prolonged storage above + 40 degrees C (104 degrees F) will cause rapid battery self-discharge.
 - 3. Relative Humidity (operating and storage): 95% maximum non-condensing.
 - 4. Elevation:
 - 1. Operational: 1000 meters above sea level at 40 C maximum. Above this level altitude de-rating as per EN62040-3.
 - 2. Transportation: Capable of air transport, excluding batteries.

UPS PROTECTION

- A. Rectifier/Charger and Bypass protection shall be provided through fusing.

- B. Battery protection shall be provided by thermal-magnetic molded-case circuit breakers in each battery cabinet (if standard battery pack is provided) or external protective device for an external battery.
- C. Electronic current limiting circuitry and fuses in the Inverter circuit shall provide output protection. To comply with agency safety requirements, the UPS shall not rely upon any disconnect devices outside of the UPS to isolate the battery cabinet from the UPS.
- D. To comply with agency safety requirements, the UPS shall not rely upon any disconnect devices outside of the UPS to isolate the battery cabinet from the UPS.

SPARES

Vendor shall recommend and provide spare parts needed for start-up and two years operation. Recommended spares should take into account related factors like equipment reliability, effect of equipment downtime upon production and safety, cost of and availability of equipment service facilities.

All spare parts furnished by vendor shall be wrapped and packed so that they will be presented in original as new condition under the normal conditions of storage to be anticipated and shall be properly taped and coded so that later identification as to intended equipment usage will be facilitated. They shall be packaged separately, clearly marked as spare parts and shipped at the same time as the equipment. Packing list shall be furnished so that the parts can be handled without uncrating, if desired.

INSPECTION & TESTING

The Battery shall be subject to inspection by Client's representative. Manufacturer shall furnish to inspectors all requested information concerning the supply.

Battery shall be tested as per relevant IS and test certificates shall be furnished before despatch.

The UPS System will be tested in the presence of ENGINEER's representative.

The following tests shall apply:

1. Full load heat run for eight hours (unit rate to be furnished separately).
2. Current forcing test.
3. Recording of time for mains to inverter changeover and vice-versa.
4. Recording of 1/2 load change transient.
5. Recording of full load change transient.

Functional Tests.

Detailed inspection will be performed to ascertain that the data sheet and other contractual aspect are complied with the earthing system must be inspected for robustness and continuity.

QAP plan needs to be submitted before inspection for approval .

SAFETY

The UPS shall be compliant with IEC 62040-1.

DRAWINGS

The Manufacturer shall Supply Drawings & documents to the satisfaction of the client in 6 sets. All drawing to be submitted in Auto CAD format only.

SUBMITTALS

A.The UPS shall be supplied with sufficient documentation, including the following manuals:

1. Installation and Operation Manual: One copy of the installation and operation manual shall be furnished. It shall possess sufficient detail and clarity to enable the owner's technicians or representatives to install and operate the UPS equipment and accessories. The manual shall include the following major items:

- a) UPS description
- b) UPS site planning and unpacking
- c) UPS installation
- d) Optional accessory installation
- e) UPS theory of operation
- f) Operating procedures
- g) System events
- h) UPS maintenance
- i) Performance and technical specifications
- j) Wiring requirements and recommendations
- k) Physical features and requirements Cabinet dimensions

DATASHEET- The Manufacturer shall Supply Drawings & Technical User Guide Documents to the satisfaction of the ENGINEER in 6 sets.

INSTALLATION

- A. Install in accordance with manufacturer's instructions.

COMMISSIONING

- A. UPS manufacturer shall offer the following optional services:
 - 1. Pre-energize visit to inspect installation and provide guidance to installers as required.
 - 2. Post-start-up visit for alarm notification configuration, operator training, etc.

B. The following procedures and tests shall be performed by Field Service personnel during the UPS startup:

1. Visual Inspection:

- a) Visually inspect all equipment for signs of damage or foreign materials.
- b) Observe the type of ventilation, the cleanliness of the room, the use of proper signs, and any other safety related factors.

2. Mechanical Inspection:

- a) Check all the power connections for tightness.
- b) Check all the control wiring terminations and plugs for tightness or proper seating.

3. Electrical Pre-check:

- a) Check the DC bus for a possible short circuit.
- b) Check input and Bypass power for proper voltages and phase rotation.
- c) Check all lamp test functions.

4. Initial UPS Startup:

- a) Verify that all the alarms are in a “go” condition.
- b) Energize the UPS module and verify the proper DC, walkup, and AC phase on.
- c) Check the DC link holding voltage, AC output voltages, and output waveforms.
- d) Check the final DC link voltage and Inverter AC output. Adjust if required.
- e) Check for the proper synchronization.
- f) Check for the voltage difference between the Inverter output and the Bypass source.

5. Operational Training: Before leaving the site, the field service engineer shall familiarize responsible personnel with the operation of the UPS. The UPS equipment shall be available for demonstration of the modes of operation.

QUALIFICATIONS

- A. The UPS manufacturer shall have a minimum of fifteen years experience in the design, manufacture and testing of solid-state UPS systems.
- B. The UPS manufacturer shall have ISO 9001 certification for engineering/R&D, manufacturing facilities and service organization.
- C. The UPS manufacturer shall maintain a staffed 7x24x365 call center for technical and emergency support.
- D. Field Engineering Support: The UPS manufacturer shall directly employ a nationwide field service department staffed by factory-trained field service engineers dedicated to startup, maintenance, and repair of UPS equipment. The

organization shall consist of local offices managed from a central location. Field engineers shall be deployed in key population areas to provide on-site emergency response within 24 hours. A map showing the location of all field service offices must be submitted with the proposal. Third-party maintenance will not be accepted.

- E. Spare Parts Support: Parts supplies shall be located in the field to provide 80% of all emergency needs. The factory shall serve as the central stocking facility where a dedicated supply of all parts shall be available within 24 hours.
- F. Product Enhancement Program: The UPS manufacturer shall make available feature upgrade service offerings to all users as they are developed. These upgrades shall be available as optional field-installable kits.
- G. Maintenance Contracts: A complete range of preventative and corrective maintenance contracts shall be provided and offered with the proposal. Under these contracts, the manufacturer shall maintain the user's equipment to the latest factory revisions.

TO BE FILLED BY UPS VENDOR.

Sr. No	Description	Requirement
--------	-------------	-------------

Vendor to Specify the UPS KVA ratings for the following facilities :

1. 230/110/11kV GIS Substation / Control Room
2. Administration Building
3. Sea Water Intake Building
4. Pre Treatment Building
5. RO Building 1
6. RO Building 2
7. Post Treatment Building
8. Water Storage Building

1.0 **MODEL** please specify

1.1 **TECHNOLOGY** IGBT Rectifier & IGBT Inverter, Microprocessor based, true online double conversion, Online Transformer free Technology

1.2 Inverter IGBT

1.3 Rectifier IGBT

1.4	Max. Permissible Non-linear loads	100%
1.5	Max. unbalanced load	100%
2.0 PHYSICAL Dimension & Weight		
2.1	Construction	Compact. Modular design
2.2	UPS Floor Space	Each UPS Floor space should not exceed 1.26 Sq meter
2.2	Ventilation	Specify
2.3	UPS Dimension & weight	
	Length in MM	Specify
	Width in MM	Specify
	Height in MM	Specify
	Weight in kgs	Specify
2.4	Battery Bank (Dimension and weight)	
	Length in MM	Specify
	Width in MM	Specify
	Height in MM	Specify
	Weight in kgs	Specify
	Accessibility (front & back with clear Dimension to be specified)	Specify
	Cable connection Bottom for Input & Output.	Specify
	Parallel Configuration upto no of Module .	no required
	DG Set Sizing No of time of UPS Module	Specify.
	& Minimum Size of DG set Required	Specify
	Minimum Input circuit breaker required to be specified	Specify
3 INPUT		
3.1	Voltage	415V
3.2	Voltage range	340 to 460V
3.3	Frequency	50 Hz
3.4	Frequency range	+/- 5 Hz
3.5	Ripple content	<1% with battery connected

3.7 Input Power Factor

100% 0.99

75% 0.99

50% 0.99

25% 0.98

3.8 Current Harmonic on source

100% <3%

75% <5%

50% <5%

25% <10%

3.9 Maximum current with out Battery Charging Amps

4 OUTPUT

4.1 Voltage 415 V

4.2 KW

4.3 Voltage regulation

Balanced +/- 1%, 3 Ph. + N

Un Balanced +/- 3%, 3 Ph. + N

4.4 Power Factor 0.8lag - unity- 0.9 lead (Derating of UPS not acceptable in this range)

4.5 Frequency 50Hz

4.6 Frequency range +/- 0.5 Hz

4.7 Frequency synch. range 0.25 to 3 Hz

4.8 Transient output voltage variation for 100% block loading +/-2%

4.9 Recovery time for 100% block load < 5 mill second (ms)

4.10 Wave form Sinusoidal

4.11 Total Voltage Distortion out put side

Linear load < 2 %

Non-Linear load < 3 %

4.12 Crest Factor 3:1

4.13 Phase Displacement

	a) Balanced load	120 +/- 0.65°
	b) 100 % Unbalanced load	120 +/- 2°
4.14	Inverter Efficiency	
	c) 100 %	Specify
4.15	Overall Efficiency for UPS	
	b) 50 %	91%
	c) 75 %	91%
	d) 100 %	92%
4.16	Efficiency of UPS in Battery Operations	
	b) 50 %	
	c) 75 %	
	d) 100 %	
4.17	Overload	
	a) 125 %	10 minutes
	b) 150 %	30 Sec
4.18	Short circuit Capability	Vendor to Specify

5	BUILT IN STATIC BYPASS	Required
5.1	Inverter and Static Bypass change over time	Specify
5.2	Fuse @ static bypass	No. as per IEEE standards.
5.3	Short circuit Capability	Vendor to Specify
5.4	Overload	Specify
5.5	Transfer time	Less than 5 milli secs.
5.6	Manual Bypass inside ups only(input/output)	Required

6	DC CHARACTERISTIC	
	Battery backup to be calculated at .9 pf.	
6.1	VAH	>43200
6.1	DC bus voltage	Specify
6.2	DC Current	Specify
6.3	No. of cells with AH	Specify
6.4	battery voltage	Specify

6.5	End Cell voltage	1.75
6.6	Float voltage	specify
6.7	DC current at 100% load	specify
6.8	Charging current	specify
6.9	Charging time 10 Hrs. max.	
6.10	True autonomy / measurement	Software on SNMP & UPS monitor panel
6.11	Temp. compensated charger	Required/ Mandatory
6.12	Automatic battery load test	Required/ Mandatory
6.13	Batt. Breaker with protection Required Battery Back Up	Required/ Mandatory 15 Minutes

7 PROTECTION

7.1	Overload (O/L)	Required
7.2	Short circuit (SC)	Required
7.3	Input low voltage	Required
7.4	Output over voltage	Required
7.5	Battery over charging	Required
7.6	Battery over discharging	Required
7.7	IP Protection	
7.8	DC over current Protection	

8 ENVIRONMENTAL

8.1	Ambient temperature range	0 to 40° C
8.1	Relative humidity	95 % RH
8.2	Max. operating altitude without derating	1000 M above MSL
8.3	Acoustic Noise	65db (Specify)

9 AUDIO / VISUAL DISPLAY

9.1	Over load	Required
9.2	Short circuit	Required
9.3	Input low voltage	Required

9.4	Input over voltage	Required
9.5	Battery over discharging	Required
9.6	Battery on load	Required
9.7	Battery low	Required
9.8	Fuse failure	Required
9.9	Fan failure	Required
9.10	Inverter failure	Required
9.11	DC over voltage	Required

10 VISUAL DISPLAY

10.1	Input/Output voltage	Required
10.2	Output current .	Required
10.3	Input/ Output frequency	Required
10.4	Output power in KVA and KW	Required
10.5	Output load power factor	Required
10.6	Output load crest factor	Required
10.7	battery DC voltage	Required
10.8	Charging current	Required
10.9	Dis-Charging Current	Required
10.10	Autonomy Time	Required
10.11	Event logs	2500 events mandatory

11 OTHERS

11.1	Software with LAN connect	Required
11.2	Auto paging	Required
11.3	SNMP compatibility	Required
11.4	Diagnostic system	Required
11.5	Single line mimic diagram	Required
11.6	Telemonitoring with software	Required- Mandatory
11.7	Capablity to parallel 6 similar UPS systems	Not required
11.8	ventilation	forced air cooling with integral fans

- 11.9 Operatating temperature 0-45deg.C
11.10 Battery management required
11.11 Power Transfer Mode auto systems (during fault condition)

12 Colour

- 13 Online Thermal Disipation in Btu/Hr
at 100 %
at 75 %
at 50 %
at 25 %

8.6.40 APPROVED LIST OF MANUFACTURERS

230KV & 110KV GAS INSULATED SWITCHGEARS

- | | | |
|--------------------|---|------------------|
| 1. SIEMENS | - | FRANCE / GERMANY |
| 2. ABB | - | GERMANY |
| 3. AREVA | - | FRANCE |
| 4. TOSHIBA TMT & D | - | JAPAN |

110KV GAS INSULATED SWITCHGEARS

- | | | |
|-----------------|---|-----------------------|
| 1. SIEMENS | - | FRANCE / GERMANY |
| 2. ABB | - | GERMANY / SWITZERLAND |
| 3. MERLIN GERIN | - | FRANCE |
| 4. ALSTOM | - | FRANCE |
| 5. TOSHIBA | - | JAPAN |

230/110 KV 150MVA AUTO POWER TRANSFORMERS

- | | | |
|-----------------|---|-------------|
| 1. SIEMENS | - | CROATIA |
| 2. HYUNDAI | - | SOUTH KOREA |
| 3. AREVA | - | TURKEY |
| 4. EFFACEC | - | PORTUGAL |
| 5. HICO HYOSUNG | - | SOUTH KOREA |

110/11 KV 50MVA AUTO POWER TRANSFORMERS

1. SIEMENS	-	CROATIA
2. ABB	-	FINLAND
3. AREVA	-	TURKEY
4. STROMBERG	-	FINLAND
5. FUJI	-	JAPAN
6. PAUWELS	-	BELGIUM

TRANSFORMER

7. BONARLONG	-	SCOTLAND
8. EFACEC	-	PORTUGAL
9. ILJIN	-	SOUTH KOREA

EARTHING TRANSFORMERS

1. ABB	-	SWITZERLAND
2. AREVA	-	FRANCE
3. STROMBERG	-	FINLAND
4. PAUWELS	-	BELGIUM

TRANSFORMER

5. BONARLONG	-	SCOTLAND
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11/0.433KV DISTRIBUTION TRANSFORMERS

1. ABB	-	SWITZERLAND
2. SIEMENS	-	GERMANY
3. PAUWELS TRANSFORMER	-	BELGIUM
4. VOLTAMP TRANSFORMER	-	OMAN
5. EMIRATES TRANSFORMER	-	UAE
6. FEDERAL TRANSFORMER	-	UAE

11/0.69KV CONVERTER TRANSFORMERS

1. ABB	-	SWITZERLAND
2. SIEMENS	-	GERMANY
3. VOLTAMP TRANSFORMER	-	OMAN
4. EMIRATES TRANSFORMER	-	UAE

5. FEDERAL TRANSFORMER - UAE

NEUTRAL EARTHING RESISTOR

1. GEC INDUSTRIAL CONTROL - UNITED KINGDOM

33/11KV OUTDOOR TYPE VACUUM CIRCUIT BREAKER AND ISOLATOR

1. SIEMENS	-	GERMANY
2. ABB	-	SWITZERLAND
3. ALSTOM	-	FRANCE

230KV HIGH VOLTAGE XLPE CABLES

1. ABB HIGH VOLTAGE	-	GERMANY
2. TAIHAN	-	SOUTH KOREA
3. BRUGG CABLE	-	SWITZERLAND
4. ILJIN	-	SOUTH KOREA
5. LS	-	SOUTH KOREA

110KV HIGH VOLTAGE XLPE CABLES

1. BRUGG	-	SWITZERLAND
2. MITSUBISHI	-	JAPAN
3. FURUKAWA	-	JAPAN
4. ABB KABEL DRAHT	-	GERMANY
5. TAIHAN	-	SOUTH KOREA
6. ILJIN	-	SOUTH KOREA
7. LS	-	SOUTH KOREA

33KV & 11KV CABLES

1. DUBAI CABLE	-	UAE
2. SAUDI CABLE	-	SAUDI ARABIA
3. OMAN CABLE	-	OMAN
4. EL SEWEDY CABLE	-	EGYPT

LOW VOLTAGE CABLES

1. DUBAI CABLE	-	UAE
2. SAUDI CABLE	-	SAUDI ARABIA
3. OMAN CABLE	-	OMAN
4. EL SEWEDY CABLE	-	EGYPT

230/110KV EXTRA & HIGH VOLTAGE CABLE ACCESSORIES

1. PFISTERER	-	SWITZERLAND
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33KV & 11KV CABLE ACCESSORIES

1. TYCO ELECTRONICS/	-	GERMANY/INDIA
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RAYCHEM GMBH

2. 3M	-	USA/INDIA
3. PFISTERER	-	SWITZERLAND

230KV OVERHEAD LINE CONDUCTOR

1. OMAN CABLE	-	OMAN
2. MIDAL CABLE	-	BAHRAIN
3. J POWER SYSTEM	-	JAPAN
4. OMAN ALUMINIUM	-	OMAN

PROCESSING INDUSTRIES

LLC

OPTICAL GROUND WIRE (OPGW) CABLE AND ACCESSORIES

1. ABB	-	UK
2. PIRELLI CABLES	-	SOUTH KOREA
3. TAIHAN ELECTRICAL WIRE	-	SOUTH KOREA

230KV OVERHEAD LINE GANTRY TOWERS

1. LTO	-	INDIA
2. ZAMIL	-	KSA

230KV OUTDOOR SURGE ARRESTER

- | | | |
|---------------------|---|---------|
| 1. ABB | - | SWEDEN |
| 2. TYCO ELECTRONICS | - | IRELAND |
| / ENERGY DIVISION | | |
| 3. BOW THORPE EMP | - | ENGLAND |

SCADA & TELECOMMUNICATION

- | | | |
|------------|---|-------------|
| 1. ABB | - | SWITZERLAND |
| 2. SIEMENS | - | AUSTRIA |

COMPOSITE OUTDOOR TERMINATION UNIT

- | | | |
|--------------------|---|-------------|
| 1. PFISTERER SEFAG | - | SWITZERLAND |
| 2. ABB | - | SWITZERLAND |

PROTECTION RELAYS

- | | | |
|-----------------------|---|-------------|
| 1. SIEMENS | - | GERMANY |
| 2. ABB | - | FINLAND |
| 3. SCHNEIDER ELECTRIC | - | FRANCE / UK |
| 4. ALSTOM | - | FINLAND |

CONTROL, METERING & RELAY PANELS

- | | | |
|-----------------------|---|-------------|
| 1. SIEMENS | - | GERMANY |
| 2. ABB | - | FINLAND |
| 3. SCHNEIDER ELECTRIC | - | FRANCE / UK |
| 4. ALSTOM | - | FINLAND |

11KV SWITCHGEARS

- | | | |
|--------------|---|---------------------|
| 1. SIEMENS | - | GERMANY / INDIA |
| 2. ABB | - | SWITZERLAND / INDIA |
| 3. SCHNEIDER | - | FRANCE / INDIA |

11KV MOTORS

- | | | |
|-------------------|---|-------------|
| 1. ANSALDO MOTORS | - | ITALY |
| 2. ABB | - | SWITZERLAND |

3. SIEMENS	-	GERMANY
4. WEG MOTORS	-	UK

LOW VOLTAGE SWITCHGEAR

1. SIEMENS	-	GERMANY / INDIA
2. ABB	-	SWITZERLAND / INDIA
3. SCHNEIDER	-	FRANCE / INDIA

LOW VOLTAGE MOTORS

1. ANSALDO MOTORS	-	ITALY
2. ABB	-	SITZERLAND
3. SIEMENS	-	GERMANY
4. GRUNDFOS MOTORS	-	USA

MOTOR CONTROL CENTERS

1. SIEMENS	-	GERMANY / INDIA
2. ABB	-	SWITZERLAND / INDIA
3. SCHNEIDER	-	FRANCE / INDIA

VARIABLE FREQUENCY DRIVES / SOFT STARTERS / PRIMARY RESISTANCE STARTERS / WYE-DELTA STARTERS / DIRECT ON LINE STARTERS

1. SIEMENS	-	GERMANY / INDIA
2. ABB	-	SWITZERLAND / INDIA
3. SCHNEIDER	-	FRANCE / INDIA
4. SOLCON	-	USA

LOW VOLTAGE DISTRIBUTION BOARDS

1. SIEMENS	-	GERMANY / INDIA
2. ABB	-	SWITZERLAND /
INDIA		
3. SCHNEIDER	-	FRANCE / IN

BATTERY CHARGERS, DISTRIBUTION BOARDS AND BATTERY CELLS

1. CHLORIDE INDUSTRIAL SYSTEMS	-	FRANCE
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2. SAB NIFE POWER SYSTEMS LIMITED	-	INDIA
3. HBL	-	INDIA
4. CEG	-	ITALY

UPS SYSTEM

1. CHLORIDE INDUSTRIAL SYSTEMS	-	FRANCE
2. SAB NIFE POWER SYSTEMS LIMITED	-	INDIA
3. HBL	-	INDIA
4. CEG	-	ITALY

FM200 SYSTEM

1. NAFFCO	-	UAE
2. ANSUL	-	USA

DELUGE WATER SPRAY SYSTEM

1. NAFFCO	-	UAE
2. ANSUL	-	USA

POWER TRANSFORMER NITROGEN INJECTION FIRE PROTECTION SYSTEM

1. SERGI TRANSFORMER PROTECTOR	-	FRANCE
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CHAPTER - 9

9. INSTRUMENTATION CONTROL & AUTOMATION (ICA) REQUIREMENTS

9.1 General

The Instrumentation, Control, and Automation specifications shall cater for 400 MLD (200MLD x 2 Lines) capacity Perur desalination plant. This specification defines the general requirements and philosophy for instrumentation, control and automation.

The ICA shall comprise, but not be limited to the following:

- a) Plant Control System incorporating Distributed Control System (DCS) and integrated system through the internet and other protocols;
- b) Plant instruments, control elements, and remote equipment;
- c) Shielded data highway (including dual-redundant fiber loop) connecting all plant items;
- d) Engineer and Operator workstations and a Control Desk with a Mimic and HMI Panel for Operator information;
- e) All required hardware, servers, software, redundancy;
- f) Local control panels, emergency stop devices, hard-wired controls, and interface terminals;
- g) Alarm management system and reporting system;
- h) Computer Maintenance Management System(CMMS), Conditioning Monitoring System (CMS), and Optimization system;
- i) Instrumentation cabling and segregation with power supply system;
- j) Secure power supplies and UPS system;
- k) Remote communications facilities and integration;
- l) Interface with external stakeholders system;
- m) Redundancy and other features to ensure two streams of 2 x 200 MLD SWRO Desalination Plants availability, guaranteed performance, operational control, and operational flexibility.

9.1.1 Reference, Codes & Standards

All the equipment's and their accessories covered in this specification shall be designed, manufactured, and tested in compliance with the latest relevant standards and codes of practices referred in the table below.

Table 9-1: Latest Standards and Codes of Practices for ICA

STANDARDS	TITLE
INTERNATIONAL STANDARDS	
ISO	International Standardization Organization
IEC	International Electro-technical Commission
ANSI	American National Standards Institute

STANDARDS	TITLE
BSI	British Standards Institution
DIN	Deutsches Institut für Normung
EN	European Standards
JAPS	Japanese Standard Organization
REGULATIONS, RECOMMENDATIONS, DIRECTIVES	
ACI	American Concrete Institute
AGMA	American Gear Manufacturers Association
AIJ	Architectural Institute of Japan
AISC	American Institute of Steel Construction
AISE	Association of Iron and Steel Engineers
AISI	American Iron and Steel Institute
AMCA	Air Moving and Conditioning Association
ASCE	American Society of Civil Engineers
ASHRAE	American Society of Heating, Refrigeration and Air Conditioning Engineers
ASME	American Society of Mechanical Engineers
ASTM	American Society for Testing Materials
AWS	American Welding Society
AWWA	American Water Works Association
HIS	Hydraulic Institute Standards
IEEE	Institute of Electrical and Electronics Engineers
IPCEA	Insulated Power Cable Engineers Association
ISA	Instrument Society of America
JEC	Japanese Electro-technical Institute
JEMA	The Japan Electrical Manufacturers Association
JIS	Japanese Industrial Standards
NFPA	National Fire Protection Association
OCIMF	Oil Companies International Marine Forum
TEMA	Tubular Exchanger Manufacturers Association
IBC	International Building Code
USEPA	United States Environmental Protection Agency
VDE	Verband Deutscher Elektrotechniker (German Society of Electrical Engineers)

All equipment shall comply with the statutory requirements of the Government of India and the State Government. Wherever required by regulations, the Supplier shall have to obtain approval of the Electrical Inspector / Director of Explosives / competent authority. Any changes required by the said Inspector shall be to the account of the Supplier. The same condition applies to obtain the approval of other statutory authorities. Wherever the

Indian Standards do not exist, the equipment/components shall be designed, assembled, and tested under the other relevant applicable standards' latest editions mentioned in the above table. KKS codification should be followed.

9.1.2 Scope of Supplies and Services

- a) The scope of supply shall include design, manufacture, assembly, testing at works, supply, erection, testing at site & commissioning, and handing over.
- b) Various Types of Field Instruments like measurement (flow, pressure, level, temperature, etc.), Transmitters, Analyzers, Sensor, etc. as required to monitor and control the process equipment's performance proposed in each process zone.
- c) Receiving, Handling, Storing, Issuing, and Transportation to the site for installation, Erection, Testing, Commissioning, and integration with DCS.
- d) The Bidder shall include everything necessary for the execution of the above scope of works, whether mentioned explicitly in this document or not.
- e) The Bidder shall finalize the required number of instruments and their ranges during the detailed design stage.

9.2 Instrumentation

This section defines the minimum mandatory technical requirement of the instrumentation for the SWRO desalination application.

It is the responsibility of the Bidder/Contractor to design the ICA that meets all criteria defined in this document as well as to achieve SWRO Desalination Plant operation, availability, guaranteed performance, operational flexibility, and durability (and service life) of the asset.

9.2.1 Instrumentation Design Considerations

- a) In addition to the technical requirements of this section, the selection of technology, design, and arrangement of instrumentations shall be based on the relevant Site conditions
- b) The instrumentation and control equipment shall have high electromagnetic and radio frequency interference immunity and shall not be affected by portable radio transmitters operated in the equipment's vicinity.
- c) Instrumentation shall be suitable in every respect for continuous operation at the maximum output as well as part loads and shall be designed to permit unconstrained operation over the full range of ambient conditions and under the anticipated transient operation conditions as well as the climatic conditions peculiar to the Site and environmental pollution restrictions.
- d) The Bidder/EPC shall apply acceptable engineering practices in preparing the Instrumentation Control & Automation design. The proposed equipment shall be new and from reputable manufacturers with sufficient experience in the application's respective field.
- e) The Bidder/EPC must utilize components and systems which are of new

manufacture and proven design. The selection of instrumentations shall be as per internationally recognized standards and shall comply with all the applicable national and statutory codes.

- f) The plant shall be designed so that the impact of a failure of any single piece auxiliary equipment will cause no reduction in the plant's output.
- g) Provision for future expansion in design & selection, e.g. space inside the control room, space on the panels / cabinets / desks etc.
- h) Wetted parts of the instrumentation equipment shall be selected to withstand the service fluid's physical and chemical properties coming in direct contact with the instrument.
- i) Where binary signals cannot be derived from an analogue value, binary transmitters, e.g., temperature switches, pressure switches, etc. may be used. All switches shall be of robust design and reliable performance and shall be of the snap-action and change over type. The switches shall have an adjustable switching hysteresis.
- j) Whenever a corrosive atmosphere is present, all instruments and associated equipment exposed to such a medium shall be designed & protected to withstand the adverse effects.
- k) All instruments components shall be tropicalized to protect against humidity, moisture, and fungal growth through hermetically sealed units, protective coating on circuit boards, etc.
- l) All equipment shall remain unaffected by radio transmissions (Levels of permissible RFI shall be as per IEC 801).
- m) The field equipment requirements are based on conventional signal interfacing using central/remote I/O equipment.
- n) Generally, two (2) wire transmitters shall be used. If for some particular purposes (e.g., analyzers) 230 V AC power supply is required, the output circuit shall be isolated. All transmitters shall be individually fused.
- o) Necessary protections shall be taken care of for the Instruments coming in contact with a high-pressure line.
- p) Colour codes for pipelines, cables, lamps, and panels shall be followed for the plant as per industry/plant standard.

9.2.2 Instrumentation Strategy

9.2.2.1 General

- a) All field instruments shall be of high standard industrial type and suitable for the coastal environmental condition.
- b) All instruments, gauges, and control equipment that perform similar duties shall be of uniform type and manufacture throughout the Works to facilitate maintenance and the stocking of spare parts.
- c) All instruments shall have high reliability, low power consumption, and low maintenance.
- d) All materials in contact with seawater and concentrate shall be of suitable design

- and shall have proven suitability in the comparable installations.
- e) All part of the instruments in contact with the process fluids shall be fully compatible with the fluid to be measured, process temperature, and the ambient conditions and shall not deteriorate under normal operating conditions.
 - f) All instruments shall be of the Latest state-of-art and proven technology.
 - g) All instruments shall be from the reputed make with field-proven supply and service.
 - h) All transmitters shall be SMART type. The Bidder/EPC shall consider all necessary software libraries to communicate with the supplied instrumentation via an appropriate protocol.
 - i) All transmitters shall have an accuracy of 0.5 or better, and the repeatability shall be within a range of $\pm 0.1\%$ of full span.
 - j) All transmitters shall have local indication installed at a visible location. The transmitter and local indicator shall be integrated with the sensor were as possible. All instruments shall be mounted in visible locations with easy access for adjustments.
 - k) The range of local instruments shall be that the normal measurement of the process variable is between 50% and 75% of the instrument's full scale.
 - l) All switches shall be of robust design and reliable performance and shall be of the snap-action and change over type. The switches shall have an adjustable switching hysteresis. Limit switches shall be of the proximity type or metallic type (SPDT/DPDT).
 - m) All instruments installed on the Product water line shall not affect the quality of the product water.
 - n) All instrumentation system components, such as transmitters, analyzers, and controllers, shall be calibrated before equipment shipment. Calibration has to be documented, and testing certificates shall be included in the scope. Calibration shall be performed in five points of operating range.
 - o) Sunshade with UV-resistant coating shall be provided for all outdoor instruments, Control Panels, and Analyzer panels.
 - p) Field mounted transmitter display, 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 requires observation.
 - q) Sampling points shall be provided for all the analytical parameters
 - r) All I&C equipment shall have enclosure classification not less than IP 54, according to EN 60529, when mounted in an enclosed building and IP 65 for mounting outdoors.
 - s) Control cubicles installed in air-conditioned rooms shall be at least IP 32.
 - t) Sunshades shall be provided for all cubicle located outdoor, and all cubicles shall be adequately ventilated or air-conditioned, if necessary, for operability.
 - u) The Dry Run Protection is mandatory for each drive.

9.2.2.2 Instrument Installation Philosophy

All work shall be of the highest quality craftsmanship and shall conform to the best applicable engineering practices and relevant codes referred to in this document.

All instruments shall be installed in a neat, professional manner, ensuring ease of operation and maintenance. The EPC shall prepare hook-up and installation detail drawings regarding each instrument's type and shall carry out the installation per these approved drawings.

The EPC shall install instruments and equipment with due consideration of the following:

- a) Instrument installations shall conform to all applicable standard and manufacturer specifications and warranty requirements.
- b) No instrument except for pressure gauges and temperature indicators shall be installed to depend on its impulse piping or electrical connections for its support.
- c) The positioning of equipment shall not constitute a safety hazard. Where possible, instruments shall be mounted so that they are protected from the effects of rain and sun while maintaining access and visibility requirements. If this is not possible; the EPC shall provide a fixed cover or hood to protect instruments, without impairing access or visibility.
- d) Visibility and accessibility to be provided for both maintenance and operations purposes.
- e) Ease of access for lifting heavy items of equipment such as valves and flow meters.
- f) All instruments and valves shall be free from vibration.
- g) Instruments shall be mounted/connected so as not to stress vessel nozzles or pipe tapping.
- h) All local process-connected instruments shall be located as close as possible to the measurement point while still accessible from the deck, ladder, or platform.
- i) Instruments shall be mounted at a functional level between 1.0 and 1.5 meters above the operating floor.
- j) Instruments shall be appropriately supported on brackets or mounted on subplates, or placed on a suitable pedestal, pipe stand, or structural support. Pipe or structural stands may be welded directly onto the platform plate, with a proper penetration in the grating, where applicable.
- k) Instruments, tubing, cables, and cable ladder shall not be fixed to gratings or handrails.
- l) Instruments (other than pressure instruments) shall not be mounted directly on process piping without approval.
- m) Fittings such as instrument isolating valves and instrument air or gas regulators shall be supported either on the instrument stand or close-coupled to the instrument in a manner that no undue stress is imposed on the tubing or instrument.
- n) Instrument installation materials, tube, tube fittings and manifolds shall be standardized throughout the plant to reduce spare supply inventories and minimize rework time for a replacement.
- o) Analyzers for primary process lines shall be installed in bypass assemblies external

to the main process headers to allow routine maintenance. The assemblies shall include an isolation valve at each process connection tap, pressure regulator, manual sample valve, flow meter with integral flow metering valve, check valve, miscellaneous piping, and fittings. Assemblies for analyzer sensors, which must remain wetted at all times (e.g., pH or conductivity sensors), shall incorporate a vacuum breaker in the drain piping. The sample drain shall be routed to a hub drain.

- p) Instrumentation taps to process lines shall be isolated by root valve at the point of connection. Isolation valves for taps to process lines shall be 1/4-turn ball valves of materials compatible with the process fluid. Isolation valves for chemical service shall match isolation valves used in other portions of that chemical piping.
- q) Critical instrumentation associated with seawater inlet, brine discharge, Product Water quality, or other essential parameters of process shall be duplicated and shall not use the same impulse line but have separate process tapping.
- r) All field mounted transmitters vulnerable to damage shall be housed inside transmitter cabinets.
- s) Wherever instrumentation equipment is installed underground, a suitable approach, sufficient space for maintenance, drainage, ventilation, and illumination shall be provided.
- t) All cables laid below surface level or in trenches are to be installed in PVC conduits, and these conduits are to be sealed to prevent the ingress of moisture or water even if submerged.
- u) Cables carrying electricity and cables carrying digital communications must be laid in separate conduits to prevent electromagnetic interference.
- v) Plugging of extra holes in JB's, panels, cabinets, etc., plugging of additional holes for conduits, filling up the conduits & conduit opening with waterproof sealing compound after completion of erection.

9.2.2.3 Instrumentation Redundancy Strategy

- a) Instrumentation shall be designed such that the impact of a failure of any single piece of instrument and auxiliaries will cause no reduction in the output of the plant.
- b) Redundancy shall be applied such that “No” single I&C failure shall:
 - Cause any danger to personnel and the plant;
 - Invalidate protection by inhibiting a trip;
 - Shut down more than one Major Equipment item;
 - Simultaneously trip a Plant item and invalidate its auto-change-over; and
 - Affect more than one control area.
- c) Instrument Voting:
 - If a parameter envisaged to trip a part of the plant process and eventually reduce the production, then the instrument voting of that parameter shall be 2oo2.
 - If a parameter envisaged tripping the entire plant and complete loss of

production, then the instrument voting of that parameter shall be derived from 2oo3.

The Bidder/EPC may propose feasible solutions as per their control strategy, considering point b above.

- d) Measuring points and measuring equipment for interlocking and protection purposes for the critical control points shall be separate and not combined with measuring equipment for monitoring or automatic control equipment, except they are designed in a redundant configuration (2oo2 or 2oo3 voting).

9.2.3 Field Instrumentation

A general guideline on the Selection and approach of the instrumentation is given below. However, the selection of a particular type of sensor shall be decided based on the application requirement.

9.2.3.1 Pressure Measurement

- a) All pressure instruments shall be provided with the isolation valve and vent/drain valve or manifold.
- b) The differential pressure transmitter/indicator shall be mounted with a manifold.
- c) Transmitter housing shall be made of Die-cast aluminum, with a minimum IP rating of IP65.
- d) All wetted parts shall be made of Hastelloy C or AISI 316 depending upon the process fluid to be measured.
- e) Pressure transmitters and gauges shall have over-range protection up to 1.5 times the maximum line pressure they may be exposed to.
- f) Where necessary, a special diaphragm shall be used to segregate the gauge tube from corrosive fluid media. Minimum it shall be used in sludge and chemical dosages.
- g) Pressure transmitters shall have accuracy typically better than 0.25% of the span.
- h) For pressure measurement in slurries, viscous and corrosive fluids, diaphragm seals of suitable material shall be provided along with pressure sensing devices.
- i) Pressure gauges shall have minimum dial size of 100 mm.
- j) Pressure gauges shall have a threaded process connection of $\frac{1}{2}$ " NPT male.
- k) Pressure gauges shall be in general bourdon type, white with black markings dials for 270 degrees of the dial. The pointer shall be externally adjustable, and the gauge movements shall be stainless steel, geared type. The case shall have a blowout disc in the back. Ranges are typically selected such that the operating point falls between 1/3 and 2/3 of the full-scale range. Indicators are located such that they are visible from the floor or adjacent platforms, where practical.
- l) The window material of the pressure gauge shall be shatterproof glass.
- m) Pressure gauges/switches used in pulsating pressure applications (e.g., the delivery side of pumps, compressors, etc.) shall be provided with externally adjustable pulsation dampener or snubber.

- n) Wherever the process pressure exceeds 30 bar, solid front type pressure gauges shall be used (i.e., a metal partition shall be provided between dial and element).
- o) The sealing liquid for the diaphragm seal shall be an inert liquid compatible with process fluid and its temperature.
- p) Pressure gauges shall have an external zero adjustment facility.

9.2.3.2 Flow Measurement – Electro Magnetic Flowmeter

- a) Flow transducers shall be rugged in construction and shall be suitable for continuous operation. Flow transducers shall have waterproof construction and shall be suitable for installation in underground/above ground applications.
- b) To avoid the effects of disturbances in the velocity profile, a straight and uninterrupted run, upstream and downstream from the flow sensor's location, shall be provided in accordance with the requirements of the flow meter manufacturer.
- c) Flow Meter shall be of the electromagnetic flow-through type with a minimum accuracy of 0.2 % at flows between 15 - 110 % concerning the nominal flow.
- d) Product water metering flowmeter shall have an accuracy of 0.1% at flows between 15 - 110 % to the nominal flow.
- e) Flow sensing element and liner shall be fully compatible with the fluid to be measured, process temperature, and the ambient conditions and shall not deteriorate under normal operating conditions.
- f) Flow meters shall be designed to operate on 230 VAC power supply, and a 10% variation in power line voltage shall not affect the meter output accuracy over 0.1 % of the full scale.
- g) The remote mounted transmitter is preferred, and it shall be located for easy access.
- h) The transmitter shall be a smart type with outputs including communication interface, 4-20mA (HART), Pulse, and programmable relay discrete output. The transmitter shall include flow rate, alarm monitoring, self-diagnostics, and forward/reverse/net flow totalizer.
- i) The measuring electrode, the reference electrode, and the empty pipe detection electrode shall be inbuilt, and the type of electrodes shall be manufacturer specifics based on the process fluid.
- j) Flowmeter shall be provided with inbuilt grounding electrodes, and the material shall be the same as the sensing material. Insulation flanges, gasket, and copper shall be provided as required.
- k) Flowmeter flanges shall be in accordance with ANSI / ASME.
- l) If the pipework has cathodic protection, the manufacturer's recommendations for bonding and protecting the instrument and its signals shall be adhered to.
- m) Rotameters
 - Rotameters shall be provided for areas where the flow parameters are only for monitoring and the least priority. Simple manufacturer standard scaled tube and float shall be used for line sizes less than 100mm, and for higher size pipes with the exception that the process pressure is not disturbed, a bypass type flow rotameter arrangement with flow restriction orifice plate

shall be used. The rotameters shall be provided with discrete SPDT switches.

- Rotameter shall be a metal tube/glass type as applicable for process fluids; material shall be selected according to process requirements and fluids.

9.2.3.3 Level measurement

- a) The level measurement system shall consist of a level transducer, level transmitter, digital level indicator, and any other items required to complete the level measuring system.
- b) Level instruments shall have weatherproof, dust, and corrosion-resistant enclosures of IP-67 grade.
- c) Level instrument materials of construction shall be compatible with the fluids to be measure and the service conditions.
- d) Level probes, waveguides, and stilling wells shall be situated to allow sufficient overhead clearance for their installation and removal.
- e) Flushing ring, drain valves, tubing shall be provided where required.
- f) Accuracy of the level measurements shall be better than $\pm 0.5\%$ of full scale or 10mm.
- g) The design and application of level meters shall consider the vessel or channel construction, the material, size, shape, environment, process fluid or material, the presence of foam, granules, size, etc.
- h) The transmitters shall be 4-20mA (24V DC loop powered) / Field bus compatible and possible to calibrate through handheld universal and field bus configurators.
- i) Ultrasonic Level Measurement
 - Ultrasonic type level transmitters shall be microprocessor-based and shall use digital signal processing techniques for signal conditioning.
 - The transmitter shall have facilities for storing the echo profile, manipulating the echo profile to remove noise, multiple profile-averaging, etc.
 - The transmitter shall have the capability to use statistical filtering techniques, wherever required, to compensate for rotating agitator blades or to suppress false signals due to heavy dust or fill-stream interference.
 - In applications where material build-up on the sensor is expected, the transducer shall have suitable build-up compensation (i.e., repetitive, pulsating displacement at its face shall be used to remove the material build-up).

9.2.3.4 Analyzer

- a) All analyzers shall be industrial type, proven design, robust construction, low maintenance, and suitable for the intended application.
- b) Each process area shall be provided with the required type of analyzer to monitor the process condition.
- c) The different types of analyzers required in plants are pH, ORP, Turbidity,

Temperature, Conductivity, Free Chlorine, Oil, Hydrocarbons, SDI, Alkalinity, .etc.

- d) The type of sensors and measuring principle shall be selected based on the liquid's electrochemical and physical properties.
- e) The analyzers shall be selected based on reagentless or reagent free operation
- f) Multi-parameter type analyzers shall be used, but transmitter output shall be individual and dedicated per each parameter.
- g) Analyzers shall be installed in analyzer panels if a cluster of analytical equipment exists in an area. Analyzer panels shall be installed, preferably in a sheltered area; when a circumstance requires the outdoor installation, the suitable shelter shall be provided to protect from direct sunlight and rain.
- h) The analyzer panel shall be made of Plastic UV resistant panel or vendor standard material to withstand the climatic condition.
- i) Suitable drain arrangement shall be provided where required.
- j) Analyzer cabinet with air-conditioner shall be provided for analyzer were required based on manufacturer recommendation.
- k) The analyzer cabinet shall be made of GRP or FRP with a minimum degree of protection of IP67.
- l) pH:
 - The measuring electrode shall be glass with a suitable reference electrode (preferably silver).
 - Measurement shall be flow-through type, and the Sensor element shall have a built-in temperature sensor for temperature compensation. The electrode response shall be linear with temperature changes.
 - The systems shall have an auto cleaning facility and facility of auto-calibration.
- m) ORP
 - The measuring electrode shall be platinum/gold with a suitable reference electrode (preferably silver)
 - pH and ORP sensors can be connected to a single transmitter, in which case the transmitter shall be capable of processing the two input signals as per the requirement
- n) Conductivity
 - In the case of flow-through, the electrode shall be preferably titanium/ SS316L with a suitable reference electrode
- o) Turbidity
 - Turbidity measurement shall be based on the Nephelometric measuring principle 90° NIR scattered light according to ISO 7027/ EN 27027
 - It shall be complete with the light source, light receivers, sensor assembly with an integrated viper, flow assembly with integrated gas bubble trap, Remote transmitter, etc.
 - An internal bubble removal system shall be included to vent entrained air from the sample stream.

p) TOC

- TOC measurement shall be based on Non-Dispersive Infrared TN1/2012/04 Sensing Technology
- The analyzer shall measure organics reliably in high-salt or brine samples with a precision of +/-2% with a range of 0-250ppm and calibration stability of min. 6 months.

q) SDI

- Online SDI measurement shall be automatic for continuous monitoring & unattended operation in the desalination plant.
- Facility for data logging, status display, fault detection, auto flushing/cleaning, control of water pressure, flow rate measurement, automatic transfer of filters after each measurement, number of measurement (as required), etc.

r) Oil

- The probe shall be a continuous-reading sensor that utilizes a UV-fluorescence technology.
- The sensor shall be equipped with a stain-resistant measuring window. The sensor shall compensate for the interference effects of ambient light and UV lamp output fluctuations.

9.2.3.5 Instrumentation Plan:

The following table represents the minimum required instrumentation but not limited to, for each process units of the Proposed Perur DSP. The EPC shall accordingly provide all required instrumentation that are necessary for process control in each 2x 200MLD process streams as applicable.

S. No.	Location	Instrumentation Plan
1.	Seawater pumping station	<ul style="list-style-type: none"> i. Travelling band screens - Ultrasonic differential level Sensors ii. Intake forebay – Total Hydrocarbon, Turbidity, Oil, Conductivity, Temperature, pH and Residual Chlorine Analysers. – iii. Pumps station: Level, Pressure, Protection/ Condition Monitoring
2.	Chemical building - Pre-treatment	<ul style="list-style-type: none"> i. The dosing tanks shall be provided with an Online Non-Contact Radar Type level sensor, and the dosing pumps shall be provided with Electromagnetic flowmeter at dosing pump discharge headers for the following chemicals - NaOCl (Chlorination), Sulphuric acid, Ferric Chloride, Polyelectrolyte etc.

S. No.	Location	Instrumentation Plan
4.	Pre-treatment – Dissolved air floatation	<ul style="list-style-type: none"> i. Dissolved Air Floatation Common effluent outlet - Turbidity meter, and other specific quality analyser to ensure the pre-treatment efficiency. ii. Electromagnetic meter on the sludge discharge line.
5.	Pre-treatment – Gravity dual media filtration	<ul style="list-style-type: none"> i. Differential Pressure sensors at each Gravity dual media filtration unit, Ultrasonic level sensors at each filter. ii. Backwash pump discharge header-Electromagnetic meter iii. Pumps: Pressure, Protection/ Condition Monitoring
6.	Pre-treatment – RO feed/ Backwash tank	<ul style="list-style-type: none"> i. Ultrasonic level sensors
7.	RO Feed Water	<ul style="list-style-type: none"> i. Chlorine, pH, conductivity, temperature, SDI and Boron Analyser before cartridge filter ii. Feed Water Pumping – Pressure, flow, Protection and Condition Monitoring
8.	Chemical building for Seawater Reverse Osmosis (SWRO)	<ul style="list-style-type: none"> i. The dosing tanks shall be provided with Online Non-Contact Radar Type level sensor, and the dosing pumps shall be provided with Electromagnetic flowmeters at pump discharge headers for the following chemicals - Sodium hydroxide, Antiscalant and Sodium meta-bi-sulphite, Biocide (as needed)
9.	RO building	<ul style="list-style-type: none"> i. RO feed pump discharge header – Online Pressure sensor ii. Micron Cartridge filter – Differential Pressure sensor iii. Micron cartridge filter outlet – Conductivity, ORP, pH, Temperature, Alkalinity, SDI Sensor iv. SWRO High-pressure pump suction – Electromagnetic flow meter, Online Pressure sensor v. SWRO High-pressure pump discharge – Online pressure sensor

S. No.	Location	Instrumentation Plan
		<ul style="list-style-type: none"> vi. ERD booster pump discharge – Online Pressure sensor vii. CIP dosing tanks- Online non-contact radar type level sensor viii. CIP dosing pumps discharge header – pH, Online Pressure sensor ix. RO flushing pump discharge header – Online Pressure sensor, Electromagnetic flowmeter x. RO permeate line outlet – pH, Conductivity, Electromagnetic flowmeter xi. Pumps: Pressure, Protection/ Condition Monitoring
10.	RO permeate tank	<ul style="list-style-type: none"> i. Ultrasonic level sensor
11.	SWRO Reject discharge line	<ul style="list-style-type: none"> i. Electromagnetic flowmeter, Online Pressure sensor, Temperature, pH, Turbidity, Conductivity, Residual Chlorine
12.	Post-treatment area	<ul style="list-style-type: none"> i. Lime filter inlet/outlet – pH, Electromagnetic flowmeter ii. Lime filter backwash – Electromagnetic flowmeter, residual chlorine iii. Lime filter Backwash air blower- Online Pressure sensor iv. Lime Silo level v. All required sensors and flow meters for CO2 injection. vi. The dosing tanks will be provided with Online Non-Contact Radar Type level sensor, and the dosing pumps will be provided Electromagnetic flowmeter at pump discharge headers for the following chemicals – Sodium hydroxide and Sodium hypochlorite
13.	Product water storage tank	<ul style="list-style-type: none"> i. Ultrasonic level sensor in the tank ii. Float type level sensor in the tank iii. Product water storage tank outlet line – Electromagnetic flow meter, Conductivity, pH, Turbidity, Residual chlorine, Temperature.
14.	Autosamplers	<ul style="list-style-type: none"> i. Seawater intake area ii. Lamella/DAF effluent and sludge line iii. Gravity dual media filter outlet

S. No.	Location	Instrumentation Plan
		iv. Reminerlised water lines v. Product water lines to CWR vi. Seawater/ Brine outfall discharge area
15.	Package sewage treatment Plant	i. Inlet Electromagnetic flowmeter and treated water flowmeter and all other process sensor
16.	Wastewater treatment units	i. Lamella clarifier sludge discharge common line – Electromagnetic meter ii. DAF sludge discharge common line – Electromagnetic meter iii. Sludge balance tank and Thickeners - Ultrasonic level sensor iv. Sludge holding tank -Ultrasonic level sensor v. Sludge transfer pumps discharge header to thickener- Electromagnetic flowmeter, Online Pressure sensor vi. The dosing tanks will be provided with Online Ultrasonic level sensor and the dosing pumps will be provided Electromagnetic flowmeter at pump discharge headers for the Polyelectrolyte dosing in Thickener inlet and Belt filter press inlet vii. All pumps pump discharge line – Electromagnetic flowmeter, Online Pressure sensor viii. Neutralisation pit – Electromagnetic flowmeter, Online Pressure sensor. ix. Outfall tank -Ultrasonic level sensor

9.2.4 Condition Monitoring System (CMS)

- a) The Integrated Machine Condition Monitoring system is required for all the critical Pumps; the criticality of the pumps shall be based on
 - The impact of the failure of a pump and auxiliaries will cause no reduction in the plant's output.
 - The failure of the pump doesn't affect more than one process area.
 - Size of the pump
- b) The critical pumps are listed below, but not limited to the following.
 - Sea Water Intake Pumps
 - RO Feedwater Pumps

- High-Pressure Pumps
- Booster Pumps

The Bidder/EPC, with their experience, shall include additional pumps, which may be sought as critical.

- c) It is recommended that the sensors for the condition monitoring system shall be supplied by the respective pump vendor duly installed and wired to their respective cabinet.
- d) Various parameters such as Vibration, axial displacement, thrust, temperature, speed, key phasor, etc. shall be measured and made available for analysis and interlocking.
- e) The data gathered from various machines shall be used for monitoring, machine diagnostic analysis, and decision support. The vendor shall provide software capable of data monitoring functionality in client-server configuration so that monitoring, diagnostics analysis, and configuration changes are possible from CMS Workstation.
- f) The CMS shall be modular and expandable.
- g) The CMS server shall have provision for interfacing Process data from the DCS in the respective control room for correlation of Fault diagnostics. The same shall be available from the OPC server's Ethernet port in the control room being provided by the DCS vendor. The CMS vendor's scope shall include coordination with the DCS vendor, including identifying process data required, developing the OPC client module at their end (CMS server), and successful integration with DCS.
- h) Condition Monitoring system server shall have OPC connectivity with DCS network and shall comply with OPC foundation standards. A firewall shall be provided for the MCMS servers by the DCS vendor for the interface.
- i) Fault diagnostic analysis software shall be able to detect various malfunctions like shift bow, high synchronous vibration, fluid-induced instabilities, radial preloads forces, shaft crack, rotor rub, loose rotating parts, electric motor non-uniform, air gap, etc
- j) Software shall have the capability to evaluate the following data for analysis, as a minimum:
 - Magnitude and amplitude of the vibration
 - Form of vibration
 - Amplitude/Phase lag angle
 - Shaft centerline position
 - Frequency of the vibration
 - Process variable data
 - Machine geometry data
 - Trend file data
 - Report history files
- k) The following list of parameters are to be included as a minimum but not limited to:

- Vibration monitoring
- Temperature monitoring

The final quantity of monitoring parameters to be installed in each type of equipment is confirmed by each equipment manufacturer's specific vendor and according to the mechanical construction.

- l) Vibration monitoring shall measure bearing vibrations by accepting any voltage output or standard electric piezoelectric accelerometer. A minimum of two vibration transducers shall be provided for each bearing when permitted by the equipment's mechanical design.
- m) Temperature monitoring shall be intended for the measurement of winding and bearing temperatures. Each equipment shall be provided for motor winding temperature monitoring points, motor bearing temperature monitoring points, and Pump bearing temperature monitoring points.
- n) The Bidder/EPC shall be responsible for coordinating with various Machine vendors (Original Equipment Manufacturers) concerning:
 - Obtaining/validation of required information for the engineering of offered CMS.
 - Verification of configuration data during Installation and commissioning.
 - Calibration verification of sensors and monitors during commissioning.

9.3 Distributed Control System (DCS)

Due to the requirement of availability, reliability, and function, the Plant processes' control and monitoring task be performed by a state of art digital Distributed Control System unified for all SWRO units and other main plant equipment. The DCS shall be of proven design successfully in operation at other similar desalination plants.

The Bidder/EPC/Vendor shall be responsible for designing the integrated DCS, based on the information given in this specification, its referenced requirements and standards, and accompanying drawings/documents.

The listed requirements presented here in this section are intended as minimum recommendations and provide general guidelines and establish minimum system requirements.

9.3.1 DCS Strategy

- a) A tentative DCS architecture for the SWRO Desalination Plant is attached within the drawing section ref: 7061563/PMC400MLD/CP1/DCS/001. The DCS shall incorporate Distributed controllers, Plant Control Station, Various Operator Workstations, engineering workstations, Control Servers, Controllers, Historian, Optimisation/CMMS server, and touch screen displays for field control & annunciation.

Remote input/output (I/O) racks shall be distributed throughout the site to minimize the amount of wiring back to the central control room. The SWRO Desalination Plant shall be visible from the Control room.

- b) The Design strategy for the DCS shall take into consideration the following criteria:
- Fail-Safe Design
 - System Availability
 - Equipment Reliability
 - Expandability
 - User friendly to operate and maintain
 - Fault Monitoring and Diagnostic Capability
 - Compatibility for Integration with the third party
- c) The DCS shall synchronize the date and time via the GPS clock provided. All DCS facilities shall be synchronized to this system time and date, which shall be used to tag all alarm and events and in all displays and reports.
- d) The SWRO Desalination Plant shall use a tree-type communications system to integrate equipment, instruments, and computers. The equipment level systems shall communicate with motor control centers, variable frequency drives, and other PLC's using standard Plant control network protocols.
The instrument-level system (field bus) shall communicate to most of the process instruments, air-operated valves, and/or motor operated valves using field bus, hardwired or equivalent.
The computers shall communicate peer to peer via standard TCP/IP or equivalent Ethernet.

9.3.2 Redundant Configuration

- a) Process and Mechanical redundancy should be reflected in the DCS redundancy as well. The plant is envisaged into two independent production lines configuration of 2 x 200MLD, and the DCS redundancy should be harmonized as per the envisaged Process and Mechanical redundancy.
- b) The following equipment shall be supplied in a redundant configuration
- All Controllers.
 - All Power supply modules.
 - All Control network equipment.
 - All communications equipment required for communications between controllers, Servers, and Workstations
 - All applicable station level equipment's
- c) The following requirements apply to those parts of the system supplied in a redundant or fault-tolerant configuration:
- The system shall continuously monitor and test all backup equipment to determine whether the backup equipment can assume control.
 - Failure of backup Equipment shall be alarmed as a system alarm.
 - Automatic switchover to backup equipment shall occur on the detection of failure of the primary equipment.
 - Switchover shall not degrade the module's performance or functionality or

- result in the operator's loss of view to the process.
- Switchover of controllers shall not cause the initialization of any control strategies implemented in the controllers.
 - Replacement of any redundant module shall not disturb or interfere with the redundant pair's functional module's performance.
 - Switch back to repaired equipment shall be permitted only after the system diagnostics function has determined that the module is fully functional.
 - Automatic and manual switchover shall be displayed, logged, and alarmed by the system.
- d) The following requirements apply to the Control Network and Internal Communications
- DCS networks shall be based upon industry standards from IEEE/IEC.
 - Communication at the control network level shall have redundant or fault-tolerant paths.
 - Communications from the controller to the I/O subsystem shall have redundant paths.
 - DCS internal communication shall be designed such that no single failure will degrade the performance of the system. This requirement applies to all communication between controllers to their I/O modules.
 - Data highways shall continuously use both paths and shall check the backup path at least once per minute to determine if the backup path is operating normally.

9.3.3 Availability

- a) A single failure anywhere in the system shall not result in the loss of production and regulatory control.
- b) A single failure anywhere in the system shall not result in the loss of an operator's ability to view or manipulate the process from his workstation.

9.3.4 Reliability

Equipment supplied as part of the DCS system shall meet or exceed the MTBF data specified below at the equipment's design temperature.

- Process controllers and input/output modules – 300,000 hrs
- Power Supply modules – 200,000 hrs
- Commercial off-the-shelf networking or communications equipment – 100,000 hrs
- All other electronic modules and power supply modules – 100,000 hrs

MTBF figures shall be "Predicted" using data and calculation provided by MIL-HDBK-217.

9.3.5 System Support

DCS Bidder/EPC/Vendor shall guarantee support of all hardware, firmware, and software associated with the controller and I/O subsystems and any proprietary communications equipment for fifteen (15) years from the hardware freeze date. Support shall include spare parts and technical support.

9.3.6 Scope of Supply and services

The scope of supply and services includes (but not limited to) for Distributed Control System (DCS) / Controller shall include designing, engineering, manufacturing, software development, testing, erection, commissioning, documentation, and handing over complete plant control system to ensure satisfactory operation of the plant. Including Complete Integrated Plant Control System for Data Acquisition, Data Processing, Process Monitoring, Process Control, Process optimization, Events and alarm handling, Data storage, retrieval and analysis, Diagnostics, and Information exchange with Management / Office network. The design shall be in accordance with Bidder/EPC/Vendor standards but with amendments to meet the CMWSSB/Engineer specifications.

9.3.7 DCS Hardware Requirement

9.3.7.1 Scope of Supply and Services DCS Hardware

The scope of supply and service for DCS hardware includes, but not limited to:

- a) Distributed Control System (DCS) /Controller, PC based HMI units; Control desks; servers and redundant servers; computers for operator stations, plant overview, process optimization, information management system, peripherals; programmable controllers (PCs); power supplies; ethernet switches; distributed / remote I/O panels along with Large Screens, Monitors for plant overview shall be Min. 55" LED type shall be provided.
- b) Modems / protocol converters / data transmission RF transmitters / receivers / link devices / Ethernet switches / coupler / terminators / routers / bridges / power supplies for communication wherever required, as per system configuration.
- c) Ergonomic furniture for operators & Engineers at Main Plant Central Control Room (CCR)
- d) The laptop computer of the latest configuration with necessary licensed software loaded as Portable Programming Unit for the programmable controller and other field instruments/devices/drives.

9.3.7.2 Distributed Process Controllers

- a) The controllers shall be of a minimum 32 bit, high performance, RISC, multi-task processing. Including adequate clock frequency capability to process in 16 bits
- b) The CPU load shall not be more than 60%. The memory utilisation shall be within 60%, the loading of communication channels like high-speed Ethernet, I/O

channels, and programming terminal channel, if any, shall be less than 60%.

- c) The controllers shall be programmed to achieve sequential interlocks for a start/stop of plant and machinery, process and safety interlocks, alarm generation & distribution, monitoring and supervision of process parameters and PI / PID, fuzzy loop controls for process optimization.
- d) Controllers shall be controlling the sections independently & the stoppage of one controller shall not affect the operation of others unless otherwise they are deliberately interlocked. However, these processors shall also communicate between themselves to take care of the safety interlocks/process requirements shared between the process related sections. Any programmable controller in the network can access the data and I/O of any other controller in the same network.
- e) The processors shall have self-diagnostic features to ensure healthy working at all times, including memory, processor loading, the status of communication channels, and to give warning through audio-visual means for any fault. Suitable programming devices to facilitate online program changes; storage of program for safekeeping and handheld terminal shall be included.
- f) Process controllers shall be redundant, with automatic failover to the backup processor on the primary processor's failure. Engineering of a redundant unit should be transparent, i.e., no extra manual synchronization shall be needed. The backup processor shall be in hot standby mode, continuously updating its memory from the primary controller. The redundancy should have a switch over time less than 10 msec.
- g) Controllers shall be supplied in a configuration to ensure continuous and bumpless processing of data while permitting online changes to control logic. There shall be an online and offline programming feature. The programmable controller shall have Remote, run, program, online program & test modes (Simulation mode).
- h) The system shall have scalability both horizontally and vertically. The details of scalability in terms of number & type of controllers, number & type of I/O, number & type of communication modules, number of MMI, number of external systems, number & type of network nodes, different communication protocols, software, size of memory, additional functionality, distance, the mix of multiple processors, networks & I/O without restrictions, etc. are to be furnished by the Bidder.

9.3.7.3 Inputs And Outputs

- a) I/Os in Panels or integrated to MCC shall be connected to DCS Controller through a redundant serial link.
- b) The I/O and their interfaces shall have provisions configured either as remote I/O or as distributed I/O. The protocol envisaged for this purpose shall be of industry standard and open protocol. The same shall be mentioned in the Bid.
- c) As far as possible, field bus devices/transmitters shall be used. If such devices/transmitters are not available for any application, they shall be with a 4-

20 mA DC analog signal with HART communication.

- d) I/O panels required to be mounted at the field away from MCC rooms etc. shall have IP65 protection.
- e) Input / Output (I/O) modules shall be capable of being inserted into or removed from their chassis or mounting assemblies without disturbing field wiring and while the chassis is powered (hot replacement).
- f) All Input / Output modules shall provide a status LED that indicates the module's health or operational condition. The status of the module shall also be communicated to the system diagnostics software.
- g) The modules selected shall be of rugged construction, low power consumption/heat dissipation, and to an extent, do not require forced cooling.

9.3.7.4 Analog Input

- a) The system shall automatically check the calibration of the A/D converters periodically.
- b) The system shall indicate calibration error.
- c) The noise level generated by the input circuitry shall be less than the minimum resolution of the measurement.
- d) Analog input modules shall power 4-20 mA field instrumentation loops with a loop resistance of 600 ohms.
- e) Analog input modules shall be able to connect to 4 wire field instruments.

9.3.7.5 Discrete Input

- a) The system shall be capable of detecting discrete input transitions with a duration of 50 milliseconds.
- b) 24Vdc inputs shall be able to use either internal or external power supplies. External power supplies may provide other voltages.
- c) Relay or solid-state input from field powered contacts shall be available.
- d) The system shall support configurable digital input filtering to prevent digital input "chatter" or "bounce."
- e) Discrete input modules shall have visible LED indicators on a per-channel basis to indicate the input's current state.

9.3.7.6 Analog Output

- a) The system shall support 4-20 mA outputs.
- b) Output modules shall be provided with individually fused outputs or current limiters.
- c) Analog output modules shall have the following configurable failsafe options:
- d) Drive to zero output or full-scale output
- e) Maintain last good output value

9.3.7.7 Discrete Output

- a) The system shall be capable of supporting the following:

- On/off
 - Single pulse, (configurable width).
 - Latching and non-latching (momentary) contact outputs
- b) The following solid state or relay board output ratings shall be available:
- 24 VDC, 80 mA, non-inductive load
- c) Relay or solid-state output contacts that are free of voltage and ground shall be available.
- d) The duration of the single pulse outputs shall be individually configurable.
- e) Output modules shall be provided with individually fused outputs or current limiters.
- f) Discrete output circuits shall be provided with protection for the switching of inductive loads.
- g) Discrete output modules shall have visible LED indicators on a per-channel basis to indicate the output's current state.
- h) Discrete output modules shall have the following configurable fail-safe options:
- Drive to either energize or de-energize output
 - Hold last output

9.3.8 DCS Software Requirement

- a) The online real-time operating system supplied shall be proven for similar applications and shall support all the equipment/peripherals.
- b) For Level -1, a Licensed software bundle for online & offline programming, configuring, diagnosis, troubleshooting, firmware update of flash PROMs of the controllers along with necessary drivers and interfaces shall be included and specified by the Bidder
- c) For Level- 2, Licensed Operator Station software / Human Machine Interface (HMI) software for graphics development, tag configuration & management, data acquisition, plant viewing, plant operation, plant control, real-time & historian trending, alarm generation, and log reporting, event log, historian, PID, and other process loop manual & auto-tuning, interfacing & access for Field Bus devices/drives, interfacing & access for Management Information System (MIS) & Process Optimization Systems, OPC interface shall be included and specified by the Bidder.
- d) Any other software required for the reliable & successful operation of the desalination plant and the system offered
- e) The DCS system shall carry out the following functions on data received from the plant facilities:
- Perform control algorithms as per configuration
 - Store historical information
 - Produce logs, reports, and trends
 - Handle alarms and events
 - Calculate derived values
 - Run application programs like measurement validation and

comparison, valve stroke testing

- Perform logic control and sequencing
- Trending and Reports generation
- Auto window generation of trending and Grouping from the tags in each Graphic display using soft key
- Safe view (Multi-window opening with the facility to open the window in the specified position with the first opened – first closing principle)
- HMI availability embedded in the FCS for viewing Advanced diagnostic and predictive maintenance feature (Latest version) for valves and transmitters
- Grouping of alarms UNIT / Equipment-wise
- Forcing I/O signals to individual states via the engineering workstation for commissioning and maintenance purposes.
- Loading I/O cards and Grouping of logics.
- Perform configuration of all HART devices from a single engineering station
- Automatically perform diagnostic checks on all conventional HART devices and continuously report their status and health to the operator interface.
- Provide the necessary software interface to the third-party devices

f) The Bidder/EPC/Vendor shall supply:

- Fully configured database(s)
- Fully configured overview, operating, alarm and trend displays sufficient to provide full control and monitoring as specified by the CMWSSB/Engineer
- Fully integrated single database for process control and asset management data
- Fully configured tabular display pages
- Fully configured mimic displays
- Fully configured reports as specified by the CMWSSB/Engineer
- All other software required to meet the Specifications
- All User-Defined Programs supplied under this Contract
- Offline Diagnostic Software for comprehensive testing of the DCS

g) The Bidder/EPC/Vendor shall ensure that all hardware and software supplied are mutually compatible and function through interfaces with any other equipment or software.

h) Control Functions:

The following standard control algorithms shall, as a minimum, be available for configuration:

- Normal PID
- Cascaded Loops
- High/Low Over-Ride Selection

- Ratio Algorithms
- Feed Forward Control
- PID with Gap Action
- Summer / Subtractor
- Multiplier / Divider
- Boolean Operations
- Differential Gap Control
- SetPoint Tracking (remote / local)
- External Reset Feedback (EFB)

9.3.8.1 Optimization Package

- a) An optimization/expert system, along with necessary hardware & software, shall be provided. This optimization package shall be an integral part of the automation system or a standalone system.
- b) The system shall be designed so that even if the expert optimization system fails, the plant operation shall not get affected, and all the controls shall automatically get transferred to appropriate control levels.
- c) The optimization system shall provide a solution for the advanced process of membranes in desalination plant with the following minimum functions:
 - Monitors the membrane fouling through Key Performance Indices (KPIs)
 - Estimates the due date for next membrane chemical cleaning
 - Provides the optimal set points to improve the productivity / minimize energy consumption
 - Maximizes membrane life and reduces unplanned outages
 - Maximizes water production and decreases operating cost

9.3.8.2 Historian Package

- a) Online History Collection and Storage

There shall be a configurable, real-time, and historical data collection package to support trending, logging, and reporting.

- b) Offline History Storage

It shall be possible to archive raw historical data for long term data storage. The facility to recall and display any data that has been archived shall be provided.

The system shall keep a record of data that is transferred to removable media.

The record shall contain the timeframe of the data transferred and the name of the file or storage area to which it has been transferred.

9.3.8.3 Computerized Maintenance Management System (CMMS)

A completely integrated computerized Maintenance Management System(CMMS) with relevant databases entirely populated and customized for desalination plant application shall be provided. The system to be provided shall include all necessary hardware,

software, firmware, and interfaces required for implementing a fully functional CMMS suitable for integrated maintenance management function for a modern SWRO Desalination.

CMMS systems shall be envisaged to automate most of the logistical functions performed by maintenance staff and management.

The typical CMMS functions shall include the following, but not limited to:

- Work order generation, prioritization, and tracking by equipment/component.
- Historical tracking of all work orders generated which shall be sortable by equipment, date, person responding, etc.
- Tracking of scheduled and unscheduled maintenance activities.
- Storing of maintenance procedures as well as all warranty information by component.
- Storing of all technical documentation or procedures by component.
- Real-time reports of ongoing work activity
- Calendar- or run-time-based preventive maintenance work order generation.
- Capital and labor cost tracking by component as well as shortest, median, and longest times to close a work order by component.
- Complete parts and materials inventory control with automated reorder capability.
- PDA interface to streamline input and work order generation.
- Outside service call/dispatch capabilities.

9.3.8.4 Database

It is required that the DCS maintains, on mass storage media, the complete current database. Any changes made to the database shall also be copied to this backup. If a memory loss occurs, then the DCS shall reload with either an archived or the current backup version of the database from the storage.

9.3.9 DCS Controller Grouping

- a) DCS controller and RIO shall be grouped. The Bidder/EPC/Vendor shall specify an indicative number of IOs. The requirement and scheme of remote IOs shall be established.
- b) The vendor shall ensure DCS IO loading is within limits.
- c) Grouping of the controller shall be such that inter controller communication for acquisition and interlock are minimized to its extent.

9.3.10 Control Room

- a) The complete desalination plant operations shall be operated and monitored from four operator stations located in Central Control Room, individual HMI operator workstations shall be envisaged for each 200MLD streams.
- b) The control desk and the associated furniture shall be ergonomically designed as

per standard industrial practices for comfortable working to the operators. The furniture shall comply with the relevant IEC standard for ergonomic design.

- c) Colour Monitors, Keyboards, mouse, printers, Public Address System Master Unit, Walkie Talkie Station, P&T telephone, intercom telephone, CCTV switching unit, Process Log Books, etc. Shall be mounted/placed on Control Desk in appropriate cut outs / suitable arrangements.

9.3.11 Local HMI

Local HMI shall be provided for the field controllers. Local HMI shall be provided at each field process area controllers, which can be used sparingly in case of urgency only. This HMI shall be hooked directly to the controller liable to control functions of the concerned area.

9.3.12 Communication

- a) DCS networks shall be based upon industry standards from IEEE/IEC.
- b) High-Speed Ethernet communication shall be used for monitoring and control of the plant. There shall be two networks, such as Plant Bus and Station Bus.
- c) Plant Bus shall have all Controllers, Application Server, Historian Server, OPC server, and Engineering Station connected to it. Station Bus shall have Operator stations, printer, and GPS clock connected to it.
- d) Ring-type Network Topology shall be followed.
- e) A firewall shall be provided for interfacing the Station bus with other LAN and interfacing outside network.
- f) Level 0 shall contain all field instruments, Profibus DP slave devices such as VSD, Package Vendor PLC's, MOV, Control valve, and electrical switchgear feeders.
- g) Level 1 shall contain all controllers and communication with field devices.
- h) Level 2 shall be having both plant and station bus. This level shall contain all controllers, application server, operator stations, engineering station, Historian server, and GPS clock
- i) Level 3 & Leve 4 shall be an interface to external systems using TCP/IP or Internet
- j) Communication network-level shall be redundant or fault-tolerant paths.
- k) Communications from the controller to the I/O subsystem shall have redundant paths.
- l) Communication shall be designed such that no single failure will degrade the performance of the system. This requirement applies to all communication between controllers to their I/O modules.
- m) Open system Interconnection type data highway shall be provided
- n) Communication speed shall be Min. 100 MB/ sec.
- o) Topology: Bus topology with (two) redundant network having Manageable Ethernet switches. The Bidder shall also ensure that 25% of spare parts are available in ethernet switches.

9.3.13 Alarms and Message Handling

Alarm Management and Optimisation shall be envisaged as per standards during the abnormal and crisis condition.

9.3.14 Displays and Graphics

- a) All displays and graphics that show real-time data shall update automatically when the collection is resident on the screen. Updates shall not require operator initiation.
- b) Special indication shall be used to indicate that a value is invalid.
- c) The update frequency for real-time data displayed alphanumerically and symbolically (shape change, color change, etc.) shall be at least once every two (2) seconds for all displays and graphics.

9.3.15 Diagnostics

9.3.15.1 General

- a) The status of all modules shall be periodically checked to verify the online status and operation.
- b) Errors shall be alarmed with an error message identifying the effected module.
- c) The status of each online module shall be checked at least once per minute.
- d) Diagnostic tools shall provide the following information:
- e) Module status (e.g., online, offline, failed, standby)
- f) Overall Processor loading (CPU) for controllers and other vendor proprietary DCS modules exclusive of I/O Modules.
- g) Network utilization of control network.
- h) Software and firmware (if applicable) version of all modules installed in the system.
- i) System and Diagnostic Displays

9.3.15.2 Communication System Status Displays

Standard displays shall show as minimum as the operational status of the communication system. Each module's state connected to the communication system (online, offline, failed, primarily failed, backup failed) shall be shown.

9.3.15.3 Module Status Displays

Displays shall be provided to show the operational status and error conditions for all system modules down to the card level.

9.3.15.4 Diagnostics

- a) Online and offline diagnostics shall be provided to assist in system maintenance and troubleshooting. Diagnostics shall be provided for every major system component and peripheral. If diagnostics do not exist for a particular peripheral device (for example, printers and terminals), the system must detect and provide

an error indication for these devices' failure.

- b) Online displays shall indicate the results of self-diagnostic tests. Failure diagnosis shall be sufficiently specific to indicate which printed circuit boards, modules, or devices are at fault. The displays shall be designed to help maintenance and engineering personnel diagnose faults in the system and communications paths. Each category of diagnostic display shall be organised hierarchically.
- c) Communications diagnostic displays shall show errors for each of the redundant paths.

9.3.16 DCS Electrical Requirements

9.3.16.1 Power Supply and Distribution

- a) Equipment shall be powered from separate Uninterruptible Power Supply (UPS).

9.3.16.2 Redundancy

- a) All controllers, I/O modules, communication networks, and I/O bus communications equipment shall be fed from redundant UPS power sources.
- b) A single failure of any power supply shall not fail more than one module in a pair of redundant DCS modules. This failure shall not cause a disturbance to the process or result in loss of operator functionality.
- c) Power supplies shall be capable of being removed and replaced without disturbing the other power supplies' operation.
- d) Power supplies for the same voltage rating shall be of the same make and model for interchangeability and spare parts management.
- e) The power supply to a controller, I/O, or communications module is supplied from the chassis or baseplate, which houses the module. The chassis or baseplate shall be fed from two separate power supply circuits. Each circuit shall be provided from different and independent power sources.
- f) Power supply redundancy shall be provided using either an N+N configuration.

9.3.16.3 Power Distribution within DCS Cabinets

- a) Power supplies that feed multiple chassis or base plates shall have their outputs wired to a power distribution panel within the cabinet. The term "power distribution panel" in the above requirement and subsequent requirements of this section refers to a collection of din-rail mounted circuit breakers and/or fused terminal blocks, terminal blocks, and wiring used to distribute power to multiple loads from a single source.
- b) Branch circuits from power supplies shall be individually fused or protected by a circuit breaker.
- c) Terminal blocks in the power distribution panel shall be segregated by voltage level.
- d) Power distribution terminal block wiring shall not be daisy-chained using wires or crimp connectors. Jumper bars or preformed jumper combs designed for the

specific terminal blocks being used are acceptable methods of distributing power supply wiring.

9.3.16.4 Revision Level

- a) All controller and I/O subsystem hardware and other vendors proprietary hardware shall be the latest "field-proven" revision level
- b) All vendor proprietary software, exclusive of application software, shall be the most recent, commercially released, software revision level
- c) All personal computers, monitors, printers, peripherals, Ethernet switches, and other commercial off-the-shelf (COTS) equipment provided by the vendor as part of the system shall be the latest model available
- d) The system shall allow for upgrading of system operating Software on all redundant modules of the system without requiring a shutdown of any process equipment, without losing the operator's view to the process, and without the loss of access to any control function.
- e) Software and hardware upgrades are to be considered and included within the proposal covering the O&M period.

9.3.17 Documents to be submitted during Bid Submission

- a) A filled-in table of Conformance to every part of the specifications. Use a chart format with the specification part identified, indicate whether each element complies, a deviation, or an exception to the specific part. If any exception or deviation, include a narrative description of how the deviation or exception can benefit the end-user.
- b) Provide a written overview of the proposed DCS system, instrumentation system describing the principal functions and capabilities of the system's PC, controllers, system communications, and general system capabilities (maximum number of network nodes, Controllers and I/O points, communication protocols available, etc.).
- c) Provide an equipment list with descriptive literature for the proposed system. Included on the list shall be all major hardware items. The list shall consist of a minimum, the manufacturer, and model numbers. Technical schedules for Instruments, Controllers & DCS shall be duly filled with relevant details.
- d) Provide an operating system and software applications list with descriptive literature for the proposed system. Include all significant software items, supplier name, quantity, and model numbers. Indicate whether any proposed software is proprietary and would not be turned over to the owner.

9.4 Interfaces – External Systems

9.4.1 CP1 – Data towards CMWSSB Control Centre

- a) To link the CP1 Desal plant data to CMWSSB control centre for monitoring and

information purpose, a new interface panel shall be located at the CP2 pumping station, which shall be connected to CP1 desal plant DCS through the FOC link. All analogue and digital signals, as requested by CMWSSB, shall be made available in this interface panel. CP2 scope bidder shall take the CP1 signals from the interface panel towards CMWSSB control centre via CP3 FOC scope.

- b) All equipment (e.g., fibre optic cables, patch panel, patch cords, fibre optic converter, cabinet, etc.) for the interface cubicle required for the connection between CP1 DCS and CP2 pumping station interface panel shall be provided.
- c) CMWSSB SCADA system shall be interfaced with DCS using Modbus TCP/IP for real-time operation.
- d) The scope of signals for interfacing will be decided during the detailed design stage.
- e) To interface CP2 pumping station data towards CP1 DCS, the same interface panel shall be used to transfer data between the pumping station and CP1 DCS.
- f) The parameters and interlocks for operations of CP2 pumping station and CP1 DCS shall be accordingly shared through communication interface.

9.4.2 TANGEDCO / TNEB

- a) The interface point to the TANGEDCO/TNEB shall be the interface cubicle for analogue/ binary signal exchange located at the central power supply receiving station. This interface panel shall be supplied, and installation is as part of the CP1 project scope.
- b) All required equipment (e.g., fibre optic cables, patch panel, patch cords, fibre optic converter, cabinet, etc.) shall be provided.
- c) All signal sharing between the TANGEDCO SCADA and DCS shall be interfaced through this cubicle. The list of signals is to be finalized during the detailed design stage.
- d) The communication protocol between DCS and TANGEDCO/TNEB shall be decided during the detailed design stage.

9.4.3 TN Pollution Control Board / TNCRZ / CMWSSB

- a) The User-specific information shall be made available to the stakeholders TNPCB, TNCRZ, and CMWSSB.
- b) The Webserver shall populate the required information based on user rights.
- c) The list of data for sharing shall be decided during the detailed design stage.

9.5 Cyber Security

9.5.1 Codes & Standards

Material or equipment supplied to this specification shall comply with the latest edition of the references listed below unless otherwise noted

STANDARDS	TITLE
IEC 62443-3-3	Industrial communication networks – Network and system security
ISO 9001	Quality Management Systems – requirements.
IEC 61000-6-2	Electromagnetic compatibility (EMC) – Part 6-2: Generic standards – Immunity for industrial environments
ISA 99	Industrial Automation and Controls Systems Security
ISA-62443-3-3	Security for industrial automation and control systems Part 3-3: System security requirements and security levels

9.5.2 Network Architecture

Ref the tentative DCS System Architecture drawing:
7061563/PMC400MLD/CP1/DCS/001

- a) Level 1 and Level 2 networks shall use physically separate network switches and routers from Level 3 & 4 networks.
- b) IT Components on Level 1 and 2 shall be separated from Level 3 and above by a managed firewall. The firewall policies or rules should be configured such that only required communications are possible.
- c) Level 3 and above systems shall be configured using firewall policies or rules that permit only required traffic. All policies or rules applied to the firewalls not required during the operate phase shall be removed before the handover is run and maintained.
- d) Internet access from IT Components directly connected to Level 1, or Level 0 shall not be allowed, and Internet access from other IT Components shall be:
 - Via the process control access domain proxy and
 - From and to explicitly authorized systems and
 - Specify a fully qualified domain name for the internet host, and
 - Route traffic through the process control access domain firewall.
- e) All unused interface ports (e.g., Ethernet and USB) on IT Components shall be protected against unauthorized access. This includes, but is not limited to, configuration and diagnostic ports or interfaces. This requirement intentionally leaves it to the project to decide on the means of protection, e.g., logical or physical.
- f) Remote user access and remote management access to L4, L3, and L2 network devices shall only be permitted via the firewall.
- g) Access to L1 network devices and below shall be limited to Internal Remote Access.
- h) All IT Components requiring antivirus or patch updates shall be network-

connected where technically possible, thus allowing centrally located services to provide these updates. This allows for centralized management and monitoring of IT Components.

9.5.3 Firewall

All firewalls implemented shall be state-full inspection hardware firewalls. The firewall rules shall be configured to deny all traffic except for the traffic, which is required explicitly for the system.

Firewalls shall be subject to a rule set review at least annually, to ensure that only the necessary traffic is permitted.

9.5.4 Access Control

- a) All network traffic between Level-2 and any other domain SHALL be through a secure firewall solution unless an IP connection is impossible. If and where non-IP modems are used to access a Level-2 IT Component, the following shall apply:
 - The modem shall be physically disconnected or disabled when not in use, and
 - A documented procedure for monitoring remote user activities when the modem is in use shall be applied. This procedure shall be reviewed and approved by the IT Security Accountable Manager.
- b) If in case external remote user access to Level-2 applications and IT Components is required, this shall be authenticated with the following minimum criteria:
 - Two-factor authentication, or
 - One-time password.
- c) External remote user access accounts shall be locked after six consecutive failed authentication login attempts.
- d) The Level-2 shall provide the capability of restricting and terminating any external remote user access session:
 - Manually by the administrator, or
 - Automatically by specifying an allowed session time, and upon exceeding the specified session time
- e) IT Components at Level 2 requiring system-to-system access to the Internet via the proxy service shall be isolated in one or more dedicated VLAN(s). The firewall policy of the firewall protecting the Level 2 network shall be configured to allow outgoing only connections from the Level 2 IT Component IP address to the proxy IP address.
- f) Each IT Component in the network shall have a documented procedure for applying system hardening techniques from the Supplier, the original manufacturer (e.g., Microsoft™), or the Center for Internet Security (CIS) or NIST. The procedure shall include Supplier endorsement.
- g) Before commissioning, all IT Component elements that are not required during the operate phase shall be removed; at a minimum, the following shall be

reviewed and removed if not needed:

- User accounts and groups
- Applications, utilities, services

9.5.5 User Groups and User Roles

- a) The system shall be capable of defining user groups or user roles. System access privileges shall be configurable for each user group or user role. Individual user privileges shall be determined based on the user group/role to which they are assigned.
- b) The system shall be capable of defining the following user roles as a minimum:
 - View Only
 - Plant Operator (1 – 10 plant operator roles shall be specifiable)
 - Process Supervisor
 - Engineer
 - System administrator

9.5.6 Operating System Security Patches

- a) Patches shall be approved (qualified) by the system Supplier before installation.
- b) There shall be a procedure for the installation of qualified emergency patches
- c) An exposure level shall be determined for each IT Component in scope to apply operating system security patches. Per the applicable component, one of the following exposure levels shall be determined and stored in the asset inventory:

Low	Qualified patches will be applied at least once every 12 months during the operating phase.
Medium	Qualified patches will be applied at least once every 6 months during the operating phase. At a minimum, this includes systems designed to use portable media and/or network file transfer during their normal course of operation.
High	Qualified patches will be applied at least once every 3 months during the operating phase.

9.5.7 Event Log Management

The log files shall, at a minimum, include the following information:

- a) For Microsoft™ Windows®-based IT Components:
 - Account login failures.
 - Discovery of an infected file.
 - Shutdown and restart.
 - Change to the event logging configuration.

- Account password change and reset.
 - Account, group, and OU addition, deletion, or group membership change.
 - Microsoft™ Windows® group policy modifications.
 - Successful system administrator and operator logons shall be logged.
- b) For other IT Components (i.e., Unix systems, switches, routers, and firewalls):
- Account login failures.
 - Discovery of an infected file.
 - Shutdown and restart.
 - Unauthorized devices.
 - Change to the event logging configuration
 - Account password change and reset.
 - Account addition, deletion, or group membership change.
 - Configuration changes.
 - Successful system administrator and operator logons shall be logged

9.5.8 Antivirus

- a) IT Components supporting antivirus software shall be checked for computer viruses before being installed into or connected to the network.
- b) Antivirus software shall be configured to automatically scan files accessed by the IT component and configured to log and notify malware-infected files.
- c) The impact of a full antivirus scan on the operational performance of the component shall be evaluated when determining the frequency for performing the full scan and use of automated or manual full scans on the IT Component

9.5.9 System Hardening

- a) Removal or non-installation of software and functionality that is not required for the system's intended functional purpose; e.g., E-mail, office applications, games, USB ports, Bluetooth, and Wi-Fi communication, etc.
- b) Physical and logical access to diagnostic and configuration ports shall be protected.
- c) All unused ports on switches and routers shall be disabled to prevent unauthorized access to the network infrastructure.
- d) The Supplier shall demonstrate the use of hardening guidelines, tools, and instructions from either the original manufacturer (e.g., Microsoft®) and/or reputable organizations (e.g., NSA security configuration guides, NIST).

9.5.10 Backup, Restore, and Disaster Recovery

- a) The system shall be backed-up at [user defined] intervals that fulfill the data restore and disaster recovery objectives for the system.
- b) A backup shall be completed before an engineering change being made to the hardware or software, e.g.:
 - Installing an operating system patch or upgrade

- Hardware modifications
 - Before a change is made for which automatic roll-back is impossible
 - After modifications to the system (scheduling changes, authorization and authentication changes, process trip, or application changes).
- c) The following types of data shall be backed-up:
- Operating system files
 - Applications (including middleware, such as an OPC tunneller)
 - Configuration data
 - Database files
 - Log files
 - Electronic logbook
 - Unconventional file types; e.g., network equipment settings, DCS controller settings (tuning parameters, set points, alarm levels, etc.), field instrumentation parameters, and Microsoft® Active Directory
 - Other files, identified by the Supplier, are required to create a complete backup of the Supplier's system.
- d) The vendor shall provide detailed instructions on making a full backup of its system using at least one of the four methods below.
- Proprietary backup architecture on removable media
 - Single system backup architecture on removable media
 - Distributed backup architecture
 - Centralized backup architecture

9.5.11 Remote Access

Where there is a requirement for remote support of DCS systems, secure connectivity solutions shall be implemented to ensure that:

- Communications outside of the electronic security perimeter are encrypted;
- User accounts authenticate users with passwords which conform at least with the baseline password standard;
- User privileges are restricted to only those required to fulfill remote support roles.
- Connectivity for remote access shall only be available when required and authorized, i.e., remote access connectivity shall not permanently be in place.

9.6 Spares

9.6.1 Equipment Spares

- a) After Commissioning of the system, at least 20% installed spare capacity shall be provided for each type of I/O module, and 20% spare software tags shall be provided in DCS

- b) At least 20% of spare terminals, PDB circuit breakers, and cable trunking shall be provided.
- c) Within each system cabinet, at least 20% spare card/module positions shall be available for future modifications within the racks.
- d) The software (application) spare capacity for the communication connections to third party devices shall be at least 20%
- e) Loading on the control processors shall not exceed 60 % of its capacity
- f) Future spare space shall be 10%

9.6.2 Spare Parts

- a) The Bidder/EPC/Vendor shall provide any special tools, spare parts required for permanent installation at the site as part of the supply.
- b) These shall include all non-standard equipment needed to perform installation and maintenance. All special tools are to be supplied in the sectionalised purpose-built cases with hinged lids.
- c) The vendor shall indicate the list of recommended tools, spare parts, etc. to be maintained by the O&M Contractor during the operational period.
- d) The vendor shall supply all spare parts & consumables required for installation and commissioning operation based on vendor recommendation.
- e) Spare parts and consumables for two years of commercial operation after commissioning operation.

9.7 Reporting System

This section describes the basic design and requirements for the Reporting system. The offered system shall collect all relevant data mentioned below to produce a consolidated monthly report:

- Water Production metering
- Water Quality verification
- Plant availability
- O&M performance verification
- O&M report backing and analysis.

Accordingly, this functional specification forms the basis of the design, engineering of the hardware and software components, selecting the right make and model, including software licenses required to be engineered by the Contractor in close co-ordination with CMWSSB.

9.7.1 International Standards

STANDARDS	TITLE
ISO 4064	Measurement of Water Flows in Closed Conduits - Meters for Cold Potable Water (Parts 1, 2 and 3)

STANDARDS	TITLE
OIML R 49	Water Meters Intended for the Metering of Cold Potable Water
ISO 7066-1	Measurement of Liquid Flow – Assessment Of Uncertainty In The Calibration And Use Of Flow Measurement Devices.
BS EN 14154-1	Water meters. General requirements

9.7.2 Design Requirements

- a) A highly reliable, secured and tamper-proof automatic reporting system shall be proposed to measure, collect, register and report all relevant data to produce an accurate monthly report.
- b) The proposed system shall perform data collection of :
 - Product Water dispatched to the transmission system, interfaced from Water flowmeters
 - Electricity consumption of the Plant, interfaced from the Plant main incomer Electricity Energy Meters
 - Product Water Quality, interfaced from DCS
 - Maintenance Report including the preceding /current /succeeding month maintenance work order/reports from CMMS (Maintenance Management System)
 - Plant/rack Availability Data from DCS
 - Seawater Quality data from DCS
 - Any other relevant data as required by CMWSSB
 - Any Manual input data which aids in reporting
- c) The data collected shall then be validated and shall be stored or marked for report generation.
- d) The system and the data should be secure and tamper-proofed
- e) Security of the system shall be as per the Cybersecurity hardening referred to in section:9.5
- f) Appropriate secured two-factor sign-in authentication to be implemented for the system, such that CMWSSB should authenticate any configuration login
- g) The data collection and the validation process shall perform the following function:
 - i. Establish robust data, flagging any discrepancies or integrity issues
 - ii. Identify potential metering equipment and communication links failures
 - iii. Identify unauthorised interference or manipulation of data
- h) For accurate Product water dispatch measurement and data validation, Data loggers shall be used.
- i) The data logger data acquisition should cover both the main and check water flowmeter. The flow meter's pulse train output shall be programmed to provide a pulse when a certain amount of (m^3) water is dispatched or passed through the flow meter.

- j) The data logger shall accept or count the pulse train and calculate the totalised quantity flow. The collected water data is then pushed or acquired by the reporting system for reporting purpose.
- k) The electricity tariff meters' data collection should be from the plant main power incomer line energy meters.
- l) The data acquisition shall be done both for the main and check energy tariff meters. The tariff meters shall communicate in the IEC-62056-21 metering protocol or any standard metering protocol. The reporting system and related components shall support the envisaged protocol.
- m) CMMS data should cater to the consolidated reports as required by the reporting system
- n) All interfaces to DCS and CMMS shall be interfaced through communication interface with a proven industrial standard protocol
- o) All measuring equipment shall be designed, procured, and commissioned as per the Indian Grid Code.
- p) The Water Metering device Main and Check flow meter shall be of the electromagnetic flow-through type with a minimum accuracy of 0.2% at flows between 15-110% nominal flow. The flowmeters shall meet the general requirements of ISO 4064/OIML R49 and the accuracy classes set.

9.7.3 System Configuration

- a) A high reliable reporting system shall be proposed to provide accurate reporting data during each reporting period, i.e. calendar month.
- b) The reporting system shall have the option to produce Manually triggered reports.
- c) The Reporting system shall comprise field mounted outstation or meters pulse interface, DCS interface, CMMS interface, Interface Unit (IU), Reporting system, and failsafe communication system to interconnect all components.
- d) The outstation unit shall consist of data logger's which receives the pulse from the water meters and perform logging and processing of data before transmitting it to the reporting system
- e) The reporting system shall be an industrial computer-based system with two redundant dedicated servers and one operator station. The data shall be acquired from all the interfaces, i.e. from the Interface Unit(IU), Distributed Control System (DCS) and Computerized Maintenance Management System (CMMS) on a routine basis; the acquisition time shall be user-definable.
- f) Archiving shall be done at the Reporting System computers.
- g) FO based communication shall form the backbone of communication connecting the flow meter MIU and Ennerymeter to the Reporting system.

9.7.4 Data Storage

The data shall be archived as per the table below as minimum parameters on equipment identification, equipment measurement, time, and any other data requested by CMWSSB to be included as mandatory within the archived data.

Period	Back-up Frequency	Retained for Minimum	Remark
Day data	End of day	One week	Each hour back-up stored separately
Week data	End of week	One month	Each week back-up stored separately
Month data	End of month	One year	Each month back-up stored separately
Monthly finalised settlement data	First of the subsequent month	Ten Financial years	Each month back-up stored separately
Financial years	End of year	Twenty Financial years	Each year back-up stored separately

9.7.5 Redundancy

Redundancy shall be taken into consideration at all levels, from the hardware level to the data level. Storage of data shall be proposed with RAID function. No single point failure of hardware or data shall directly or indirectly affect the Reporting system's normal required function or any other auxiliaries.

9.7.6 Time Synchronisation

Time synchronisation shall be envisaged, and the time shall be synched with Control system time or from the GPS clock. The vendor shall provide time synch resolution.

9.7.7 Security

External or remote access to the system shall be monitored and governed; the latest technology firewall and router shall be envisaged.

The system shall maintain separate user accounts for each user for accessing the system

All the instrumentations and data acquisition devices shall be assembled inside a panel; any panel or instrumentation access should be authorized and logged into the reporting system.

Instrumentation configuration should be accessible through user credential rights, and all credentials are to be authorized in the two-factor authentication.

The reporting systems shall be interfaced to the CMWSSB web portal through a secured data interface, and the data shall be published on to the public web-portal.

9.7.8 Datalogger Water Meter

The water meter data logger shall be capable of recognising 10 msec digital impulse from the flow meters. Each pulse represents a value represented by meter constant. The pulse

shall be counted, multiplied as per the meter constant in the data logger. The values then shall be available as load profile data. The data shall be stored in the data logger periodically. The data collected shall then be transmitted to the reporting system database after validation.

Time synch pulse from the GPS or the DCS shall be considered to synchronise the time accurately accordingly when a report is published, the time integrity is maintained.

The flow meters shall be programmed to provide pulsed outputs with the impulse shall be free programmable, which shall be acceptable by the data loggers.

Two data loggers shall be provided. The Main and Check flow meters shall be interconnected to both the dataloggers, which will aid in data validation and duplication.

Data loggers shall store all meter data collected by the meters, including alarms, for a minimum of forty days.

9.7.9 Product Water Meter - Flow data

9.7.9.1 Meter Registration

The Contractor is required to register in writing with CMWSSB, the Metering System.

Registration information shall include the Contractor respective identities, loss adjustment details whether by meter biasing or software and full technical description of the Metering Equipment, single-line drawings of the installation, and all applicable calibration/approval documentation applying to the specified equipment following the procedures. Such registration shall be subject to CMWSSB confirmation that the Metering System is compliant for billing.

9.7.9.2 Water Meter - Electro Magnetic Flowmeter

- a) Flow transducers shall be rugged in construction and shall be suitable for continuous operation. Flow transducers shall have waterproof construction and shall be suitable for installation in underground/above ground applications.
- b) To avoid the effects of disturbances in the velocity profile, a straight and uninterrupted run, upstream and downstream from the flow sensor's location, shall be provided in accordance with the requirements of the flow meter manufacturer.
- c) A product water metering flowmeter shall have an accuracy of 0.1% at flows between 15 - 110 % concerning the nominal flow.
- d) Flow sensing element shall be fully compatible with the fluid to be measured, process temperature, and the ambient conditions and shall not deteriorate under normal operating conditions.
- e) Flow meters shall be designed to operate on 230 VAC power supply, and a 10% variation in power line voltage shall not affect the meter output accuracy over 0.1 % of the full scale.
- f) The remote mounted transmitter is preferred, and it shall be located for easy access.

- g) The transmitter shall be a smart type with outputs including Fieldbus, 4-20mA (HART), programmable Pulses, and programmable relay discrete output. The transmitter shall include flow rate, alarm monitoring, self-diagnostics, and forward/reverse/net flow totaliser.
- h) The measuring electrode, the reference electrode, and the empty pipe detection electrode shall be inbuilt, and the type of electrodes shall be manufacturer specifics based on the process fluid.
- i) Flowmeter shall be provided with inbuilt grounding electrodes, and the material shall be the same as the sensing material. Insulation flanges, gasket, and copper shall be provided as required.
- j) Flowmeter flanges shall be in accordance with ANSI / ASME.
- k) If the pipework has cathodic protection, the manufacturer's recommendations for bonding and protecting the instrument and its signals shall be adhered to.

9.7.9.3 Inspection, Testing and Calibration

- a) Bidder/EPC shall ensure that all Metering Equipment registered with CMWSSB shall be calibrated to meet the accuracy requirements according to the Code.
- b) CMWSSB shall be granted access to all such Metering Equipment and any other plant or apparatus on any site in order to inspect the basis of any adjustments made to Metering Equipment.
- c) Calibration shall be undertaken using working standards that have traceability to suitable reference standards verified at an Accredited Laboratory.
- d) No calibration adjustment shall be carried out to any Metering Equipment outside of an internationally Accredited Laboratory with traceability of calibration techniques i.e. ISO 17025.

9.7.9.4 Site Verification testing

Bidder/EPC shall carry out a routine test of the accuracy and/or verification of all Metering Equipment performance.

9.7.10 Product Water Quality Data

- a) The product water quality data are to be interfaced through DCS.
- b) In principle, the monitoring equipment must comply with the requirements set out in Seawater Quality Monitoring, Product Water Quality Monitoring and outfall discharge water quality monitoring requirements.
- c) According to ISO standards, the Plant shall be equipped with a laboratory that allows testing of all relevant parameters.
- d) Scope of analysers to be harmonised and frozen in discussion with CMWSSB and PMC, during the detailed design stage.
- e) All analysers shall be industrial type, proven design, robust construction, low maintenance, and suitable for the intended application.
- f) The analysers shall be selected based on reagent less or reagent free operation.
- g) 2oo2 voting to be proposed for the continuous online analysers.

- h) Multi-parameter type analysers shall be used, but transmitter output shall be individual and dedicated per each parameter.
- i) Analysers shall be installed in analyser panels if a cluster of analytical equipment exists in an area. Analyser panels shall be installed within a sheltered spot; when a circumstance requires the outdoor installation, a suitable shelter shall be provided to protect from direct sunlight and rain.
- j) The analyser panel shall be made of a Plastic UV resistant panel or vendor standard material to withstand the climatic condition.
- k) A suitable drain arrangement shall be provided where required.
- l) Analyser cabinet with air-conditioner shall be provided for analyser were required based on manufacturer recommendation.
- m) The analyser cabinet shall be made of GRP or FRP with a minimum degree of protection of IP67.
- n) Refer to ICA section 9.2.3.4 for more specific details.

9.7.11 Plant / Rack Capacity Data

The reporting system shall gather the “RO Rack IN-Service” data from the DCS, and this data shall be interpreted as plant capacity data. The Reporting system's interface shall be through OPC or any feasible communication finalized during the detailed stage.

The frequency of data fetching shall be user-configurable, the data shall be available on 24 hours basis.

9.7.12 Plant Maintenance Data CMMS

The Maintenance Management System (CMMS) shall be interfaced to the Reporting system using OPC interface or any feasible communication to be decided during the detailed design stage.

The CMMS shall interface data related to the summarised work orders data during the current month and the preceding month. An additional report shall be included within the data interface to cover works-related to the commencing months, including the planned work orders.

This CMMS report interface will ensure that the plant maintenance has been carried out as per the requirements and shall monitor the O&M performance.

Minimum following data's are to be made available for the reporting system:

- Calendar report on Work order status Current and Preceding Month
- Planned Work order for succeeding month
- Breakdown Maintenance report

9.7.13 Reports

The reports shall be available by default monthly. The Reporting system shall be configured such that user-triggered reports shall be available on demand.

The report formats shall be finalized during the detailed design stage in close co-ordination with CMWSSB and PMC.

9.8 Operation Control & Monitoring Strategy

The following Operation, Monitoring, and Control strategy section set forth the essential specific requirement for safe operation and control of the SWRO desalination Plant. The listed requirements presented here in this section are intended as minimum recommendations and provide general guidelines and establish minimum system requirements.

It is the responsibility of the Bidder/EPC to design each system that meets all criteria defined in this document as well as to achieve SWRO Desalination Plant operation, availability, guaranteed performance, operational flexibility, and durability (and service life) of the asset. In close collaboration with CWSSB and PMC.

9.8.1 Seawater Intake System

9.8.1.1 System Description

Seawater enters the plant through the intake pumping station. The intake system consists of:

- a) Intake pump station: with pumps equipped with VFDs, regulating the flow of raw water according to water demand delivers the raw seawater to the pre-treatment system.
- b) Screens: Mechanical screening equipment consisting of rotating band screens (mesh \leq 5mm) provided upstream of the intake pumps for screening debris and marine organisms. Spray jets arrangement shall be provided to clean the band screen.
- c) Sodium hypochlorite Dosing: To prevent the growth of marine organisms in the intake structure
- d) Airburst system: Jellyfish prevention system

9.8.1.2 Instrumentation

- a) Instrumentations are to be envisaged as per the instrumentation requirements referred to in section 9.2.
- b) As a minimum following instrumentation is to be provided, but not limited to:
 - i) Total Hydrocarbons, at intake forebay
 - ii) Turbidity at intake forebay
 - iii) Conductivity at intake forebay
 - iv) Temperature at intake forebay
 - v) Oil in water analyzer
 - vi) pH, at intake forebay
 - vii) Chlorine, at intake forebay

- viii) Parameters listed in the Seawater Intake Quality specifications
 - ix) Level for intake chamber, intake forebay, and Pump bay
 - x) Flow and Pressure for Pump discharge
 - xi) Protection and Condition monitoring for the pumps
 - xii) Any other device required to meet the operations, guarantee, and environment.
- c) Instrumentations to ensure the raw seawater is within the design envelope and to provide sufficient information to adjust the Pre-treatment process.
 - d) Instrumentation shall be sufficient to operate and follow over the project life of the pumps and associated equipment.
 - e) Any other instruments to achieve SWRO Desalination Plant operation, availability, guaranteed performance, operational flexibility, and durability (and service life) of the asset.

9.8.1.3 Automation Control Strategy

- a) Intake Pump Flow: The intake pump station shall be demand driven by the RO requirement and maintain the RO feed water tank level. During the plant's initial startup, the intake pump station level control loop shall control the RO feed water tank level maintaining at 95%. Once the RO trains are functioning, the seawater pumping station control loop shall switch to a cascaded control loop maintaining the RO flow demand and the RO feed water tank level.
- b) Combined control system control loop programming and the VFDs tuning shall consider operating the pumps at its best efficiency point. If the intake flow is suspended for any reason, including non-routine, this shall trigger an automatic intake pump shutdown sequence.
- c) Intake Pump Flushing: Flushing with service water shall be incorporated during the pump stopping sequence to avoid long time contact of seawater with the idle pump.
- d) Intake pumps Screens Cleaning: There will be a consistent spray of water to clean the traveling screen. In case manual cleaning is needed, the screens cleaning sequence will be controlled based on level difference or based on the timer for scrapping and cleaning.
- e) Chlorine Shock dosing: Timer or intermittent dosing shall be envisaged for the intake pipeline as per the Operator decision, the dosing system to maintain the dosing > 12ppm. Simultaneously a flow controlled dosing to be envisaged for the intake forebay.
- f) The flowrate on the seawater supply pumps' discharge shall regulate the coagulant, flocculants, and acid dosing rates towards the Pre-treatment system.

9.8.1.4 Key Operational Monitoring Points

- a) Following seawater parameter shall be continuously monitored, appropriate alarms should be raised with high priority:
 - Low Intake Well Water Level at intake forebay

- High TOC, at intake forebay
 - High TDS (Conductivity), at intake forebay
 - High Turbidity, at intake forebay
 - High Temperature, at intake forebay
 - High pH, at intake forebay
 - High Chlorine, at intake forebay
 - High Oil level, at intake forebay
 - High/Low Flow, Pressure & Level, for pumps & intake forebay
 - Loss of REMOTE status and Measurements from connected devices
- b) Pump Condition Monitoring: The condition monitoring system alarms are set as per the Original Equipment Manufacturer (OEM) limits. All warnings are to be configured as high priority alarms.
- c) Dry run protection: The pumps shall be protected from running dry by appropriate hardwired and software interlocks. The level measurement readings are to be considered the early warning and proper actions to be taken by the operator.
- d) Other monitoring and safeguarding strategies align with the instrumentation design criteria philosophy referred to in section 9.2.2.

9.8.1.5 Critical Control Point, CCP-1:

- a) Seawater Intake, Oil, Turbidity and Hydrocarbon CCP-1
The intake pump control system shall incorporate provisions to alarm at the high seawater quality parameters' level above the acceptable limits. Provision shall be there to automatically shut the pumps and the intake structure(Gates) connected to the seawater supply line; if seawater Oil, Turbidity and Hydrocarbons are excessively high beyond the limit. Appropriate instrument voting should be provided for the instrumentation reading the parameter.
- b) Instrument voting on (2oo2) shall be provided, thus avoiding damage to the downstream plant.
- c) The automatic closure or shutting must not result in transients that cause damage to any of the infrastructure.

9.8.2 Pre-Treatment System

9.8.2.1 System Description

The Pre-treatment system aims at transforming the raw seawater into feedwater for the RO membranes. Pre-treatment facilities shall be provided ahead of the RO system to protect the integrity and consistent performance of the downstream cartridge filters and reverse osmosis membrane system. The pre-treatment system will:

- Remove suspended and settleable colloids and particles.
- Achieve a pre-treatment product water quality

9.8.2.2 Instrumentation & Monitoring:

- a) Instrumentations are to be envisaged as per the instrumentation requirements referred to in section 9.2.
- b) As a minimum following instrumentation is to be provided but not limited to:
 - i) Chlorine Residual, before Cartridge filters
 - ii) pH, before Cartridge filters
 - iii) Conductivity, before Cartridge filters
 - iv) Temperature, before Cartridge filters
 - v) Boron, before Cartridge filters
 - vi) SDI before Cartridge Filter
 - vii) Any other Quality Analysers to monitor the performance of the Pre-treatment
 - viii) Pressure and Flow measurements for all associated pumps and discharge lines
 - ix) Protection and Condition monitoring for the pumps
 - x) Any other device required to meet the operations, guarantee, and environment
- c) Instrumentations to ensure RO feed Water meets the quality and quantity for the RO process.
- d) Any other instruments to achieve SWRO Desalination Plant operation, availability, guaranteed performance, operational flexibility, and durability (and service life) of the asset.
- e) All pumps of Backwash Pumps, Scour Blowers, Filtrate Pumps, Maturation pumps, and other equipment shall be monitored. All ancillary equipment should be arranged on duty/standby and provided with a VSD to ensure efficient operation.
- f) Instrumentation shall be sufficient to operate and follow over the project life of the associated equipment

9.8.2.3 Process Strategy

The Pre-Treatment system installed on the plant shall be equipped with Coagulation, Flocculation chambers, Lamella Filters, DAF, and DMF.

a) Flash Mixing

The coagulant dosing provides a positive charge in the form of metallic cations that destabilize the particles' natural negative charge. The metallic cations combine with hydroxide in the water to form a metallic hydroxide that is an insoluble compound. The destabilized particles and metal hydroxide precipitate after agglomerating into small visible particles called flocs.

b) Flocculation Chamber

The flocculation reagent added to the seawater eases the formation of flocs. A complete line for its preparation and dosage has been included. This reagent is added to the seawater before the flocculation chambers (with low-speed mixing).

c) Lamella Filters

Lamella filters are to be designed and supplied by OEM; Lamella filters shall be designed to remove 90-95% of the suspended solids from the raw seawater. The collected turbid materials shall be drained from the filter to the wastewater tank periodically. The effluent from the lamella filters flows into the DAF.

d) DAF

Dissolved Air Floatation (DAF) system shall be operated to reduce the light TSS particle in seawater. The DAF system shall be instrumental if the algal blooms' occurrence prevents the desalination plant operating at the design availability of 98% and/or complying with the water quality requirements of the pre-treatment system.

The DAF uses microbubbles that cause the coagulated and flocculated particles to float onto the clarification basin's surface. If the raw seawater condition concerning Turbidity and algal measurement is within range and not very bad, recycling and micro bubbling processes will be held in standby mode. In this operational mode, the seawater will pass the DAF without treatment.

The operator will determine the micro bubbling floatation operation according to the conditions of the raw seawater and requirements in the downstream DMF.

e) GDMF

Effluent from DAF flows into DMF, which contains anthracite and Silica in each Bed. Adequate size and Layer thickness to be specified by the Bidder/EPC. When gravity filters are chosen following objectives are to be considered as a minimum:

- Low energy consumption
- Capacity to deal with essential loads of suspended solids and other contaminants
- To deal with fast variations
- The quality of the obtained filtered water is steady
- Very low or none, chemical product needs

The backwashing system shall be provided with all pumping setup and scenario to maintain the GDMF performance. Maturation pumps shall be provided to recycle the bed rinse water back to the filter inlet channel.

f) RO FEED Water and Backwash Tank

After the gravity filtration stage, the filtered water is collected into an inline tank with two compartments first one compartment for backwash overflowing to the second compartment to ensure the backwash reserve is always maintained full.

Filtered water is forwarded to the RO system's inlet, through the cartridge filters, utilizing RO Feed pumps. Two types of RO feed pump (HPBP to HPP) with discharge pressure to satisfy HP NPSHr conditions and (ERDBP to ERD) with minimum pressure to feed ERD to pressure the brine to the outfall tank.

9.8.2.4 Automation Control Strategy

a) GDMF Backwash

Gravity Media Filters are to be back washed automatically. Filtered water stored

in the filtrate storage tank shall be used for filter backwash.

The following shall be the minimum procedural steps in Backwashing; the Bidder/EPC shall optimize the Backwash step and timing as per performance requirement:

- Drain step
- Air scouring step
- Venting step
- Backwashing step
- Rinsing step

Backwashing programming shall be triggered by controlling the water level inside the gravity filters, the difference of flow between the filter inlet and output, and the Turbidity of the filtered water. It shall be possible to determine the necessity of cleaning the filter beds. Alternatively, a Timer based on 24hr countdown shall be used as an option once a filter is sequenced into filtration mode.

b) RO Feed Water Pumps

The flow rate from the RO feed transfer pumps' discharge shall be controlled automatically by the pressure and flow control of the RO demand.

c) Sea Water Intake Dosing

The flow controller on the seawater supply pumps' discharge shall automatically regulate the coagulant, flocculants, and acid dosing rates towards the Pre-treatment system proportion to the feed flow rate.

d) Pre-Treatment Chemical Dosing

Several dosages of chemical reagents are present in the Pre-treatment System. These dosages' objective is to prepare water characteristics to those required by physical pre-treatments and RO stages. The following sections include a description of this part of dosing:

- Coagulant Dosing

Flash mixing is done in the Coagulation chamber after injection, coagulant and polymer are mixed with a mixer impeller running at 40-100 RPM, and contact time about 20 seconds.

- Flocculant Dosing

Slow mixing is done in the Flocculation Chamber with slow mixing impeller running at 3-6RPM and contact time about 20min.

e) All chemical feed dosing rates shall be tuned, optimized, and sent via the plant control system.

f) A presentation of the dosing points are included in the CCP drawing 7061563/PMC/400MLD/CP1/PFD/001, and final dosing points are to be optimized by the EPC.

9.8.2.5 Key Operational Monitoring Points

a) Level transmitter installed in the RO Feedwater tank shall be used to prevent the RO feed transfer pumps and GDMF backwash pumps from starting if the tank level is low, high priority alarms are to be configured.

- b) Following filtered water parameter shall be continuously monitored before pumping towards Cartridge filter, appropriate alarms should be raised with high priority:
 - High Turbidity, before Cartridge filters
 - High pH, before Cartridge filters
 - High Boron, before Cartridge filters
 - High Residual Chlorine, before Cartridge filters
 - High SDI, before Cartridge Filters
 - High / Low; Flow, Pressure, and Level, for associated pumps and tanks
 - Loss of REMOTE status and Measurements from connected devices
- c) Pump Condition Monitoring: The condition monitoring system alarms are to be set as per the OEM limits. All warnings are to be configured as high priority alarms.
- d) Dry run protection: The pumps shall be protected from running dry by appropriate hardwired and software interlocks, the readings from the level measurement to be considered as the early warning and appropriate actions to be taken by the operator
- e) Other monitoring and safeguarding strategies are in line with the instrumentation design criteria philosophy referred to in Section 9.2.2.

9.8.3 Reverse Osmosis System

9.8.3.1 System Description

The RO system envelopes the following:

- RO Feedwater Conditioning.
- RO Membrane Trains.
- Membrane Cleaning System.
- Membrane Flushing System.

9.8.3.2 Instrumentation & Monitoring:

- a) Instrumentations are to be envisaged as per the instrumentation requirements referred to in section 9.2.
- b) As a minimum following instrumentation is to be provided but not limited to:
 - i) Instrumentation and Controls to Protect the Integrity and Life of the RO Membranes
 - ii) ORP(Redox), after cartridge filters
 - iii) Turbidity, after cartridge filters
 - iv) pH, after cartridge filters
 - v) Conductivity, after cartridge filters
 - vi) Temperature, after cartridge filters
 - vii) Differential Pressure Measurement
 - viii) Pressure and Flow measurements
 - ix) Protection and Condition monitoring for the pumps
 - x) Any other device required to meet the operations, guarantee, and environment.

- c) Any other instruments to achieve SWRO Desalination Plant operation, availability, guaranteed performance, operational flexibility, and durability (and service life) of the asset.
- d) RO instrumentation shall be sufficient to implement the membrane follow up (as per membrane supplier recommendation), in particular, NSP (Normalised Salt Passage), NDP (Normalised Differential pressure), NPF (Normalised Permeate flow).
- e) An instrument station equipped with Residual Chlorine, Redox, Conductivity, Turbidity, and pH instruments shall be installed to monitor quality before the reverse osmosis membranes.
- f) The cartridge filters shall be equipped with a differential pressure meter with high differential pressure alarm.
- g) HP Pumps, Booster Pumps, RO Feed pumps, CIP pumps, and Flushing pumps shall be monitored. All ancillary equipment should be arranged on duty/standby and provided with a VSD to ensure efficient operation.
- h) Necessary instrumentations to follow over the project life on the performance of membranes, to trigger CIP operation (and follow CIP efficiency), and to trigger membrane replacement.

9.8.3.3 Process Strategy

a) RO Feedwater Conditioning

Pumped filtered RO feed water to the RO system shall be conditioned to remove residual oxidants, prevent scale formation of the membrane elements, and provide a final barrier against incidental particulate breakthrough from the pre-treatment system.

Anti scalant shall be injected into the low-pressure feed stream to prevent sparingly soluble salts' precipitation in the RO concentrate stream. Scale inhibitors (antiscalants) shall be used to control mainly carbonate, sulfate, and calcium fluoride scaling. Preparation and dosing systems have to be considered.

The feedwater must be de-chlorinated to prevent oxidation of the RO membranes. The feed water to the SWRO system shall be treated with sodium bisulfite when the oxidation-reduction potential in RO feed water exceeds 250 mV. Similarly, an online Boron Analyzer shall be provided in the RO feed pump discharge to measure the Boron content and appropriately dose NaOH. Chemical preparation and dosing systems for Sodium bisulfite and NaOH to be considered.

The retention of the final particulate barrier in the pre-treated water shall be achieved through cartridge filtration sized $\leq 5 \mu\text{m}$. These filters' function is to protect the RO HPP and RO membranes from contamination introduced after the pre-treatment system and/or failure or breakthrough through the membrane filters/granular media filters.

b) RO Membrane Train

RO Membrane Train is a stand-alone modular unit incorporating a high-pressure feed pump, pressure vessels with membrane elements installed on racks, vessel

manifold piping, permeate header, and concentrate header flow control, booster pump, ERD, associated instrumentation, and valves. The train shall be operated manually from the local control panel and control system.

c) Membrane Cleaning System

Membrane Cleaning System is a permanently piped clean-in-place (CIP) system to clean membranes in each RO train in-situ. Cleaning solutions shall be prepared in a cleaning solution storage tank(s) and pumped through the train vessels being cleaned via dedicated solution feed and return pipe headers.

Membrane Cleaning system the capacity of the installed cleaning solution storage tank(s) shall be sufficient to clean all vessels from a single batch of prepared solution. In addition to the cleaning solution feed and return connections on the feed/concentrate manifolds of each train, individually isolated return connections shall be provided on each train's permeate header to recycle permeate created during cleaning back to the cleaning solution storage tank(s). The system shall be designed to mix and recirculate a range of other cleaning chemicals made up of RO permeate

d) Membrane Flushing System

Membrane Flushing system is a permanently piped membrane flushing system that automatically flushes vessels of the RO trains along with the high-pressure pump within 30 minutes of a shutdown to remove residual concentrate or as stipulated in the RO membrane warranty. The Flushing shall be accomplished using the RO system permeate, which does not contain post-treatment chemicals. The flushing shall be done simultaneously for the RO pumps and membranes.

9.8.3.4 Automation Control Strategy

a) RO Membrane Train

Each train shall be fed, discharge, and controlled independently from the other trains, and each train shall be capable of being started and stopped from the control system interface terminal(s). Configurable operating parameters shall include the train permeate flow setpoint and recovery set point.

Automated control sequences shall be developed to start up individual trains, monitor train performance during operation, shut down trains (under both emergency and non-emergency conditions), and flush trains. The control system shall be configured to allow operators to select individual trains for operation; or input an overall system setpoint, designate trains available for operation, and enable the control system to determine trains for operation.

The system shall receive status feedback from all controlled devices (e.g., ON, REMOTE, OPEN, CLOSED, etc.) to confirm that all devices are in the correct operating mode and that requested control actions are successfully implemented. System operation shall require all associated devices in the REMOTE or AUTO operating modes before system start or continued operation.

Train permeate flow shall be controlled by varying the high-pressure feed pump's speed to achieve the selected permeate flow set point. Train recovery shall be

regulated by controlling concentrate flow to a set point derived from permeate and recovery set points through modulation of the energy recovery system or train concentrate control valve (as applicable). Additional automated flow valves shall be provided for each train as follows but not limited to:

- Feedwater inlet valve on the suction side of the high-pressure feed pump.
- Flush inlet valve on the suction side of the high-pressure feed pump.
- Permeate isolation valve, on the train permeate header.
- Permeate dump valve, on the train permeate header (configured to fail open on loss of power).

b) Membrane Cleaning System

The membrane cleaning system shall be initiated manually by the operator, located near the cleaning tank(s) and recirculation pump. The panel shall house system indicators and alarm lamps and controls for the pump and tank immersion heaters. All instrumentation indicators (including gauges) shall be mounted on the panel or the panel support frame assembly.

c) Membrane Flushing System

Train flushing shall be controlled automatically through the control system to flush individual trains on shutdown. The system shall be configured to allow manual initiation of train flushes and stop a flush in progress. If multiple trains require a flush simultaneously, the control system shall be configured to flush them one at a time in sequence.

d) RO Feed Water Conditioning Chemical Dosing

All chemical feed dosing rates shall be tuned, optimized, and sent via the plant control system. The dosing points presentation is in the CCP drawing 7061563/PMC/400MLD/CP1/PFD/001 final dosing points are to be optimized by the EPC.

The proposed dosages, type, and locations of water conditioning chemicals shall not contradict the RO system membrane manufacturer's standards, as documented on the RO membrane supplier guarantee. System design shall incorporate the listed facilities and any additional facilities required to guarantee compliance with the acceptance criteria.

9.8.3.5 Key Operational Monitoring Points

a) Based on the measured parameters, the following configurable alarms shall be provided as a minimum for the continued operation of the train, alarms should be configured as a high priority, and associated interlocks should be programmed accordingly:

- High Differential Pressure across Cartridge Filters
- High feed water pressure.

- The high differential pressure across the individual bank of pressure vessels.
 - High permeate flow.
 - Low permeate flow.
 - Low concentrate flow.
 - High permeate pressure.
 - High permeate conductivity.
 - Loss of REMOTE status and Measurements from connected devices
 - High Boron, before Cartridge filters
 - High SDI, before Cartridge Filters
- b) Pump Condition Monitoring: The condition monitoring system alarms are to be set as per the OEM limits. All warnings are to be configured as high priority alarms.
- c) Dry run protection: The pumps shall be protected from running dry by appropriate hardwired and software interlocks. The level measurement readings are considered the early warning and proper actions to be taken by the operator.
- d) Other monitoring and safeguarding strategies align with the instrumentation design criteria philosophy referred to in section 9.2.2.

9.8.3.6 Critical Control Point – CCP 2:

- a) RO Feed Water Oxidizing Agents CCP-2a

The control system shall incorporate the provisions to automatically shut the running RO trains when high oxidizing agents are detected in the RO feed filtered water after the dose of SMBS.

The maximum allowable value and duration of exposure should be chosen based on warranties by the membrane supplier/vendor.

- b) Instrument voting on ORP (2oo3) shall be provided, thus avoiding damage to the RO membranes.

- c) RO Feed Water Boron measurement, CCP-2b

Boron analyzer shall be installed in the main RO feedwater pump discharge. When the online Boron measurement is high, the control system shall incorporate the provisions to alarm in the beginning and allow NaOH's controlled dose before the RO system to reduce the Boron in permeate within the permissible limit. The shutting of the trains shall be strategically planned based on the combination of parameter readings.

- d) The trip or shutting down of the RO system in an adverse situation must not result in transients that damage any other systems or infrastructure.

9.8.3.7 Critical Control Point – CCP 3

- a) Permeate Water TDS/Conductivity and Flow, CCP-3

The control system shall incorporate the provisions to alarm in the beginning and later automatically shut the running RO train where the high TDS detected in the permeate water. The maximum allowable value should be chosen based on

warrantees by the membrane supplier/vendor. After early warnings are included in the Key Operational Monitoring points, the shutting down the RO train should be programmed based on a timer or by operator decision. The same philosophy shall be implemented for the permeate flow parameter.

9.8.4 Post-Treatment

9.8.4.1 System Description

Post-treatment system to include two key components

- Remineralization
- Disinfection

The objective of remineralization is to achieve sufficient Hardness and Alkalinity in the product water while maintaining acceptable Turbidity according to the Indian standard, IS 10500 (2012), that shall be <1 NTU.

The objective of disinfection is to ensure protection during transportation in the product distribution line. Chlorine, in the form of sodium hypochlorite (NaOCl), shall be used as a disinfection chemical for biological growth control.

Permeate from the SWRO system shall be conditioned with a combination of lime and carbon dioxide and disinfected with NaOCl to ensure safe and non-corrosive water supply. The final pH adjustment, if needed, shall be done by NaOH doing after disinfection to keep the LSI (Langelier Saturation Index) within the acceptable limit to avoid corrosion in the transmission pipeline.

The post-treatment system shall be designed such that the water exiting the Product water tank meets the drinking water quality requirements.

9.8.4.2 Instrumentation & Monitoring:

- a) Instrumentations are to be envisaged as per the instrumentation requirements referred to in section 9.2.
- b) As a minimum following instrumentation is to be provided but not limited to:
 - i) Hardness, after limestone filter
 - ii) Chlorine Residual, after limestone filter
 - iii) Turbidity, after limestone filter
 - iv) pH, after limestone filter
 - v) Conductivity, after limestone filter
 - vi) Level, at limestone silo
 - vii) Pressure and Flow measurements
 - viii) Calcite Bed Blanket level Measurement
 - ix) Any other device required to meet the operations, guarantee, and environment
- c) Instrumentations shall ensure for the online parameters that product water meets contractual requirements in quality and quantity.

- d) Any other instruments to achieve the Water Quality, SWRO Desalination Plant operation, availability, guaranteed performance, operational flexibility, and durability (and service life) of the asset.
- e) Necessary instrumentation shall be sufficient to operate and follow over the project life of the pumps and associated equipment

9.8.4.3 Process Strategy

a) Remineralization

Up-flow type Limestone filters shall be envisaged. The Limestone bed with Continuous Feeding Remineralization where only a portion of the main permeate flow is treated (45-55%) in limestone filter and the remaining flow bypasses it. Both the streams are mixed outside the limestone building. With the up-flow type, the stream passing through the filter receives the hardness necessary for the full flow before mixing with the bypassed flow.

The limestone filters shall have in-built reserve silo in their upper part and series of small feeding funnels placed at the bottom of the silo guide the Calcite from the silo to the surface of the Bed. In this way, the Calcite feeds the Bed by gravity, replenishing it continuously as it becomes dissolved. With such a design, the bed thickness always remains the same.

A backwash system shall be installed for Backwashing the limestone filter, which shall comprise air and water circulation.

b) Disinfection

Chlorine, in the form of sodium hypochlorite (NaOCl), shall be used for disinfection to kill micro-organisms and to prevent biological growth in the transmission line. The point of application will be in the pipeline at the outlet of the limestone beds.

c) LSI

The Langelier Saturation Index (LSI) shall be kept positive within the range of $0 < \text{LSI} < 0.5$. For this purpose, sodium hydroxide dosing shall be envisaged.

9.8.4.4 Automation Control Strategy

a) Remineralization, Lime Filters

With an up-flow type lime filter system, the permeate stream passing through the filter receives hardness depending on the flow split ratio, pH, and contact time in the limestone bed. The automation control loop shall be programmed to achieve the targeted hardness $\text{CaCO}_3 > 80\text{ppm}$ as CaCO_3 in the mixed product water outside the limestone filter.

The permeate flow control loop shall adjust the control valve to attain the desired permeate flow rate split ratio based on the number of RO racks running. At the same time, the media level is maintained by gravity filling from the limestone silo. Lime level monitoring to be envisaged in the silo.

The CO₂ dosing shall be a dosing control loop based on the permeate flow to the lime filter to allow the controlled dissolution of the Calcite to obtain the required

hardness in the overall product flow.

b) Disinfection

Desalination water product does not require a high level of disinfection chemical dosing, and most of the injected Chlorine will remain as free active Chlorine. Hence dosing of at 1mg/l shall be envisaged for the treated water flow to maintain the residual Chlorine > 0.5 mg/l. The chlorine analyzer shall be provided strategically considering the contact time the signals shall be included in the cascaded control loop.

c) LSI

The final optimal pH is obtained when the Langlier Saturation Index (LSI) is slightly positive (saturation of calcium carbonates) and maintained between $0 < \text{LSI} < 0.5$. For this purpose, sodium hydroxide dosing shall be envisaged.

9.8.4.5 Key Operational Monitoring Points

- a) Limestone filter backwash shall be initiated manually by the operator or automatically when the outlet treated water turbidity hits $>0.5\text{NTU}$. RO permeate water shall be used for Backwashing.

The following shall be the minimum procedural steps in Backwashing;

- i. Drain step
- ii. Air scouring step
- iii. Venting step
- iv. Backwashing step
- v. Rinsing step

The Bidder/EPC shall optimize the Backwash step and timing as per performance requirement.

- b) Based on the measured parameters, the following configurable alarms shall be provided as a minimum for the effective operation of the post-treatment system, alarms should be configured as a high priority, and associated interlocks should be programmed accordingly:

- High Turbidity
- High / Low Hardness
- High / Low pH
- High / Low LSI (calculated)
- High Conductivity
- Loss of REMOTE status and Measurements from connected devices

- c) Pump Condition Monitoring: The condition monitoring system alarms are to be set as per the OEM limits. All warnings are to be configured as high priority alarms.

- d) Dry run protection: The pumps shall be protected from running dry by appropriate hardwired and software interlocks. The level measurement readings are considered the early warning and appropriate actions to be taken by the operator.

- e) Other monitoring and safeguarding strategies align with the instrumentation design criteria philosophy referred to in section 9.2.2.

9.8.5 Product Water System

9.8.5.1 System Description

The Product water Metering system includes two key components

- Product water Flow Tariff Metering
- Product water Quality monitoring

9.8.5.2 Instrumentation & Monitoring:

- a) Instrumentations are to be envisaged as per the instrumentation requirements referred to in section 9.2.
- b) As a minimum following instrumentation is to be provided:
 - i) Main and Check Flow Measurement in the product water line
 - ii) Hardness in the product water line
 - iii) Chlorine Residual, in the product water line
 - iv) Turbidity in the product water line
 - v) pH, in the product water line
 - vi) Conductivity/TDS, in the product water line
 - vii) Temperature, in the product water line
 - viii) Level, in the product water tank
 - ix) Devices required to monitor the desalination plant-oriented parameters referred to in Indian Water Standard specification “IS:10500-2012 Drinking Water Specification.”
 - x) Any other device required to meet the operations, guarantee, and environment
- c) Instrumentations to ensure the online parameters that product water meets contractual requirements in quality and quantity shall ensure the online parameters.
- d) Any other instruments to achieve SWRO Desalination Plant operation, availability, guaranteed performance, operational flexibility, and durability (and service life) of the asset.

9.8.5.3 Process Strategy

- a) Product water Flow Tariff Metering

The product water delivery pipeline shall be equipped with one main flow meter and one check flow meter connected to the site Metering or Reporting system for production reading. The flow meters are connected to the Plant DCS to measure and control plant production flow.

- b) Product water Quality monitoring

The Quality monitoring arrangement shall be equipped with the required water quality analyzer connected to the Site Metering system for Contractual quality conformance. The quality monitoring instruments are connected to the plant DCS for measurement, control, and out spec water management.

9.8.5.4 Automation Control Strategy

- a) Dispatch & Product water Storage Tank Level
The control system shall be programmed to ensure that the dispatch requirements are always met, the level in the Product Water Storage tank is always maintained at the required level.
- b) Water Quality Management
The control system shall ensure that the water qualities are always within limits. Any abnormal conditions shall be alarmed, and individual action plans are triggered.

9.8.5.5 Key Operational Monitoring Points

- c) Flow Deviation
The control system shall be programmed to alarm if the main and check flow meter deviation is more than 0.3% at flow rates 15%-49% and 0.25% at flow rates 50% -100%.
- d) Following configurable alarms shall be provided, alarms should be configured as a high priority, and associated interlocks should be programmed accordingly:
 - Turbidity - High
 - Hardness – Out of Limit
 - pH – Out of Limit
 - LSI (calculated) – Out of Limit
 - TDS – Out of Limit
 - Chlorine out of limit
 - Flow – Low
 - Product Tank Level – Low
 - Loss of REMOTE status and Measurements from connected devices
- e) Other monitoring and safeguarding strategies align with the instrumentation design criteria philosophy referred to in section 9.2.2.

9.8.5.6 Critical Control Point – CCP 4

- a) Product Water Storage Tank Level Low – 4A
The control system shall incorporate the provisions to alarm when the Product Water Storage tank level becomes Low. If the level further creeps below Low, the control system shall initiate the sequence to start the required number of RO rack automatically. This RO rack starting shall be coordinated with other process areas through the Plant Level Global Automation sequence programmed in the control system.
- b) Product water Quality Limit violation – 4B
When following product water quality parameter measurements are set limits referring to the Indian Water quality, the Control system shall incorporate alarm with High priority annunciation.

- LSI
- Residual Chlorine
- Conductivity / TDS
- pH
- Turbidity
- Boron

Further, if the measured limits continued to stay after an elapsed time, operator actions specified in the water quality manual must be followed. Appropriate action should be envisaged such that the out-spec water should not reach the transmission mains network.

Instrument voting on 2oo3 shall be considered for continuous online measurement, and 2oo2 measurement shall be considered for semi-continuous sample aspirated type online measurement.

The Bidder must provide details on out-spec water management procedure in the bid with a summary of the intended operations when the water goes out of specification.

c) Product water Quantity

The product water quantity shall be continuously monitored and compared with the dispatch instructions, any deviation from the dispatch instruction shall be alarmed at high priority.

9.8.6 Outfall

9.8.6.1 System Description

The brine from the RO system and treated wastewater shall be disposed to the outfall facilities, where the treated water is disposed to sea.

9.8.6.2 Instrumentation & Monitoring:

- a) Instrumentations are to be envisaged as per the instrumentation requirements referred to in section 9.2
- b) As a minimum following instrumentation is to be provided:
 - TSS, at outfall tank
 - Residual Chlorine, at outfall tank
 - Iron, at outfall tank
 - Temperature, at outfall tank
 - pH, at outfall tank
- c) Devices required to monitor the outfall wastewater parameters referred to in State Pollution Control Board under Water Act 1974.
- d) Any other measurement required by the Environmental Approval to ensure there will be no harm to the marine environment;
- e) Any other instruments to achieve the Water Quality, SWRO Desalination Plant operation, availability, guaranteed performance, operational flexibility, and

durability (and service life) of the asset.

9.8.6.3 Key Operational Monitoring Points

- a) Following configurable alarms shall be provided, alarms should be configured as a high priority, and associated interlocks should be programmed accordingly:
 - TSS - High
 - Residual Chlorine - High
 - Iron- Out of Limit
 - Temperature – High
 - pH – Out of Limit
 - Loss of REMOTE status and Measurements from connected devices
- b) Other monitoring and safeguarding strategies are to be in line with the instrumentation design criteria philosophy referred in section 9.2.2

9.8.6.4 Critical Control Point – CCP 5

- a) Outfall Wastewater Quality Parameters Limit violation

When outfall wastewater quality parameters are out of limits, the Control system shall incorporate alarming with High priority annunciation. The operator has to take necessary actions by appropriate tuning parameters to bring the parameters within range.

9.9 Integrated Security System

This specification describes the technical requirements for the Security System at 400 MLD SWRO desalination plant and covers the minimum requirements for design, engineering, manufacture, erection, inspection and testing.

The Integrated Security System (ISS) and related equipment shall be complete in every respect and suitable for safe and reliable operation.

Preferably, the whole integrated security system of the entire plant would be one unified system of the same make and type, which would ideally be sub-contracted as a whole to a single reputable company subject to Employer's approval.

This specification does not enumerate or describe all the materials and equipment to be supplied and all the services to be performed. All materials and equipment shall be provided as are required to make a complete, properly functioning installation and shall conform to the highest standards of engineering design and workmanship.

The Integrated Security system shall cover the whole area of the Plant site and shall cater for all potential risks and provide correct response to any if detected. The Integrated Security System (ISS) shall comprise following discrete systems:

- CCTV Surveillance System
- Access Control System

- Identity Management system
- Central Security Control
- Public Addressing System
- Communication System

The above systems are required to safeguard the assets by various collusion threats from insider or outsider and to improve the overall security & surveillance.

The scope of work includes as a package: designing, obtaining authorities approval, manufacturing, construction, factory testing, packing for transport, transport and delivery to site, unloading at site, storing, complete erection, testing at site, painting, commissioning, acceptance tests, preparation of test reports and handing over a fully Integrated Security System.

9.9.1 Scope

The scope of supply includes but is not limited to : a computer-based central security system, CCTV cameras, TV monitors, video recorders, intrusion detectors, work stations, card readers, door switches, uninterruptible power supply, any special tools or test equipment and software for the purpose of installation, maintenance, administration and operation of the system.

A functional design specification (FDS) shall be prepared for approval of the Engineer.

The factory acceptance test procedure (FAT) for the ISS shall be approved prior to the execution of the tests.

The proposed system should provide a fully functional and integrated command and control security system. This system shall assist the security managers and security staff in maintaining the maximum level of security at the site. The main control of the system will be from a dedicated security control room.

The ISS shall include:

- CCTV Surveillance system with recording and playback facility with LCD screen technology display showing a sitemap and lower-level maps of buildings of various zones. The details are given in Chapter 9.
- Intrusion Detection & Assessment System (IDAS) based on CCTV system, other trending technologies if any shall be proposed by the contractor.
- Access Control System (ACS) with door monitoring system, access control, metal detectors, raising arm barrier, turnstiles, barriers, under- vehicles surveillance system. The details are given in Chapter 9.
- Identity Management System (IDMS) inline with the Access Control system(ACS) with computer-based security system for ID badge, security administration, event/alarm management, recording of all the information, etc.
- Integration with public address, telephone and site radio system.
- Security Control Centre (SCC) including all security equipment as also furniture.

- All programmable equipments must be supplied with software, hardware communication protocol and documentation and necessary licenses.
- Cable, cable trays, conduits, channels and related accessories as required.
- Power supplied for all the system components, including cameras, sensors and recording system, should be powered by a centralized uninterruptible power source/ solar power fully compliant with project specifications.
- Complete design and installation
- The Contractor shall submit welding procedure specifications (WPS) and procedure qualification records (PQR) and Quality Assurance Plan (QAP) for approval before starting any welding work.
- Training for the operation and maintenance of the system
- Commissioning of the system

9.10 CCTV Surveillance System

9.10.1 Design Considerations and Overview

A Common CCTV System shall be designed for surveillance of both security and operations purposes, providing continuous monitoring and recording of security as well as operation cameras.

The system design and system component specification shall meet all the operational, security and emergency response requirements of desalination plant. CCTV cameras to be utilized for operational use shall be installed strategically within the plant to optimally capture all the intended operational activities and store them in the video storage server of the system.

Based on the need of surveillance, the camera shall be chosen to be a PTZ camera or fixed camera. All the CCTV equipment shall be of a modern, proven and reliable design and shall follow ROP standards.

The CCTV cabinet shall be installed in RO Building – Engineering or Control room. The CCTV central system shall be common for both the plant & security CCTV systems. Both the CCTV systems will be configured on separate VLAN's and will be independent of each other. The CCTV camera footage storage duration shall be 30 days at CIF 25 frames per second.

The intelligent CCTV system shall be capable of running different video analytics which shall ensure proactive information to guards as well as operators thereby reducing their investigation time.

The CCTV Management System shall be a fully distributed solution, designed for 24/7 surveillance with support for devices from different vendors. The Management System shall offer centralized management of all devices, servers and users.

All the servers of CCTV system shall be installed in engineering room located in RO Building. No remote monitoring of CCTV cameras (operational as well as security) is envisaged. However, the system shall be capable of providing this functionality (if required in the future).

The cameras shall be strategically positioned around the main areas, perimeter, entrances of the Plant as well as inside the buildings, whilst the monitor/controller shall be located in the Control room in RO Building as well as in Guard house.

The Vendor shall design the number of cameras to cover intended areas of the plant. The number of cameras shall increase if the required area of coverage demands additional cameras. The following components shall be provided, as part of the IP Surveillance system:

- a. Fixed & PTZ Outdoor Cameras
- b. Indoor Dome Cameras
- c. Indoor Ex proof PTZ Cameras
- d. Indoor Fixed Cameras
- e. Network Switches
- f. Hardware (Server & Storage) and software
- g. Management System with Monitor and Control keyboard
- h. Video Recorder
- i. Poles, Structures and Supports for CCTV cameras
- j. Marshalling box for power & other control signals

The cameras of CCTV system will be spread around the desalination Facility and the video streams and control signals of these cameras shall be transported to the CCTV system servers by means of dedicated individual fibre optic cables. All the cameras shall operate on 240VAC UPS to operate in all situations which shall comply with the autonomy of 2 Hours.

The CCTV system shall be completely designed by the vendor and approved by the PMC. The system shall be commissioned using vendor engineers and staff and then certified by the vendor validating that it meets the design requirements.

Following sections provide minimum specifications of the camera systems.

- a. Several simultaneous video streams using different video compression formats including H.264.
- b. Megapixel resolutions and vandal resistance.
- c. Input/output ports for connection to external devices such as sensors and alarms
- d. Built-in intelligence including video motion detection and tampering detection.
- e. Sophisticated alarm and event management functions that shall communicate with different devices and applications simultaneously, and can send separate video streams in different resolutions, at different frame rates and to different places.
- f. Audio support.

- g. Power over Ethernet, which enables power to be delivered over the same cable as for data transmission.
- h. The network camera shall capture and send live images, enabling authorized users to locally or remotely view, store and manage video over a standard IP-based network infrastructure.
- i. All network cameras shall have an auto iris lens to regulate how much light is received.
- j. Outdoor cameras shall have a protective housing or designed with a protective enclosure to withstand the harsh environment conditions mentioned in section 4.
- k. All cameras shall have protection from harsh environments such as dust and humidity, and from vandalism or tampering.
- l. PTZ cameras and PTZ domes shall be used having full 360-degree.
- m. Dome cameras shall have optical zoom of 35X.
- n. Image sensor: CCD (charge-coupled device) shall be used.
- o. Progressive scan technology shall be used.
- p. Lens shall be zooming allowing the camera to stay in focus when zooming in on objects.
- q. A lens iris, which controls the amount of light coming into the camera automatically. An auto iris lens shall be controlled by the camera's processor (DC-controlled), or by video signal.
- r. Lenses shall be CS-mount types.
- s. The cameras shall have automatic day/night functionality: This feature shall be incorporated into outdoor cameras to enable the automatic removal of the infrared (IR) cut filter that is incorporated into all colour cameras to prevent colour distortion from near-infrared light. When there is light, the IR-cut filter is on and the camera delivers colour video. In dark conditions, the camera removes the filter to make use of near-infrared light to deliver infrared-sensitive black and white video.
- t. Input and output (I/O) ports shall be provided in the camera: Input/output connectors enable external devices to be connected to a network camera. Inputs to a camera shall include a door contact, infrared motion detector, glass break sensor or shock sensor, as applicable. The camera shall react to an external event by initiating the sending and recording of video. Outputs shall enable the camera to control external devices such as activating alarms, triggering door locks, generating smoke or turning on lights, as applicable. This shall be finalized during the detailed design and according to the PMC/CMWSSB requirement.
- u. Video motion detection shall be provided for security cameras that monitors changes in the camera's field of view and if a change occurs (e.g. an intruder enters

- the scene); an alarm condition shall be generated. This function shall be a built-in feature of a network camera and video management software.
- v. Active tampering alarm shall be provided in the cameras: When a camera is manipulated in any way (e.g. accidental redirection, blocking, defocusing spray-painted, covered or damaged), it shall automatically trigger recordings and alert notifications.
 - w. Alarm and event management shall be supported. With this capability, event triggers shall be programmed based on schedule, I/Os, video motion detection, active tampering alarm or temperature, among others, as specified by the PMC. Pre- and post-alarm image buffers within a network camera shall save and send images collected before and after an alarm occurs. Once an alarm or event is detected, a network camera shall raise alarms and send notifications via e-mail, TCP, HTTP and upload images via e-mail, FTP and HTTP.
 - x. Network management features shall be provided. This shall include support for Quality of Service (QoS), which can prioritize and reserve network capacity for mission-critical surveillance in a QoS aware network, and support for Internet Protocol version 6 (IPv6) in addition to IPv4 addresses.
 - y. The outdoor cameras shall be provided with a built in wiper as cleaning mechanism that can be controlled.
 - z. All equipment and software shall be designed with 20% growth capacity allowance to allow for possible expansion at a later date without the need to add any additional hardware, software for the network operating system, or any additional changes to the network management system.

All the detail specification given in this document for CCTV system equipment/cables should be verified by vendor to be before procurement.

9.10.2 Security CCTV System

The CCTV system required for desalination facility shall be IP based intelligent surveillance and analytic system. The CCTV system shall cater to the security requirements for which the cameras shall be installed along the fence of the facility and on the main entrance gates as well as entrance doors of the buildings. The monitoring and control of these cameras shall be extended to the guard house as well as RO building Control room, so that the perimeter of the facility is continuously monitored by the guards and operators for safe operation of the facility. The CCTV system shall be equipped with analytic features which shall enable the guards to be proactive and would reduce the analysis time during any emergency.

The security cameras shall have Intelligent Video Motion Detector (iVMD) feature to analyses video in real-time and detects valid motion in a scene. The resolution of the cameras shall be sufficient enough to identify the object intruding the facility.

One no of 55" and one no of 21" LED screens shall be installed respectively in Control Room and Guard House. The monitoring and control of the cameras from these locations should be provided with the help of the control accessories that shall be provided along with the CCTV package.

The security cameras shall be mounted on 6m fixed poles. The CCTV poles are to be located within the facility close to the fence. For cameras, lighting arrestors shall be provided to protect the camera from any damage due to lightning.

The security CCTV cameras around the fence/perimeter and main gate shall allow the guards to monitor movement of any intruder, animal, trespasser or any unidentified object around the fence. Upon detection of such incident, the guards can take necessary actions required as per the response plan.

The cameras shall not compromise the quality of video feeds in harsh and adverse environmental and zero illumination levels. Infrared illuminators shall be provided on the relevant perimeter cameras for operation under zero illumination levels.

All cameras shall have a junction box for termination of fibre optic cable, to house FO converters, power supplies and other associated items. There shall be a separate lockable type isolator to ensure proper power isolation procedures are followed during maintenance.

9.10.2.1 Security Camera Specification

The following cameras shall be used for security CCTV system. The vendor shall provide their specifications for approval:

- IP 66 Outdoor Weather Proof Fixed Cameras

The Fixed CCTV cameras to be located around the perimeter at 50m interval and must have a maximum view of 75m. Each fixed perimeter camera is to have an overlap view of the next camera in line; the overlap is to be not less than 30m to cover any surveillance blind spots.

Each fixed camera is to be fitted with an LED infra-Red illuminator to support an illumination range of not less than 75m and the IR unit is to operate in the 850nm wavelength spectrum.

- IP 66 Outdoor Weather Proof PTZ Cameras

The PTZ cameras are to be located at each corner of the facility and guard house to monitor along the perimeter fence and entrance/exit gate to a maximum distance of 300m enabling the option for intruder detection.

The PTZ cameras are to be fitted with an LED infra-Red illuminator to support an illumination range of not less than 300m and the IR unit is to operate in the 850nm wavelength spectrum.

The cameras installed at the main gate shall ensure recognition of all the personnel entering in the plant and shall also capture the registration number of vehicles entering/exiting the

plant. The guards shall control the security cameras with the help of the control accessories which shall be provided along with the CCTV package.

9.10.2.2 Fixed IP CCTV Camera

General

External fixed CCTV cameras are to be mounted on 6m fixed poles and located at 50m intervals around the perimeter with a maximum surveillance distance of 75m. The camera is to be designed for harsh environments and is to be able to withstand high temperatures and dust storms.

- The internal camera and housing is to be specifically designed for day/night surveillance in hot, and dusty conditions. The unit is to have an optimised heat - sinking design that protects the camera from internal overheating caused by solar heat gain.
- The unit is to provide reliable performance to 65 °C.
- The unit is to incorporate MFP (Mechanical Filter with Photocell) technology using dual window mechanical filter technology to deliver accurate colour during the day and high-resolution infrared sensitivity at night.
- Using minimal mechanical moving parts, the unit is to be weather sealed and tested to perform in hot conditions.

Fixed IP CCTV Camera Specification

Resolution	:	2 MP/HDTV 1080p, maximum
Image Sensor	:	Progressive scan RGB CMOS 1/3"
Lens	:	DC-iris IR corrected, CS-mount 5-50mm F1.2 (Lens selection to be confirmed during site survey)
Illumination	:	Colour: 0.1 lux, F1.2, B/W: 0.02 Lux, F1.2 with dynamic capture and power line frequency 50 Hz, 1/231 s to 1/44 s.
Resolution	:	1920 X 1080 (2 MP) to 160 X 90
Frame Rate	:	H.264 25 fps in 50Hz capture mode.
Security	:	Password protection, IP address Filtering, encryption, IEEE 802.1x network access control, user access log
Memory	:	256 MB RAM, 128 MB Flash
Power	:	PoE IEEE 802.3af POE, IEEE 802.3af
Operating Conditions	:	0° to 60°C
Humidity	:	10 – 100% RH (Non – Condensing)
Housing Construction	:	Robust aluminium/Zinc/Stainless steel casting/extrusion

Mount	:	Top Mount 6m CCTV column
Sun Hood	:	Integral Sun Hood compulsory
Connection	:	Cat6a cable for video and PoE
Operating Temperature:	:	-50° C to 65°C
Storage Temperature :	:	-50° C to 85°C
Environment Rating :	:	IP 66/NEMA 4 x compliant

Fixed CCTV unit Housing Infra-Red Illumination Specification

Each fixed camera is to be fitted with an LED Infra-Red Illuminator to support an illumination range of not less than 75m and the IR unit is to operate in the 850nm wavelength spectrum. The IR illumination is to provide coverage of the outside and sterile area of the perimeter fence.

9.10.3 PTZ CCTV Camera

9.10.3.1 General

External 1/3" 2MP camera fitted long range Megapixel zoom lens for PTZ CCTV cameras, to be mounted on 6m columns (Dual Mounted where a PTZ camera position coincides with a fixed camera position). The camera is to be designed for harsh environments and is to be able to withstand high temperatures and dust storms.

The PTZ unit is to be a high-performance integral unit containing camera, zoom lens telemetry, PTZ unit and infra-red illuminator. The unit is to have a continuous high speed rotation and positioning precision on alarm pre-sets. The Infra-Red Unit is to provide illumination up to 300m.

9.10.3.2 PTZ Camera Specification

Lens	:	4.7 – 141mm Megapixel 1/3" lens – High Sensitivity
Optical Zoom	:	28
Digital Zoom	:	Optional
Day/Night	:	Auto ICR
Image Sensor	:	1/3" Low Light 2 Megapixel Progressive scan CMOS
Resolution	:	1920 X 1080P
Shutter Time	:	Automatic increase adjustment to improve night time performance
Focussing system	:	Auto
Video line	:	Cat6e as appropriate
I/O alarm card	:	alarm inputs and relay outputs
Variable pan speed	:	0.1° to 40°/sec manual operation

Variable tilt speed	:	0.1° to 30°/sec manual operation
Pre-set accuracy	:	0.1 degrees
Fixing	:	Pole mount/Wall mount adaptor to be included, as required
Operating Temperature:	:	-40° C to 65°C
Storage Temperature	:	-50° C to 85°C
Environment Rating	:	IP 66/NEMA 4 x compliant

9.10.3.3 PTZ CCTV Unit Infra-Red Illumination Specification

IR LED	:	Integral, built onto the camera housing or P/T unit
Beam Pattern	:	10 degrees
No of LED's	:	As required for distance up to 300m
Wavelength	:	850nm
Camera/Light Beam	:	Must be factory aligned
Lighting sensor	:	Built in photocell or keyboard command

9.10.4 Operations CCTV System

CCTV cameras to be utilized for operation shall be installed strategically within the plant to optimally capture all the intended operational activities and store them in the video storage server of the system. The cameras catering to operational requirements within the plant shall be PTZ cameras. The stream transmission of individual cameras to servers shall be based on Fibre optic backbone communication.

The CCTV system will be interfaced with the Fire Alarm System (FAS) through redundant Modbus TCP/IP interfaces. The vendor shall integrate CCTV Management software with FAS software. The Fire alarm from the FAS should trigger the camera to be directed to the alarm location in the facility. The PTZ CCTV camera installed in the area of detection shall automatically focus on the intended area of coverage (i.e. the programmed PTZ pre-set shall be activated) and the live coverage of the affected area shall automatically get displayed on the CCTV screen installed in control room.

The cameras shall be installed on steel structures/walls within the plant or on a fixed pole and does not obstruct any normal operation activities or approach ways.

The PTZ/Fixed cameras to be installed at all the building entrances shall be monitored by both security guards and operators.

9.10.4.1 Operations CCTV Camera Specification

A wide variety of network cameras shall be provided ranging from indoor fixed and dome cameras to Explosion Proof and weather proof PTZ cameras, and designed for use indoors or outdoors.

For any application requiring constant monitoring, fixed cameras shall be provided. For other applications that require covering the field, PTZ cameras shall be used.

The following cameras shall be used, depending on the application at the facility and provide their specifications for PMC approval:

- Indoor Dome Cameras
- Indoor Fixed Cameras- for RO building entrance
- Indoor Explosion Proof PTZ Cameras- for Battery rooms
- PTZ Outdoor Cameras

As appropriate, each camera station shall be either structure/wall or pole mounted, fixed or pan/tilt/zoom, with auto iris. A facility shall be provided to access the camera easily for maintenance. The exact quantity of camera stations, types, mounting arrangements and locations shall be determined by the Vendor in conjunction with the PMC.

For cameras, lightning arrestors shall be provided to protect the camera from any damage due to lightning.

All cables installed indoor shall be flame retardant type.

All material supply and installation in Battery rooms shall be Explosion proof.

9.10.4.2 Indoor Fixed Camera

The indoor fixed camera shall be Day/Night infrared Bullet camera with the following minimum requirements:

Resolution	:	2 MP/HDTV 1080p
Image Sensor	:	Progressive scan RGB CMOS 1/3.2"
Lens	:	3-9mm, 1000 – 300 view, F1.3
Illumination	:	Colour: 0.2 lux, F1.3, B/W: 0.04 Lux, F1.3
Resolution	:	1920 X 1080 (2 MP) to 160 X 90
Frame Rate	:	H.264 25 fps in 50Hz capture mode.
Memory	:	256 MB RAM, 128 MB Flash
Power	:	PoE IEEE 802.3af/802.3at Type 1 Class 3
Operating Conditions	:	0° to 55°C
Humidity	:	10 – 100% RH (Non – Condensing)
IR Distance	:	15m

Automatic Day/Night switching, photocell control and Video motion detection.

9.10.4.3 Explosion proof PTZ Camera

The Explosion proof PTZ cameras shall:

- The camera shall be designed to provide simultaneous Motion JPEG, MPEG-4 video and H.264. However, H.264 shall be used.
- Resolutions HDTV 1080i, 1920 X 1080
- Be designed to provide video at 30 frames per second (NTSC) or 25 frames per second (PAL) for all resolutions.
- Provide high speed pan and tilt functions and be equipped with 35x optical and 12x digital zoom.
- Operate on an open source, Linux-based platform, and include a built-in web server.
- Be manufactured with an all-metal body.
- Use a high-quality IR-sensitive 1/4" progressive scan CCD sensor.
- Be equipped with a removable IR-cut filter, providing so-called day/night functionality.
- Be equipped with a high quality F1.4 – F4.2 DC-iris lens with horizontal angle of view between 55.8° and 1.73°.
- Provide pictures down to 0.16 lux at F1.4 while in day mode (with IR-filter in use) and down to 0.0015 lux while in night mode (with IR-filter removed).
- Use a dedicated video compression chip, and be equipped with a minimum of 128 MB Flash memory and 512MB Random Access Memory (RAM).
- Provide 256 MB memory for pre & post alarm recordings.
- Be able to provide a total data throughput of up to 20Mbit/s on the network port.
- PoE IEEE 802.3af/802.3at Type 1 Class 3
- Wall mount
- Explosion proof housing suitable for hazardous area Zone1, Gas Group II C, Temperature Class T4, IP 65 and ATEX certified with glands.

9.10.4.4 Indoor Dome Camera

The indoor dome cameras shall be Day/Night camera with the following minimum requirements:

Image Sensor	:	1/4" CCD Day/Night camera
Lens	:	3.6 - 44.3mm, F1.6 Wide / F2.0 Tele
Zoom	:	10 x Optical, 12 x Digital
Min Sensitivity	:	0.7 lux colour at 50 IRE F1.65, 0.07lux monochrome at 50IRE F1.65
Focus	:	Automatic with manual Override
Iris	:	DC Auto-Iris
Max Frame Rate	:	30 fps
Memory	:	256 MB RAM, 128 MB Flash

Power : PoE IEEE 802.3af/802.3at Type 1 Class 3

Mount : Ceiling mount or wall mount

Automatic Day/Night switching, Automatic white balance and gain control and Video motion detection.

9.10.4.5 PTZ Outdoor Camera Specification

Lens : 4.7 – 141mm Megapixel 1/3" lens – High Sensitivity

Optical Zoom : 28

Digital Zoom : Optional

Day/Night : Auto ICR

Image Sensor : 1/3" Low Light 2 Megapixel Progressive scan CMOS

Resolution : 1920 X 1080P

Shutter Time performance : Automatic increase adjustment to improve night time

Focussing system : Auto

Video line : Cat6e as appropriate

I/O alarm card : alarm inputs and relay outputs

Variable pan speed : 0.1° to 40°/sec manual operation

Variable tilt speed : 0.1° to 30°/sec manual operation

Pre-set accuracy : 0.1 degrees

Fixing : Pole mount/Wall mount adaptor to be included, as required

Operating Temperature : -40° C to 65°C

Storage Temperature : -50° C to 85°C

Environment Rating : IP 66/NEMA 4 x compliant

9.10.5 CCTV Management System

The CCTV Management system is to monitor and control using software based Management System with a graphical user interface and operator man machine interface.

9.10.5.1 Required Interfaces

The Management System is to control all aspects of the CCTV Security and Operation systems.

The video management system shall allow multiple users to share common resources. The system shall be viewable on a single monitor that displays a facility map and video overlay,

or it shall be viewable on a two-monitor system in which the facility map displays on one monitor and video on the second.

The following sections describe the Management system and the components (products) of the system. The Vendor shall provide all the supporting functionalities and specifications, as mentioned below. The Vendor shall include in the Management system all the below supported components and specifications in the solution to be provided to the PMC. The milestone corporate latest edition is the preferred Management software.

9.10.5.2 System Description

The proposed solution shall provide a secure, scalable and easily accessible software based solution for the management of the CCTV Systems. The Management System shall be capable of managing the following:

- System Explorer
- Maps
- Reports
- Forms
- Workflow & Alarm Stack
- Video Wall Management
- Video Recording & Storage

The system will be capable of displaying video images on a minimum of 2 Large Screen Monitors which will act as Video wall & General display screen where required. The system will also provide a “Slave Position” within the proposed new security gatehouse on the facility; this will allow the guards inside the gate house full access to the system.

9.10.5.3 Management System General Specifications

The Management System is to form the centralised management of the CCTV systems and also control the recording and storage of the CCTV images.

The system will be built around network technology so all CCTV and alarm data will be carried over the security LAN and stored in dedicated servers within the RO Building Engineering Room.

The system should confirm to the following specifications as a minimum standard:

- The CCTV system is to be monitored and controlled using software based Security Management System (SMS) with a Graphical User Interface and operator man machine interface.
- The SMS will also interface to the Milestone Corporate 5.0 system and will interface with the Video Recording system.

The other features of Management System are:

- a. The IP video management system shall be an IP network-based, fully distributed digital video system. The security video system will utilize local area networks

- (LAN) as a transmission medium for video, configuration, as well as storage of all data.
- b. The system shall provide full video control at the control room as well as guard house, with additional full selection capability at any point within the network from a workstation or a video console display. The system shall provide unlimited expansion capability for the addition or modification of video inputs.
 - c. The system shall recognize the intruder detection and raise alarm working closely with the motion detection alarms from the cameras.
 - d. The Vendor shall furnish and install all security video cameras, pan/tilt/zoom (PTZ) cameras, mounts, housings, power supply systems, network cables, connectors, equipment racks, monitors and consoles, computer controlled network switchers, work stations, network storage managers , video console displays and keyboards, and all other hardware and software to provide a fully operational system.
 - e. The IP video management system shall permit normal and event monitoring of all secured areas on digital monitors as required. Video monitoring consoles shall be installed at the control room and guard house.
 - f. The IP video management system shall permit the normal and event monitoring of all secured areas on monitors as required. Video monitoring of all security cameras shall be possible at the control room and at the guard room. Review capabilities for the digitally recorded video via the secure network specified without interruption to recording capabilities.
 - g. Network Storage Manager shall be configured using fault-tolerant RAID-6 drive arrays. Network Storage Manager Devices shall be sized to record the camera videos at 4CIF resolution, 25 images per second for 31 days.
 - h. The IP video management system based digital recording and monitoring system shall incorporate a fault tolerant architecture and shall include redundancy in critical areas of concern. Network Storage Managers shall provide RAID 6 redundancy for the storage drives.
 - i. The IP video management system shall provide multi-level diagnostics of each component in all critical areas. These diagnostics shall be reported to a diagnostic console for processing. In addition, the diagnostic data shall be capable of being scripted into actionable events within the system.
 - j. The intent of this specification is to provide to the owner a networked digital security system supplied by the Vendor and shall be a complete and operational system as per the performance requirements and objectives of this specification. Vendor shall be responsible for the coordination of related work with other trades affecting his work or the work of others.

- k. The management system shall be provided such a way that Guard room shall monitor and control all the security cameras and Control Room all the security/operation cameras.
- l. One number HD LED 55 inch and one number HD LED 21 inch display shall be provided respectively at the central control room and the guard house. The LED displays shall be connected to the video surveillance system private network. In addition, keyboard, joystick and PC shall be provided at each location connected to the video surveillance system. PC shall be located inside the Cabinet. Only Monitor shall be kept in Control room. Monitors shall be positioned in such a manner that reflections from other materials and cabinets are minimized.
- m. The system including all the components shall be powered by Uninterruptible Power Supply (UPS). As a guideline the UPS shall be sized with sufficient capacity to supply power to all systems for a minimum of 2 hours autonomy. The decision on autonomy requirement purely depends on the custodian/customer of the CCTV system.

9.10.5.4 Management /Recording /Failover Server System Requirements

The following are the minimum requirements for the servers running the System Manager/Recording/Failover applications.

- Rack Mount HP Server
- Processor Intel Xeon E3 – 1220 (for Management/Failover servers)
- Processor Intel Xeon E5-2420 v2 (for Recording server)
- RAM : 12GB RAM
- HP Slim SATA DVDRW
- 2 no's 500GB+ HDD, 10K RPM (SATA/SAS) - OS / Application / SQL DB and Transaction Logs RAID 1
- HP NC364T PCI express Quad port gigabit Server Adapter
- HP 750 W CS HE power supply kit
- Graphics Adapter – 2 X DVI-I
- Gigabit Network Connection
- Windows Server 2012 x64 Standard/Data Centre
- SQL Express (Included)

9.10.5.5 Client Viewer

- a. The Client Viewer shall provide remote users with a comprehensive suite of features including as minimum:
 1. Viewing live video from cameras on the surveillance system.
 2. Browsing recordings from cameras on the surveillance system, with a selection of advanced navigation tools, including an intuitive timeline browser.

3. Creating and switching between an unlimited number of views, each able to display video from up to 64 cameras from multiple servers at a time. The system shall allow views to be created which are only accessible to the user or to groups of users.
 4. Accessing views of cameras on any camera with a Client Viewer application installed.
 5. Creating special views for widescreen monitors.
 6. Using multiple screens as well as floating windows for displaying different view simultaneously.
 7. Quickly substituting one or more of a view's cameras with other cameras.
 8. Viewing image from several cameras in sequence in a single camera position in a view or a so called carousel.
 9. Viewing video from selected cameras in greater magnification and/or higher quality in a designated hotspot.
 10. Receiving and sending video through the Matrix application
 11. Include HTML pages and static images (e.g. maps or photos) in views.
 12. Controlling PTZ cameras.
 13. Using digital zoom on live as well as recorded video.
 14. Activating manually triggered events.
 15. Activating external outputs (e.g. lights and sirens)
 16. Using sound notifications for attracting attention to detected motion or events.
 17. Getting quick overview of sequences with detected motion.
 18. Getting quick overviews of detected alerts or events.
 19. Quickly searching selected areas of video recording for motion (also known as Smart Search).
 20. Skipping gaps during playback of recordings.
 21. Configuring and using several different joysticks.
 22. Printing images, with optional comments.
 23. Copying images for subsequent pasting into word processors, email, etc.
 24. Exporting recording (e.g. for use as evidence) in AVI or JPEG database formats.
 25. Using pre-configured as well as customizable keyboard shortcuts to speed up common actions.
 26. Selecting between a numbers of language versions, independent of language used on main surveillance system.
- b. The Client Viewer shall allow remote users to connect to the Management Server for initial authorization then to the Recording Servers for access to video recordings.
 - c. The Client Viewer shall have the ability to adjust the display parameters for the video images from the recording server to optimize bandwidth utilization.
 - d. The Client Viewer shall typically be installed on remote user's computers.

- e. The Client Viewer shall provide a Graphical User Interface (GUI) and feature Live, Browse and Setup tabs for the convenient access of live and recorded video as well as camera properties and display quality.
- f. The Client Viewer shall support the use of standard PTZ controller or 3-axis USB joysticks for control of pan, tilt, zoom and auxiliary camera functions.
- g. The operator shall have the ability to use digital zoom where the zooming is performed in the image only on any number of cameras simultaneously. This functionality shall be the default for fixed cameras. The use of digital zoom shall not affect recording or other users.

9.10.5.6 Client Viewer System Requirements

The workstation shall be a server-class computer with two dual links DVI-I monitor outputs, USB keyboard, and mouse. The following are the minimum requirements for the computers running the Client Viewer application.

Processor	:	Intel i7 3770 Ivy Bridge Quad-Core 3.4GHz (3.9GHz Turbo)
Memory	:	8GB2 DDR3 SDRAM at 1600MHz
Hard Drive	:	500GB 3.5 6.0Gb/s SATA with 16MB Data Burst Cache
Video Card	:	Intel Integrated Graphics
Operating System	:	Windows server 2012 R2
Key Board	:	USB 104 Quiet Key Keyboard, English
Mouse	:	USB 6-Button Laser Mouse
Monitor	:	24" LED Monitor
Network Connection	:	100Mbits/sec or greater, GB recommended. An Adapter for Ethernet Networking compatible with TCP/IP network

9.10.6 Joystick Controller / Keyboard

- a. The keyboard shall be used in conjunction with a complete network-based video system product, and it shall be the point from which all user functions can be accessed. The keyboard shall be compatible with all Network Series distributed, network-based video products. One keyboard can control all system cameras through either a PC or video console display.
- b. The keyboard controls are located on three interchangeable modules in the keyboard.
- c. Modules can be positioned and rotated to suit user preferences. The keyboard modules shall include a variable speed, vector-solving joystick for precise PTZ control, jog/shuttle for playback control and pattern control, a keypad for camera and monitor control, and a built-in speaker.

- d. The keyboard shall be part of an integrated system and shall be configured so any number of keyboards can be added to the system.
- e. The keyboard shall meet or exceed the following design and performance specifications.

Keyboard Base Specifications

- i. Keyboard Interface : USB 2.0
- ii. Cable : USB, captive, 16.4 ft (5.0 m)
- iii. 3. Input Voltage : 12 VDC
- iv. 4. Input Current : 1.3 A (maximum)
- v. 5. Upstream Port : USB 2.0 (USB type B connector)
- vi. 6. Downstream Port : 2x USB 2.0 hi/full/low speed (USB type A connector)
- vii. 7. Audio Output : Embedded speaker
- viii. 8. Audio Input : Plug-in microphone

Keyboard Module Specifications

- i. Keyboard Keypad : 0-9 keys, camera, monitor, and multiple view keys
- ii. Joystick : Fully proportional PTZ, variable speed
- iii. Jog/Shuttle : Proportional, fast forward, reverse, and video transport.
- iv. Module Connectors : Three (one for each module), USB 1.1 mini-USB.

Power Supply Specifications

- i. Input Voltage : 100-240 VAC, 50/60 Hz
- ii. Output Voltage : 12 VDC
- iii. Power Output : 20 W
- iv. Input Connector Type: Universal, interchangeable
- v. Output Connector Type : 2.5 mm screw-on barrel

9.10.7 Network Storage Manager

- a. The network storage manager shall record video and audio streams from IP cameras on the network.
- b. The network storage manager shall incorporate the server functions and storage elements into a purpose-built chassis.
- c. The network storage manager shall use RAID 6 parity across the storage drives to protect recorded data against a hard disk drive failure.
- d. The network storage manager shall only use enterprise-level hard disk drives specifically rated for operation in RAID systems.

- e. The network storage manager chassis shall be designed for video surveillance recording applications and encompass redundancy at all vital points:
 - 01. Redundant, hot swappable power supply modules
 - 02. Redundant, hot swappable system fans
 - 03. Hot swappable O/S drive
 - 04. Hot swappable CPU fans
- f. The network storage manager chassis shall be designed for online service and maintenance and cannot be removed from the rack when hard disk drives, fans, power supplies, or operating system drives must be replaced.
- g. The network storage manager shall support the recording of MPEG-4 and H.264 baseline, and high-profile streams from standard resolution and megapixel cameras.
- h. The network storage manager shall support continuous, scheduled, alarm/event (including analytics alarms), motion, and manual recording. Pre- and post-alarm periods shall be configurable up to the total capacity of the system.
- i. The network storage manager shall support bookmarking and locking/unlocking of video content on the drives.
- j. The network storage manager shall support privacy tools that allow administrators to establish maximum retention times for normal, alarm, and locked video.
- k. The network storage manager shall support an intelligent video grooming protocol that can reduce the frame rate of recorded video as the video ages. Administrators shall have the flexibility to determine whether to groom alarm video or leave it at its real-time level.
- l. The network storage manager shall be fully managed from a remote workstation, including the ability to configure settings and update firmware and software.

9.11 ACCESS CONTROL SYSTEM

9.11.1 Design Considerations and Overview

Access Control System shall be provided to monitor access of authorised personnel into the facility, including main entry/exit gate (excluding escape gates) and main entry doors of the buildings.

All the Access Control equipment shall be of a modern, proven and reliable design.

The scope of supply shall include but not be limited to the provision of access control for the Buildings and locations mentioned above and the access card issuing equipment to enable the access cards to be programmed with the requisite user and access information. Access shall be obtained by the use of contact less ‘proximity cards.

Badge readers shall be installed along with Reader interface module and locks at the doors/entry points of the specified rooms in the buildings. Exit push button shall be installed on the other side of the door.

Entry to these points shall be made through swiping/placing the Badges issued to personnel's/visitors on the Badge reader. On recognition of the badges, the door shall open, and under normal circumstances the door shall remain closed.

The movement of people shall be recorded on a Management Terminal located in the RO Building. This Management Terminal shall be connected to the Ethernet LAN and allow access to the system database from other defined PCs or terminals elsewhere within the total Plant Complex.

All the readers shall be connected to their respective Reader Interface Module, which shall be connected in an independent network extended till the Segment controller. The initial configuration of ACS system and cards shall be done by using the ACS server which shall be installed in Engineering room in RO building.

In case of emergency, all the doors with access control within the facility shall be released for easy evacuation of personnel working in facility. Hence an emergency push button shall be installed at operator's desk in CCR so that they can initiate immediate release of the access-controlled gates and doors.

For assured safety, the Fire Alarm System shall be interfaced with the access control panel so that upon the detection of fire, the associated access-controlled doors shall be released for prompt evacuation of personnel.

The break glass unit shall be provided at every exit of the access-controlled doors so that the personnel can break the glass unit and activate the door release in case of emergency.

The system shall operate on 240V AC and shall have 240V AC UPS input to operate in all situations. The autonomy required for ACS shall be minimum 4 hours.

The ACS shall constitute the following main components at the locations mentioned below:

- ACS server and Management system with associated hardware, installed in the Telecom cabinet located in RO control room Building.
- Central Control and Monitoring station with all related hardware and software in the CCR and Guard house
- Badge maker set with camera and badge printer at Guard House.
- Access control panels/Segment controllers, as required per building.
- ACS door Hardware: Reader Interface Module (RIM), Card readers, door contacts, magnetic locks, Emergency Break glass and Exit push button per Access controlled door. For emergency doors, only door contact will be provided.
- Vehicle Entry/Exit Lane: The vehicle entrance/exit to the facility is to have an Access Control System installed; this will take the form of a Reader Pedestal mount at the entrance/exit which will have an Access Control Reader at car height and

lorry/tanker height, with a traffic light system. An Intercom connection to Guard house shall also be provided at Entry side to facility.

- Main Pedestrian Entry/Exit to facility: In order to register pedestrian entry/exit to the facility, 2 card readers are to be provided in Guard house.
- Access gate: In order to secure access gate, Card readers at both sides as well as door contact, magnetic lock, Junction box, etc. as required to be provided.
- Passive badges (minimum 100 numbers).

The access-controlled doors and gates shall be monitored via access control operator workstations located in Control Room and Guard House.

The ACS to be supplied shall have a badge printing station which shall also configure new cards and reconfigure existing cards for allowing access to specific locations of the facility.

The badge printing station (containing access configuration software) shall be installed in Guard House and shall be connected to the main ACS server located in engineering room of Facility. Hence any new entrant to the facility will first visit Guard House, where after all the required inductions and depending on nature of work, the access cards will be configured and provided. On receipt of valid card, the visitor shall be allowed to access the Facility.

All equipment and software shall be designed with 20% growth capacity allowance to allow for possible expansion at a later date without the need to add any additional hardware, software for the network operating system, or any additional changes to the network management system.

9.11.2 System Requirements

The Vendor shall ensure that the Access Control System meets or exceeds the following requirements:

- Reliable and proven equipment.
- Modular in design.
- Badge reader interrogation should be by inductive coupling or radio and not rely on physical contact with the badge.
- Central Equipment to hold database of authorized personnel.
- ACS system shall function as a standalone system and shall be interfaced with Fire Alarm System.
- The Control room shall have the ability to release all the locks in the event of an emergency.

9.11.3 Technical Requirements

9.11.3.1 Access Control Panel / Segment Controller

The ACS Control Panels shall have the following minimum facilities:

- Have multiple zone capability to allow or restrict personnel from entering building or a number of buildings.
- Have the facility to program specified access times to different buildings enabling personnel to enter the buildings only within these specific periods.
- Have the facility to permit access to personnel only on specific dates or days of the week, weekend or public holiday restrictions

Access Control Panel shall be microprocessor-based hardware, equipped with RAM and Flash memory (or other equivalent non-volatile memory) in order to maintain application program, configuration data, resident data base, events log and transactions.

All Access Control Panels shall be able to interface a local printer for logging, reporting and maintenance purposes. Local database shall be stored in removable static memory in order to easily restart system operation (simply moving the memory cartridge to the new unit) should the need arise for a new Controller to be installed in lieu of a failed unit.

If the entry from card reader is valid then the Control Panel shall release the locking mechanism to allow entry to take place. If an invalid access card is presented more than three times to proximity card reader the Control Panel shall activate an alarm signal warning of an illegal entry attempt.

Access Control Panel shall be capable of connecting and managing access control terminals providing personal card reading as well as input of additional data (PIN codes, biometric parameters, etc.) and output of messages and other information to the user.

Access Control Panels shall have inputs for connection of local hardware such as exit push buttons, lock monitoring and position monitoring (via contact sensors installed on emergency exit doors), BGU monitoring, device tampering etc. They shall also provide outputs for electromagnetic locking devices and onward connection to other ACS devices and transmission units.

Access Control Panels shall ensure communication on LAN and WAN networks. Access Control Panel will store alarms, events and transit transactions and send them to server either establishing a connection when the buffer memory has reached a given level or at scheduled times.

9.11.4 Card Readers

The proximity card readers shall use inductive coil, radio technology, or any state-of-the-art technology to identify the access card and feed the data to the System Controller Unit. The proximity card readers shall be Multi-technology contactless smart card reader and be able to accurately read the data from the access identification cards from a distance of >6 cm, preferred 9 cm.

The multi-technology contactless smart card reader(s) shall be designed to securely read, interpret, and authenticate access control data from 13.56 MHz contactless smart card credentials and 125 kHz proximity cards.

Long range card readers shall be installed for Main entry/exit gate enabling the drivers not to get out of their vehicle for badging. Card readers for small vehicles as well as trucks shall be installed in same pedestal with dual head.

The card reader units shall be protected against the ingress of dust and moisture.

The contents of the memory of the badge reader shall not be lost in case of power failure. The system shall start automatically at power return.

There shall be communications between the reader and the controller such that if wiring is cut, or the reader is disabled or tampered, an alarm message shall be sent to the system to inform the operator about the condition.

The card readers shall provide the ability to transmit an alarm signal to the Controller via an integrated tamper switch if an attempt is made to remove the reader from the wall.

All card readers should be affixed with tamper proof screws.

The outdoor card reader units shall be IP65 or higher, making them suitable for external installation. The Electronic equipment installed outdoor are working under hard environmental conditions so must be tropicalized.

9.11.5 Door Locks

All doors located throughout the plant that are required to be access controlled shall make use of magnetic door locks to hold doors closed under normal conditions and release the door for access once suitable access is granted via the card reader. All magnetic locks shall also have a break glass unit on the inside (secure area) to release the door for egress during an emergency.

In emergency situations the door locks should be released to allow speedy evacuation of the secured area. Fire Alarm system interface shall be provided to release the door lock instantaneously during a confirmed emergency.

Door locks shall suit door hardware proposed for the facility and should have a holding force of 1200 lbs.

9.11.6 ACS Management System

The ACS management system will use a Client Server architecture based around a modular PC network, utilizing industry standard operating systems, networks and protocols.

Main application areas covered by the management system shall include:

- Access Control (including Visitors management, Reception management, Guard Tour management, Risky Area Access Control management).
- Time & Attendance.
- Security Management for intruder detection.

Access Control will be based upon personal identification of employees and visitors using personal identification cards supplemented by additional personal data (PIN, biometric, etc.) should the need arise.

The ACS management system shall receive the data from the system Controllers, where the access control data from proximity card readers is gathered, to determine the validity of the presented access card.

The ACS management system shall record the identification of the location of the door, the person entering or leaving along with the day, date, and time of the entry or exit from the facility.

The records maintained by ACS management system shall be used for statistical purposes to identify who is in anyone building at any one time for use in the event of any emergency or evacuation. Access to the database shall be made available to the security at the Guard House as well as operators in CCR. The storage at this place shall be sufficiently large enough to maintain the data for a period of one month.

The management system as a minimum shall have the following facilities:

- Restricted access with password security to access the data.
- Anti-Pass-Back facility configuration.
- Trouble shooting facility.
- Statistical information on the Access Control System.
- Specific graphics showing as a minimum the access points.
- Access recording and personnel ID file database.
- Display of list and the total no. of personnel in each building.
- Display of date / time of entry / exit.

This management system shall be capable of displaying all the network settings, system interface modules and their individual settings. It shall allow the system manager to configure, control, fault find, activate or de-activate interface modules, monitor status and alarms etc.

There shall be several levels of password-controlled access to the management terminal from low level, (monitor only), to the highest level, (able to reconfigure etc).

All the local controllers, badge readers, locks and sensors associated with each door, on the Access Control system shall be monitored and managed from the management station.

System failures shall be automatically reported on the PC and shall include, as a minimum, date, time, location and type of all the alarms in the system.

9.11.7 Alarm Communication

The ACS shall provide monitoring and alarm communication functions for Doors / Gates including all entrance and emergency exit doors.

The ACS shall provide real-time alarm communication to security system operators in the event of:

- Door forced open
- BGU activation
- Door held open (for greater than x seconds)
- Door opened under duress (via duress PIN code input)
- Unauthorised access attempt
- Access attempts by pre-defined cardholders/cards
- Communications failure
- Mains & battery power failure
- Reader Tampering
- Panel Tampering
- PSU Cabinet Tampering

Alarms shall be communicated to the central workstation in the CCR where they shall be displayed on a GUI showing the location of the alarmed door and gate. The system shall use dynamic icons that change in colour and appearance in accordance with the alarm status of each door.

A unique icon shall be displayed for each type of device, including reader, locking device and emergency exit monitoring device. In addition, an audio alarm shall be sounded.

Alarms shall be automatically assigned a priority level according to the type of alarm.

In the event of two alarms having the same priority level they shall be displayed in chronological order by time of occurrence.

The system shall present the operator with a list of predefined actions to instruct them what to do in the event of that alarm occurring. Operators shall only be able to cancel alarms when the alarm condition has returned to normal.

Supervisor rights shall be required to acknowledge and cancel alarms that have not returned to their normal state, or to cancel multiple alarms.

All alarm details shall be recorded on the central database server, along with the identity of the operator who acknowledged and cancelled the alarm, in order to allow future reporting.

9.11.8 Access Cards

Read/write contactless smart card technology in a single card - providing high-speed, reliable communications with high data integrity shall be provided for this project. iCLASS technology ensures high security with mutual authentication between card and reader, encrypted data transfer, 64-bit diversified keys for read/write capability.

Access cards shall meet ISO standards for thickness for use with direct image and thermal transfer printers. The cards shall have the ability to add a magnetic stripe, barcode, custom

artwork, or photo ID and shall be available in 2k bit (256 byte), 16k bit (2K Byte) or 32k bit (4K Byte) memory configurations.

9.11.9 Door Contact Switch

Door Contact switch shall be mounted on top of door (not close to hinge side) to show the position of the door (This will give indication of unauthorized opening).

In the case of authorized access, door status changing to open will be taken as an indication to the Access Control Panel that the authorized presenter has pass through the door and to cancel any remaining unlock time.

All Emergency doors shall have door contacts.

9.11.10 Exit Push Buttons

- All exit push buttons are to be made of stainless steel and with an IP rating of IP54 due to the requirement for heavy and prolonged usage
- All devices should have a pictorial illustration of operation
- All devices should have a maximum operation temperature of up to 55.C
- All devices should have a minimum mechanical life of 1,000,000 cycles
- All devices should have a potential free contact rating of 5A@240V AC N.O/N.C Output

9.11.11 Card Issuing Facility

Vendor shall supply an access identification card issuing facility that shall enable Company to issue valid Access Cards.

Cards shall be credit size cards that shall indicate the following information as a minimum:

- Registered owners name
- Works number
- Department of employment
- Photograph
- Plant name, returning address and logo.
- Expiry Date

The identification cards shall not contain any visible information or indication of the buildings to which the holder is permitted access, this information shall be retained within a microchip embedded within the card.

Guest or visitor passes shall be made available programmed to restricted areas in the buildings.

The card issuing facility shall comprise a PC based recording and information system with a digital camera unit linked to the PC for taking the users photographs and the facility to enter access data to the passive system on the card.

The data, which is required to be programmed onto the card, shall include as a minimum:

- Card Holder's details
- Name
- ID Number
- Department/Organisation
- Building or Buildings for which the card is valid.
- Times of days for which the card is valid.
- Days for which access is permitted. Start and finish dates for the card's validity.

9.12 Public Addressing System

9.12.1 Design Consideration and Overview

A Public Address (PA) system shall be installed in 400MLD Perur Desalination facility where people may be present and aural communication is practicable.

An IP based Public Address system shall be provided within the Facility including RO building and Guard house.

The PA system shall provide basic functions for:

- Announcements: The capability to support prioritized one-way voice audio broadcasts to one or more zones from PA access panel and external audio interfaces.
- Emergency Notification: The capability to support prioritized alarm responses that include audio notification when initiated from PA access panels or external interfaces.
- Supervision: The capability to continually monitor all critical audio paths and circuits so that any failure can be brought to the attention of the system operators or maintenance personnel for corrective action.

An IP based Public Address System (PA system) shall be designed and installed in the Central Control Room or at the Security Control Room so that the operator can page any instructions to the personnel.

PA speakers shall be installed within the plant facility at the strategic locations where it is necessary to page important and emergency messages. PA speakers shall also be installed in RO building and guard house.

All the loudspeakers shall be connected to the same control cabinet in RO building.

Suitable speakers with acoustic specifications shall be installed in plant areas and buildings. PA access panel with goose neck microphone and zone selection facility shall be installed in the Control room of RO building through which the operator will be able to make speech announcement.

The PA system and its workstations shall be powered up by 240V AC station UPS which shall comply the autonomy of 8 Hours.

9.12.2 PA System Features

The system shall provide facilities for the control and management of a high integrity, IP based Public Address and Alarm System specially designed for industrial environments where advanced technology coupled with very high system availability is demanded. The materials used shall have characteristics suitable for the installation site and for the service required.

The equipment shall be fully solid state type, multi-microprocessor based and programmable. The system shall be software program controlled to enable easy system configuration and self- diagnostics, as well as future software upgrade. Configuration of the system shall be achieved by software for maximum flexibility. A user friendly set-up and checking routine shall provide system management and programming through LCD displays and Personal Computers, which enables an operator using a system controller to implement quick commissioning and fault finding functions. The use of these methods shall allow adjustments to be easily made after the system is installed, without resulting in modifications to the system wiring.

Facilities to indicate the status of the main system units shall be provided. Such indications shall show any faulty unit for easy replacement. The system shall be provided with standard serial/Ethernet interface for local or remote access for supervision and maintenance activities (such as diagnostics with a mimic panel, status and logging of events).

9.12.3 Main System Features of the Public Announcement System

a) Sound Pressure Level (SPL) Requirements

The design of the PA system shall be such that the ratio of PA speech level to background noise is a minimum of 6 dB and optimally 12 dB above ambient noise in all parts of the plant where persons may be present during normal operations and ambient noise levels permit.

Alarm tones shall be a minimum of 15 dB(A) and a maximum of 20 dB(A) above noise level in all parts of the plant where persons may be present during normal operations and ambient noise levels permit.

In areas where the ambient noise exceeds 85 dB (A) flashing beacons shall be provided.

The SPL at the listener shall not exceed 110 dB (A) or be less than 65 dB (A) in any circumstance.

The SPL in high ambient noise areas shall be checked during commissioning and any necessary adjustments made to the PA SPL to ensure requirements are met.

b) Loudspeakers

The Sound Pressure Level at the listener shall not exceed 110 dB (A) or be less than 65 dB (A) in any circumstance.

All outdoor loudspeakers shall be protected against water ingress to IP 65 as defined in IEC 60529 and indoor loudspeakers shall be IP54.

c) Configuration of Alarm Tones and Priorities

Alarm tones and priorities shall be just a feature inbuilt in the PA system. No alarms will be initiated by PA and PA shall be used for routine speech, emergency speech & operator announcements etc.

d) Configuration of Announcement Priorities

Announcements from different sources shall be configured to override others.

e) Pre-Announcement Tones

Single chime or double chime as pre-announcement tones shall be generated under software control, with the possibility to associate these different chimes to different sources and activation types. For example, typically a single chime precedes a routine announcement and a double chime precedes a telephone access.

f) Zone Selection of Announcement and Alarms

Real time voice messages and Emergency Alarm signals may be diverted to predetermined groups of amplifiers/loudspeakers. The access priority regime will determine which announcement has priority of access and is broadcasted.

The configurations of groups of zones shall be changed via software without the need to alter wiring of audio inputs or the speaker loops and this shall be inherent feature of the PA system.

g) Gain Control of Alarms and Announcements

Alarms and announcements shall be individually configurable to different volume levels to allow for clearly audible emergency broadcasts. An alarm in progress can be attenuated (up to 12 dB) or fully muted while an emergency broadcast is made and then increased back to its original level afterwards.

h) Digital Tones and Important Messages

The microprocessor shall control the generation of alarm tones, as well as digital speech messages. The system shall be provided with alarm and test tones.

Emergency notification alarms can be broadcast manually. Each alarm is fully configurable and initiated by a direct command from an access panel for security reasons it shall only be possible to reprogram either the important message or the alarm tones.

i) Audio Alarm

Suitable and sufficient speakers shall be provided in the facility to ensure all areas are covered.

Alarm tones shall be a minimum of 15 dB(A) and a maximum of 20 dB(A) above noise level in all parts of the plant where persons may be present during normal operations and ambient noise levels permit.

j) Power Amplifiers

Industry standard 300 Watt power amplifiers shall be provided with the following minimum features: low idle current, LCD indicators for output level, built-in thermal protection, overload and short circuit protection. The short circuit protection shall shut off the power amplifier for a 5-second period, repeating until the fault is rectified. Power amplifiers shall be provided with built-in supply capability from AC mains.

k) Multiple Sources of Speech

Announcements shall be able to be made from a variety of sources, such as engineer test panel, operator access panel, microphone panel, Secretary desk panel and from telephones.

l) Built-in Self Diagnostics

Each piece of system equipment shall have a comprehensive built in diagnostic test feature so that at all times the status of the system can be monitored. Circuit failures shall be reported on the LCD display of the Controller Unit and on the operator's control sets, and reported remotely through dry contacts and/or serial lines.

The system monitoring functions shall include; Management System alarms, power amplifier alarms, power supply alarms, speaker loop alarms and communication alarms between the various system equipment.

m) Speaker Loop Monitoring

The system shall provide the facility for monitoring speaker loop status. Automatic setting procedures shall be able to be programmed in order to check all output line conditions at real time (or scheduled) trouble-shooting of the individual speaker loops.

The system shall provide facility for detection of speaker line earth leakage and for detection of speaker line impedance deviation.

n) Audio Recording

The calls originated from telephone or microphone consoles shall be automatically recorded through a suitable digital audio recorder, with a removable storage media.

During an incident or emergency, it shall be possible to record voice traffic on the system for future replay.

o) Alarm Attenuation

Attenuation of alarms while a broadcast is being made shall be provided. The alarm audio

level shall be reduced up to 12 dB from the broadcast level.

p) Audio Path Monitoring

The system shall provide full audio path test from microphone panels for loud speaker checks.

q) Background Broadcast

The system shall be able to provide broadcasts of background sound/music from various sound/music sources such as CD players, cassette recorders or tuners.

r) PABX Access

A priority telephone interface unit shall be installed at equipment cabinet.

Upon receipt of a valid access code (e.g., 333) a confirmation tone is returned to the call originator and the message to be broadcast shall be recorded.

s) Public Address Announcement

The PA system shall provide one-way voice audio broadcast primarily utilizing access panels located in the Control room. Additional broadcast services shall be provided through interfaces to the telephone system.

Alarm audio notification shall employ circuitry integral to voice audio broadcast so as to facilitate prioritization. Access panel, external audio interface and alarm audio sources shall be prioritized by content to allocate access to the most critical broadcast information.

A facility to combine both zone selection and announcement initiation shall be supported. This facility shall allow an operator to select one momentary switch to launch a routine announcement to one pre-configured zone. Zone selection is automatically terminated after an announcement.

Status facilities shall be provided to display system information regarding active or non-active announcement information on access panel indicators. This status serves to sequence equal access announcements.

t) Emergency Notification

The PA system shall support alarms that consist of distinctive tones to predetermined destinations. The system shall have the provision to provide Visual notification for alarms and emergency announcements to supplement audio notification in areas where noise levels typically exceed 85dBA or in accordance with customer requirements. Visual notification shall be through colour coded beacons that indicate the severity of the alarm or emergency announcement.

Each alarm may be initiated through an access panel, serial link and external voltage free contact interface. The standard manual format for alarm operations from an access panel shall be through switches for activation. The external interface shall support configurable

serial interface, normally open or normally closed, maintained or momentary voltage-free contacts for each automatic alarm activation.

Audio notification shall be prioritized to assure the broadcast of the most critical alarms. Customization of the system design shall be provided for additional alarms.

Status facilities shall be provided to display system information regarding active or non-active alarm information on access panel indicators. This status serves to provide a visual interpretation to access panel operators.

u) Supervision

The central equipment shall incorporate configurable automatic monitoring facilities. These facilities shall be selected during system design in accordance with the customer requirements.

The standard set of monitoring facilities shall interrogate:

- Controller unit with built-in message/tone generator.
- Power amplifiers.
- Loudspeaker loops.
- Digital communication paths between different system equipment.

The interrogation of supplemental circuits shall be supported as required.

The standard system design shall ensure that all critical audio paths and operation of the PA system are continuously monitored, so faults are immediately identified. The Controller Unit located in the central equipment cabinet shall assist in fault location and diagnosis during a failure condition. Voltage free relay contacts shall be provided to enunciate equipment failure conditions to external systems.

Facilities shall be provided to display system information regarding health or fault information on access panel indicators.

Another access panel shall be provided to the operator in control room to monitor the PA alarms.

v) Plant Telephone Access

The following steps are completed to make an all zone page announcement from a plant telephone:

Dial the “PA Access” number – the system will auto-answer if the line is not already engaged; otherwise, a busy notification will be returned. As an alternative it is possible to provide zone selection from PABX access by keying the appropriate zone once a seize condition has been registered. Make announcement – then through the use of the page delay feature to eliminate feedback, the system broadcasts the user’s voice to all zones if no other higher or equal priority broadcast is active.

w) Loudspeaker Loops

The loudspeaker distribution shall be based on a PA coverage study/noise report developed by the Vendor during detailed design.

The number of PA speakers and their tapings for required SPLs shall be finalized/specified by Vendor. The HSE noise study shall be used in the background during the PA coverage study, to determine the Signal to Noise ratio for speaker allocation.

Loudspeaker loops shall be designed in such a way that there will be always an overlap between two independent loops, so that in case of a loudspeaker failure, service would be maintained.

Loudspeaker loops shall be fed from both ends so that in case of cable damage service would be maintained on both half loops.

9.13 Fire Detection and Alarm System

9.13.1 General

A centralised electronic fire detection and fire alarm system shall be designed, installed and commissioned with all necessary equipment, accessories and cabling.

A complete system shall be provided with all components required for automatic operation. The main functions of the system shall be as follows:

- The actuation of any fire detection device shall be audible and visible displayed on a central fire alarm control panel and audible alarms shall be initiated throughout the building.
- The system shall differ whether the alarm was initiated by an automatic detection device or by a manual fire alarm station.
- Audible alarms may be silenced by pushing a silence button on the central fire alarm control panel. Any subsequent actuation of a detection device shall again sound the audible alarms.
- Fire doors, fire dampers, if any, air handling units or any other equipment or devices shall be released or shut down as required.
- Short circuit, wire break or any other system troubles shall be indicated on the central fire alarm control panel.
- After restoration of the alarm detection device to its normal condition, the system shall be returned to normal stand-by condition.

The fire alarm system shall comply with requirements as per the latest applicable Indian Standards, Indian Electricity Rules 1956, Fire Regulations and relevant Code of Practices. NFPA Standard 72 for Protected Premises Signalling Systems except as modified and supplemented by this specification. The system shall be electrically supervised and monitor the integrity of all conductors.

Any item which may not have been specifically mentioned herein but are needed to complete the equipment / system shall also be treated as included and the same shall be furnished and erected, unless otherwise specifically excluded as indicated.

Wherever the Indian Standards do not exist the equipment / components shall be designed, assembled and tested in accordance with the latest editions of the other relevant applicable Standards. In such a case the Bidder shall clearly indicate the standards adopted, furnish a copy of the latest revision of standard along with copies of all official amendments and revisions in force as on date of opening of bid and clearly bring out the salient features for comparison.

For fire protection, firefighting system refer to section Fire Protection System specification.

The fire detection and fire alarm system shall mainly consist of the following equipment.

9.13.2 Main Fire Alarm Control Panel:

Main Fire Alarm Control Panel (FACP) shall contain a microprocessor based Central Processing Unit (CPU) and power supply. The CPU shall communicate with and control the following types of equipment used to make up the system: intelligent addressable smoke and thermal (heat) detectors, addressable modules, printer, annunciators, and other system-controlled devices.

In conjunction with intelligent Loop Control Modules and Loop Expander Modules, the main FACP shall perform the following functions:

1. Supervise and monitor all intelligent addressable detectors and monitor modules connected to the system for normal, trouble and alarm conditions.
2. Supervise all initiating signaling and notification circuits throughout the facility by way of connection to addressable monitor and control modules.
3. Detect the activation of any initiating device and the location of the alarm condition. Operate all notification appliances and auxiliary devices as programmed. In the event of CPU failure, all SLC loop modules shall fallback to degrade mode. Such degrade mode shall treat the corresponding SLC loop control modules and associated detection devices as conventional two-wire operation. Any activation of a detector in this mode shall automatically activate associated Notification Appliance Circuits.

9.13.3 Fire Alarm Control Panel - System Capacity and General Operation

- A. The FACP shall be capable of communicating over a Local Area Network (LAN) or Wide Area Network (WAN) utilizing a peer-to-peer, inherently regenerative communication format and protocol. The network shall support communication speed up to 100 Mb and support up to 200 panels / nodes per network.

- B. The control panel shall be capable of expansion of up to 10 SLC loops. Each module shall support up to 318 analog/addressable devices for a maximum system capacity of 3180 points.
- C. The Fire Alarm Control Panel shall include a full featured operator interface control and annunciation panel that shall include a backlit 640-character liquid crystal display, individual, color coded system status LEDs, and a QWERTY style alphanumeric keypad for the field programming and control of the fire alarm system. Said LCD shall also support graphic bit maps capable of displaying the company name and logo of either the owner or installing company.
- D. All programming or editing of the existing program in the system shall be achieved without special equipment and without interrupting the alarm monitoring functions of the fire alarm control panel.
- E. The FACP shall be able to provide the following software and hardware features:
 1. Pre-signal and Positive Alarm Sequence: The system shall provide means to cause alarm signals to only sound in specific areas with a delay of the alarm from 60 to up to 180 seconds after start of alarm processing. In addition, a Positive Alarm Sequence selection shall be available that allows a 15-second time period for acknowledging an alarm signal from a fire detection/initiating device. If the alarm is not acknowledged within 15 seconds, all local and remote outputs shall automatically activate immediately.
 2. Smoke Detector Pre-alarm Indication at Control Panel: To obtain early warning of incipient or potential fire conditions, the system shall support a programmable option to determine system response to real-time detector sensing values above the programmed setting. Two levels of Pre-alarm indication shall be available at the control panel: alert and action.
 3. Alert: It shall be possible to set individual smoke detectors for pre-programmed pre-alarm thresholds. If the individual threshold is reached, the pre-alarm condition shall be activated.
 4. Action: If programmed for Action and the detector reaches a level exceeding the pre-programmed level, the control panel shall indicate an action condition. Sounder bases installed with either heat or smoke detectors shall automatically activate on action Pre-Alarm level, with general evacuation on Alarm level
 5. The system shall support a detector response time to meet world annunciation requirements of less than 3 seconds.
 6. Device Blink Control: Means shall be provided to turn off detector/module LED strobes for special areas.
 7. History Events: The panel shall maintain a history file of the last 4000 events, each with a time and date stamp. History events shall include all alarms, troubles, operator actions, and programming entries. The control panels shall also maintain a 1000 event Alarm History buffer, which consists of the 1000 most recent alarm events from the 4000-event history file.
 8. Passwords and Users: The system shall support two password levels, master and user. Up to 9 user passwords shall be available, each of which may be

- assigned access to the programming change menus, the alter status menus, or both. Only the master password shall allow access to password change screens.
9. Environmental Drift Control: The system shall provide means for setting Environmental Drift Compensation by device. When a detector accumulates dust in the chamber and reaches an unacceptable level but yet still below the allowed limit, the control panel shall indicate a maintenance alert warning. When the detector accumulates dust in the chamber above the allowed limit, the control panel shall indicate a maintenance urgent warning.
 10. Custom Action Messages: The system shall provide means to enter up to 100 custom action messages of up to 160 characters each. It shall be possible to assign any of the 100 messages to any point.
 11. Local Mode: If communication is lost to the central processor the system shall provide added survivability through the intelligent loop control modules. Inputs from devices connected to the SLC and loop control modules shall activate outputs on the same loop when the inputs and outputs have been set with point programming to participate in local mode or when the type codes are of the same type: that is, an input with a fire alarm type code shall activate an output with a fire alarm type code.
 12. Read status preview - enabled and disabled points: Prior to re-enabling points, the system shall inform the user that a disabled device is in the alarm state. This shall provide notice that the device must be reset before the device is enabled thereby avoiding activation of the notification circuits.
 13. Custom Graphics: When fitted with an LCD display, the panel shall permit uploading of a custom bit-mapped graphic to the display screen.

F. Network Communication

1. The FACP shall be capable of communicating over a Local Area Network (LAN) or Wide Area Network (WAN) or Fiber to Fiber utilizing a peer-to-peer, inherently regenerative communication format and protocol. The network shall support communication speed up to 100 Mb and support up to 200 panels/nodes per network.
2. List of Minimum Interface using IFU / Modules. Final list shall be discussed with client & based on plant operation philosophy it shall be expanded.
3. Fire Fighting System shall be interfaced with CCTV System Via Modbus TCP/IP Protocol
4. Interface List (Minimum services)
 - Fire Fighting Systems
 - Extinguishing Agent System if available
 - Access Control System
 - DCS/SCADA Networks
 - Building Automation System
 - AHU & Fire Dampers
5. The FACP shall be capable of communicating with a Distributed Control System

6. All FACP's shall be networked through Single Mode Fibre Optic Networking & also dedicated Fire fighting Central Control station shall be provided. Central control station shall communicate with DCMS via Modbus TCP/IP protocol

G. Central Processing Unit

1. The Central Processing Unit shall contain and execute all control-by-event (including Boolean functions including but not limited to AND, OR, NOT, ANYx, and CROSSZONE) programs for specific action to be taken if an alarm condition is detected by the system. Such control-by-event programs shall be held in non-volatile programmable memory, and shall not be lost with system primary and secondary power failure.
2. The Central Processing Unit shall also provide a real-time clock for time annotation, to the second, of all system events. The time-of-day and date shall not be lost if system primary and secondary power supplies fail.
3. The CPU shall be capable of being programmed on site without requiring the use of any external programming equipment. Systems that require the use of external programmers or change of EPROMs are not acceptable.
4. The CPU shall provide an EIA-232 interface between the fire alarm control panel and the UL Listed Electronic Data Processing (EDP) peripherals.
5. The CPU shall provide two EIA-485 ports for the serial connection to annunciation and control subsystem components.

H. Display

1. The system display shall provide a 640-character backlit alphanumeric Liquid Crystal Display (LCD). It shall also provide eleven Light-Emitting-Diodes (LEDs) that indicate the status of the following system parameters: AC POWER, FIRE ALARM, PREALARM, SECURITY, SUPERVISORY, SYSTEM TROUBLE, OTHER EVENT, SIGNALS SILENCED, POINT DISABLED, CONTROLS ACTIVE, and CPU FAILURE.
2. The system display shall provide a QWERTY style keypad with control capability to command all system functions, entry of any alphabetic or numeric information, and field programming. Two different password levels with up to ten (one Master and nine User) passwords shall be accessible through the display interface assembly to prevent unauthorized system control or programming.

I. Loop (Signaling Line Circuit) Control Module:

1. The Loop Control Module shall contain its own microprocessor and shall be capable of operating in a local/degrade mode (any addressable device input shall be capable of activating any or all addressable device outputs) in the unlikely event of a failure in the main CPU.
2. The SLC interface board shall receive analog or digital information from all intelligent detectors and shall process this information to determine whether normal, alarm, or trouble conditions exist for that particular device. Each SLC Loop shall be isolated and equipped to annunciate an Earth Fault condition.

J. Field Programming

1. The system shall be programmable, configurable and expandable in the field without the need for special tools, laptop computers, or other electronic interface equipment. There shall be no firmware changes required to field modify the system time, point information, equations, or annunciator programming/information.
2. It shall be possible to program through the standard FACP keyboard all system functions.
3. All field defined programs shall be stored in non-volatile memory.

9.13.4 Automatic Fire Detectors

Automatic detectors shall be of the fixed temperature and/or rate-of-rise heat detectors, optical smoke and/or ionization smoke detectors and ultraviolet and/or infrared flame detectors, subject to approval.

Each automatic detector shall be addressable. Actuation of any detector shall be displayed individually on the central fire alarm control panel.

Each automatic detector shall have a continuous condition supervision by using pulsing, trend evaluating or equivalent system techniques. The detector spacing on smooth surfaces shall not exceed the distance recommended by the approving authorities.

In areas, where irregularities occur, the detector spacing shall be reduced in such a way as to obtain approved spacing. Detectors generally shall be connected in groups to the central fire alarm control panel. The number of detectors installed on anyone signalling line shall be limited as recommended by the manufacturer. Signalling lines shall be designed as loop connections, unless otherwise approved.

The detectors shall be ceiling-mount and shall be plug-in mounted into a twist-lock base. These detectors shall be constructed of off-white UV resistant polymer and shall be detachable from the mounting base to simplify installation, service and maintenance. Mounting base wiring connections shall be made by means of SEMS screws. The detector shall allow pre-wiring of the base and the head shall be a plug-in type. Mounting base shall be mounted on junction box which is at least 1.5 inches (3.81 cm) deep. Mounting base shall be available to mount to standard junction boxes.

As a minimum following list of main areas are to be covered by the fire alarm system:

S. No.	Building/Area/ Equipment	Detection Systems
1.	Intake pump station	Smoke detectors. Automatic fire alarm system and manual fire alarm stations
2.	Potable/permeate Water Pump Station	Smoke detectors. Automatic fire alarm system and manual fire alarm stations

3.	Chemical Buildings	Smoke detectors. Linear heat detectors. Automatic fire alarm system and manual fire alarm. Gas detector.
4.	Chemical Stores	Smoke detectors. Linear heat detectors. Automatic fire alarm system and manual fire alarm
5.	HV, MV, LV Switchgear Buildings housing switchgears. Electrical Buildings-RO building	Smoke detectors. Automatic fire alarm system and manual fire alarm stations
6.	All Oil Filled Transformers	Fusible bulb/quartzoid bulb as well as sprinkler head heat detectors. Automatic fire
7.	Diesel Generator	UV/IR detectors. Smoke detectors. Automatic fire alarm system and manual fire alarm stations.
8.	RO Buildings DAF/DMF buildings	Automatic fire alarm system and manual fire alarm stations. Smoke detectors.
9.	Workshop/ warehouse	Automatic fire alarm system and manual fire alarm stations. Smoke detectors.
10.	Storage buildings (RO membranes, mechanical, etc.)	Automatic fire alarm system and manual fire alarm stations
11.	Local Control, Computer, Electronic and Switchgear Rooms	Smoke detectors. Automatic fire alarm system.
12.	Cable Floors, Shafts and Tunnels, including 110 kV cable tunnels	Smoke detectors for ventilated cable floors and tunnels. Linear heat detectors for non-ventilated cable floors and tunnels. Automatic fire
13.	Battery rooms	Automatic fire alarm system and manual fire alarm stations. Smoke detectors.
14.	Administration Building / Engineering – Operation building / Laboratory/ computer building	Smoke and heat detectors. Automatic fire alarm system
15.	All other buildings and areas	Manual fire alarm stations

A. Photoelectric type smoke detectors

The intelligent photoelectric smoke detector shall use the photoelectric (light-scattering) principal to measure smoke density and shall, on command from the control panel, send data to the panel representing the analog level of smoke density.

Photoelectric type smoke detectors shall be low voltage, two wire, solid state devices that provide for integral communication with microprocessor-based fire detection system. The detectors shall be able to communicate with the control panel regarding individual address, sensor type and analogue signals.

B. Heat Detector (Intelligent Thermal Detectors):

These shall be analog addressable, fixed cum rate of rise type and designed to operate when the ambient temperature rises beyond a fixed temperature or if the rate of rise is faster than the pre-determined rate and allowing the increase / rise for a specified period.

The detectors shall have the following features:

- Dual thermistors for fast response to temperature increases.
- Alarm temp. : Preferably within 10oC of max ambient temp.

The intelligent thermal detectors shall be series addressable devices rated at 135 degrees Fahrenheit (58 degrees Celsius) and have a rate-of-rise element rated at 15 degrees F (9.4 degrees C) per minute. A high heat thermal detector rated at 190 degrees Fahrenheit shall also be available. The thermal detectors shall connect via two wires to the fire alarm control panel signalling line circuit.

C. Multi Criteria Acclimating Detector or Combination Detector:

These detectors shall combine the principles of photoelectric and heat detection into single sensor head. detector shall be an addressable device, that is designed to monitor a minimum of photoelectric and thermal technologies in a single sensing device. The design shall include the ability to adapt to its environment by utilizing a built-in microprocessor to determine its environment and choose the appropriate sensing settings.

The intelligent multi criteria detection device shall include the ability to combine the signal of the thermal sensor with the signal of the photoelectric signal in an effort to react hastily in the event of a fire situation. It shall also include the inherent ability to distinguish between a fire condition and a false alarm condition by examining the characteristics of the thermal and smoke sensing chambers and comparing them to a database of actual fire and deceptive phenomena.

9.13.5 Manual Fire Alarm Stations or Manual Call Stations

Manual fire alarm stations shall be of the break glass push button operated type and individual addressable and displayable on the central fire alarm control panel if activated. The boxes shall be painted red with white or black lettering in the local language and in English.

The unit shall be addressable and communicate with the FACP like other detectors. Manual call points for outdoor mounting shall have IP-65 enclosure protection.

9.13.6 Announciators or Hooters

Electronic hooters shall be used for audio alarm to alert people in case of fire and shall be fully solid state with audio output sufficient to be heard at a distance not less than 50m. Normally the hooters shall be loop powered using suitable addressable modules. The hooters shall have facility for adjustment of volume as per requirement at site. The units shall be located at vital places and shall have minimum audible level of 65 dB or 5 dB above noise level of the working area and in the plant area also. Outdoor type hooters shall have IP65 protection class.

They shall have a minimum noise level of 110 dB(A) at a distance of 1 m and shall be different in sound from other sirens, if any, installed in the area for other purposes.

The hooting must be audible throughout the entire premises.

9.13.7 Human Machine Interface (HMI)

One HMI Station shall be supplied with the system for showing the graphics related to system connection, Detector layouts etc. and for carrying out the FAP programming functions. The software shall be suitable for operation with Windows XP / 2003 OS or latest versions.

The system shall be supplied / loaded with the necessary software for operation of the panel as per the desired sequence / scheme of operation / specification / system configuration, smoke detector environmental compensation, detector pre-alarm, history logging, output control by event, check & change time based control, detectors sensitivity, alarm verification device or zone, system operations passwords etc.

9.14 IP Telephone and LAN Systems Overview

As part of this project it is essential to provide IP Telephone extensions and LAN network in RO Building, Guard house, Substation buildings, administration buildings and other utility areas.

The IP Telephone exchange shall be located in RO building and shall be digital with open architecture equipped with PSTN trunk interfaces, voice mail system (VMS) and Windows based configuration, diagnostic and billing software.

As part of this project scope, the PSTN network shall be extended from a local service provider to RO building of SIWP facility over fibre optic network. Telephone and LAN services shall further be extended to the end users within the buildings mentioned above over Optical fibre and UTP/STP structured cabling system.

The number of wall sockets in the Buildings shall be finalized based on the building architecture and furniture layout.

9.14.1 IP Telephone System Overview

An IP telephone network shall be provided to provide voice services to the facility. The IP telephone network shall be based on a distributed architecture, with a main IP PBX exchange and Cisco switches, using the Fibre Optic infrastructure for interconnection.

The system shall be capable of providing services for voice, data (via modems) and fax communications inside and outside the plants, and voicemail facility.

As a minimum IP telephone system shall provide for the following:

- Calling to/from the public switched telephone network (PSTN),
- PA System Access

The system shall comprise but not be limited to the following equipment:

- a) A main IP exchange located in the RO building Engineering room with duplicated cards/modules and in-built redundant power supply with automatic changeover in the event of failure.
- b) The system shall be designed to accommodate specific requirements as well as future developments. It shall be modular in design so that should the system require expansion, units can be added without substantial system changes.
- c) Cisco switches with POE located in the buildings of the facility. The switches will be connected to the main IP PBX through a dedicated LAN, using FO infrastructure. The switches will be sized according to the number of extensions to serve, including the 25% of additional active extensions.
- d) Internal IP telephone sets for office use. The phones will be desk mounted type except specific locations in substations where wall mounted type is required.
- e) Fax machines
- f) Operator Console for operator assistance.
- g) Networked voice mail services for all telephone users.
- h) Dedicated PC workstations for local management, maintenance, configuration, accounting and supervisory
- i) Connection of the internal phones and fax machines through the structured Cabling System between the outlets and the switches.
- j) Provision of STP & UTP Cat 6 cables, CAT6 Patch panels, Patch cords and RJ45 socket outlets in the buildings.
- k) Provision of modem/ Interfaces for connection to local service provider telephone network and international gateway. Liaise with local service provider for connection to PSTN is also part of this project scope.
- l) Software licences and associated documentation and programming manuals required to operate, configure and programme the IP PBX system, and all individual equipment, cards and modules within the system. The software shall be compatible with and suitable for operation with the provided system.

All the IP telephone system equipment shall be fed from 240V AC UPS which shall comply with the autonomy of 2 Hours.

9.14.2 IP PBX System Description

- The IP PBX must be of physically duplicated configuration for control, processing, memory, power supply without any single point of failure and in a full hot standby operation mode.
- The IP PBX must be SIP enabled system with capability for 100 subscriber lines with a provision of expandability minimum up to 200 subscribers lines without changing or cascading multiple IP PBXs to achieve the future capacity. The IP Exchange must have capability for connecting of 5 numbers of 2Mbps trunk lines with redundancy.
- In hot-standby operation mode, during changeover from active module to standby, any active/ongoing calls across the entire network/locations must not be interrupted or affected. There must not be any restriction on number of endpoints being backed up in case of failure.
- The standby module must be in automatic synchronization with the active one and must be able to take over the database and telephony functions seamlessly in case of failure of main active one without any need of manual configuration & administration.
- The call processor at the core must be standard SIP based and must be able to register SIP phones directly to it and supports the standards-based principles of IP Multimedia Subsystem (IMS) to allow custom core services to be delivered to each user in the enterprise.
- The IP PBX, gateway and IP Phones must support IPV4 and IPV6.
- The IP PBX shall support DECT and Wifi.

9.14.3 Expansion Capabilities

All critical & common IP PBX's modules including microprocessor, power supply, network switching, etc. shall be duplicated (Hot standby automatic changeover).

The equipped capacity of the IP PBX's shall be the initial working line and trunk requirement, plus a minimum of 25% (installed and already wired) spare equipment for future use.

9.14.4 Interfaces

The following type of interfaces shall be provided on the main IP PBX:

- a) Interfaces to connect to other systems like PA system.
- b) Interfaces to connect to local service provider telephone network and international gateway.
- c) Interfaces to connect to PSTN for direct lines
- d) Gigabit Ethernet interface (optical module 8 nos.) for connection via Fibre Optic Cabling Network.

9.14.5 System management and maintenance

The IP PBX shall be equipped with a Maintenance Terminal consisting of a standard PC with LCD monitor, keyboard and printer installed in the Engineering room.

The Maintenance Terminal shall incorporate all facilities required for configuring the IP PBX, for automatic troubleshooting and for maintenance.

A call accounting software on a dedicated PC shall be provided. Traffic management software shall also be provided to produce various traffic analysis reports and graphs.

9.14.6 Numbering plan

The Numbering plan of all extensions and IP PBX ports will be provided by CMWSSB so that the Vendor can program the system during the procurement phase.

9.14.7 Voice Mail System

The IP PBX shall be equipped with integrated voice mail system to enable one mailbox to each subscriber.

9.14.8 Operator Console

Two Operator console position shall be provided for the Plant, that shall have standard IP telephones installed complete with a display unit, hands free operation and user programmable personal keys.

Access to the PA system, shall be made available from the operator positions.

One Operator console shall be installed as part of the management terminal in the Engineering Room of RO building. Another Operator console shall be installed in the Reception area of the RO Building. Both these consoles shall be PC based and shall have access to a directory database that shall include subscriber names, designation, department, class of service and other allied information. Both terminals shall be password protected to prevent unauthorised personnel from accessing the operational facilities.

The console shall also give access to pre-defined IP PBX management functions, with visibility of traffic, configuration data and alarm report of the IP PBX. Day/night service shall be configurable.

9.14.9 Equipment Specifications

9.14.9.1 Common Systems Provisioning

The IP PBX supplied shall use the latest proven technology. Proven technology shall be taken as being in full production and systems operating in a commercial environment. All utilized hardware components shall be the latest commercial release version.

The equipment shall be modular in design. All critical systems shall be duplicated and operate in a hot-standby mode, with automatic switching between active and standby sub-systems.

The switching network shall be non-blocking.

Operation in a 100% Direct Inward Dialling / Direct Outward Dialling mode shall be supported since operator service may not be available on a 24-hour basis.

9.14.9.2 Software System Requirements

Software shall be of the latest issue commercially released and be modular, upgradable and flexible.

Beta release level software shall not be acceptable. Software shall have a User-friendly graphical environment with plug and play detection of boards, easily manageable database, automatic configuration, hardware diagnostic routines, Remote line testing, billing, reporting and other standard features.

User defined configuration and assignment data shall be changeable. No configuration data shall be fixed in the software load.

9.14.9.3 Direct Inward Dialling

Direct inward dialling shall be possible from all incoming calls to all lines on the IP PBX.

By the assignment of service classes it shall be possible to exclude specific lines from the direct inward dialling facility.

9.14.10 Direct Outward Dialling

Direct outward dialling shall be possible from all lines to all outgoing calls on the IP PBX.

By the assignment of service classes it shall be possible to exclude specific lines from the direct outward dialling facility.

9.14.11 General Subscriber Facilities

Facilities to be made available on the IP PBX shall be, but not necessarily limited to, the following:

- Call Forward – All Calls
- Call Forward – Busy
- Call Forward – No Answer
- Hold
- Call Transfer
- Call Waiting
- Conference
- Do Not Disturb
- Executive Override
- Follow Me
- Group Call Pickup
- Hotline

- Hunting
- Ring Back When Available
- Ring Back When Free
- Speed Call – Individual
- Speed Call – System

9.14.12 Conference

Meet-me and progressive conference capabilities shall be provided on the IP PBX. Conference groups of up to six (6) subscribers shall be provided.

Multiple separate conferences shall be possible at the same time.

9.14.13 Internal IP Telephone sets and Faxes

All the telephone sets are IP type and will be located inside buildings. Majority of telephone sets are desk mounted. However, a number of telephone sets will be wall mounted type.

The telephones shall be fully compatible with the IP PBX system and shall include a full range of features and functions. The IP phones will be equipped with LCD display and hand-free facility as a minimum features.

The fax machines shall be from the latest models range of the market and shall include a full range of features and functions, not limited to: storage, plain paper printing, distribution to multiple destinations, calls log, password restriction.

Labels shall be affixed to each telephone indicating Tag Number and extension number. A phone directory will be provided.

9.14.14 IP Telephone Sets

The IP phones shall support the following minimum features:

- Graphical TFT colour display, 16-bit colour depth, 320 x 240 effective pixel resolution, with backlight.
- Support for wideband (G.722 codec, adherence to TIA 920), including handset, headset, and speakerphone.
- G.711a, G.711, G.729a, G.729ab, G.722, and iLBC audio compression codecs shall be supported.
- Full-duplex speakerphone with acoustic echo cancellation.
- Provides direct access to voicemail using message keys.
- Internal 2-port Ethernet switch allows for a direct connection to a 10/100/1000 BASE-T Ethernet network through an RJ-45 interface with single LAN connectivity for both the phone and a collocated PC. System administrator can designate separate VLANs (802.1Q) for the PC and phone, providing improved security and reliability of voice and data traffic.
- Shall support differentiated services code point (DSCP) and 802.1Q/p standards.

- IP address assignment can be statically configured or configured through the DHCP client.
- Support both SIP & H.323 protocol.
- PoE Class (IEEE 802.3af) registers as class 1 device.
- Hard buttons for messages, call history, home, navigation cluster, contacts, headset, volume, mute, speaker etc.
- Wideband audio for both handset and headset.
- LEDs for speaker, mute, call history, message etc.
- Message waiting indicators.
- Desk/wall mounted type with all installation accessories.

9.14.15 Office Lan Network Architecture

All the equipment and relevant software required for Office LAN network at plant is part of this project scope.

This shall include but not be limited to:

- Provision of server switches.
- Provision of Router for connection to local service provider network
- Provision of STP & UTP Cat 6 cables, CAT6 Patch panels, Patch cords and RJ45 socket outlets in RO building and Guard house.
- Provision of LAN distribution and access Cisco Switches.
- Connection of Switches to server switches in RO Control Room.
- Provision of the required telecom cabinets to house telecom equipment.

Liaise with local service provider for connection to service provider network is also part of this project scope.

All the conduits, CAT6 cables, LAN sockets, Computer PCs with monitor, keyboard and mouse and other materials to provide extensions in RO building and Guard house required for Office LAN network at Sohar IWP plant shall be provided as part of this project.

The equipped capacity of the Office LAN network shall be the initial working line plus a minimum of 25% (installed and already wired) spare equipment for future use.

All Office LAN system components shall be powered from 240V AC UPS which shall comply with the autonomy of 2 Hours.

9.14.16 LAN Distribution/Router Switch

The LAN distribution switch for the plant shall be reputed make core switch and shall meet the following minimum requirements.

- Fast Ethernet modules (with IEEE 802.3af Power over Ethernet [PoE])
- Gigabit Ethernet modules (with IEEE 802.3af PoE)
- 10 Gigabit Ethernet modules
- Multiprotocol Layer 3 routing supports

- Redundant Control Channel to increases resiliency to protect against backplane control channel failures.
- Redundant supervisor engine to increase availability
- Redundant power supply option
- Supports both AC and DC power supply options, including AC and DC mixing. One of the power supplies shall be 48VDC and the other 240VAC.
- Hot swappable fan trays
- Front-to-back air flow to support hot aisle or cold aisle designs.
- Supports NEBS L3 compliance

9.14.17 LAN Access Switch

The LAN access switches shall meet the following minimum requirements:

- 12 and 24 10/100/1000 PoE+ models
- 4 x 1GE Network Module
- Industry first PoE + with 30W power on all ports in 1 rack unit (RU) form factor
- Support for dual redundant, modular power supplies and fans
- Media Access Control Security (MACsec) hardware-based encryption
- IPv4 and IPv6 routing, Multicast routing, advanced quality of service (QoS), and security features in hardware.
- Enhanced Cisco Energy Wise for operational cost optimisation by measuring actual power consumption of the PoE devices, reporting, and reducing energy consumption across the network.
- USB Type-A and Type-B ports for storage and console respectively and an out-of-band Ethernet management port.
- Cisco Stack Power technology: Feature for sharing power among stack members.
- Cisco Stack Wise Plus technology for ease of use and resiliency with 64 Gbps of throughput.

CHAPTER - 10

10. INSPECTION AND TESTING REQUIREMENTS

10.1 Inspection and Testing During Manufacture

10.1.1 General

All items of Plant shall be liable to inspection and testing before despatch. Detailed Manufacturing Quality Plan indicating various stages of inspection for each item / equipment shall be submitted to the Employer for review and approval. Unless otherwise authorised by the Engineer, the Contractor shall arrange routine and functional tests to demonstrate to the Engineer, conformity with the Specification and appropriate Standards. Factory Acceptance Test Procedures and Site Acceptance Test Procedures for Major Electrical Equipment shall be submitted to the Engineer for approval.

Inspection and testing witnessed by the Engineer and PMC (termed witness testing) shall be carried out at the manufacturer's works in accordance with the relevant clauses of Clause 7 of the Conditions of Contract.

CMWSSB shall have the right to have their representatives, PMC and any other relevant engineer present during inspections and tests of the major equipment and plant systems off-site, on-site tests and during construction. Unless otherwise specified, the Contractor shall submit to CMWSSB the procedure and a testing schedule for workshop testing and construction testing of all major equipment and systems of the RO Plant at least fifteen (15) Working Days prior to the commencement of such testing. The Contractor shall provide regular updates regarding such testing schedules to CMWSSB. The Contractor shall be responsible for all expenses incurred by the Engineer or Employer's representatives in attending inspection and tests of Plant carried out during manufacture within India and abroad. Maximum 2 persons from PMC and maximum 2 persons from Employer's representative will witness the inspection and testing said above.

Witness testing will normally be waived on standard types of equipment such as small motors made by approved manufacturers, individual standardised instruments, small mass produced components used in the manufacture of Plant items, small bore pipework and fittings, minor installation materials and low voltage cable. This shall not relieve the Contractor of his obligation under the Contract to ensure that all Plant is tested at the manufacturer's works prior to delivery to Site.

As a guide to the Contractor, the Engineer will require to witness test of the following, but not limited to the Plant items listed below:

Electrical and Instrumentation:

- power transformers (above 0.415kV)
- 230kV, 110kV & 11kV switchboards
- MCCs and switchboards

- Capacitor banks with APFCR
- Motors above 20 kW
- Battery and battery charger with DC distribution board
- Power and control cables
- Control and instrumentation
- Plant control and HMI software systems
- DSC/SCADA and PLC
- Control panels
- HMIs
- UPSs

Mechanical:

- All process equipment/ units
- HDPE Pipes, travelling screen and pumps
- Tube settler media
- Clarifier rotating bridge, flocculator and scraper assembly
- Flash mixer
- DAF system
- Filter underdrain system and media
- RO membranes, microfilters, vessels, skid, ERD and pumps
- Metallic tanks and steel structure for warehouse
- Thickener drive, scraper mechanism
- All Chemical dosing systems
- Mixers, pumps and blowers including their motors rated at greater than 20 kW
- Valve and valve actuators
- Valves greater than 300 mm diameter
- Sluice gates and gate actuators
- Chlorination system
- Agitators, mixers, static mixers
- Cranes 2 ton and above
- Belt filter press and associated plant
- Piping & specials above 300mm diameter

The Engineer reserves the right to be present during the testing of all Plant items. The

Contractor shall carry out tests as per the current appropriate Indian Standards; performance tests and such other tests as are necessary, in the opinion of the Engineer /Employer's representatives, to determine that the Plant/equipment complies with the Employer's Requirements and as per the Performance Guarantees either under test conditions in the manufacturer's works, or on site.

The Engineer reserves the right to require the Contractor to meet any costs which are occasioned by failure of the Contractor, in the opinion of the Engineer to take sufficient care before presenting the Plant for inspection or tests. If unauthorised delivery has taken place, the Contractor may be required to arrange for the equipment/units to be returned to the manufacturer for inspection and/or witness testing by the Engineer at the Contractor's expense.

If the tests are beyond the resources of the manufacturer he shall make arrangements for these to be carried out elsewhere having authorized accredited facility. Any variation of this requirement shall be agreed and confirmation in writing obtained from the Engineer.

Test certificates including check sheets shall be submitted as part of the QA/QC plan. These shall include all test results, calculations, performance graphs and curves, etc and shall be endorsed by representatives of the manufacturer and the Contractor. No inspection or passing by the Engineer of Plant items shall relieve the Contractor of his obligations under the Contract. Material test certificates shall have traceability.

All apparatus, instruments and connections required for the tests shall have been tested and calibrated for accuracy and safety and certified as such within the preceding six months.

Any equipment used in the testing of the Plant shall in all respects comply with the appropriate safety regulations and/or requirements regarding electrical apparatus for the safety of the Plant and the personnel working thereon.

10.1.2 Factory Acceptance Test Document/Quality Assurance Plan

Sixty (60) days prior to commencement of inspection of each Plant/equipment item the Contractor shall supply a Factory Acceptance Test (FAT) Document/Quality Assurance Plan (QAP) with reports at various inspection stages for review and approval. This shall comprise four copies of the following:

- unpriced copy of the Contractor's order for the Plant item concerned
- details of the inspection and test procedures to be carried out

The FAT Document shall provide comprehensive details of the tests to be carried out, the purpose of each test, the equipment to be used in carrying out the test and the methods to be adopted in carrying out the tests. The FAT Document shall provide space within the documentation for results of the tests to be added and for each test and for the FAT Document as a whole to be signed off by the Contractor and the Engineer.

On completion of the tests the Contractor shall provide four copies of all test certificates,

curves etc. for the inspected Plant items. To remove doubt test certificates shall be provided for the Plant items as a whole plus certificates for the relevant component parts such as:

- Power transformers (all ≥ 0.433 kV)
- 230kV, 110kV& 11kV switchboards
- MCC s and switchboards
- Capacitor banks with APFCR
- Motors
- Battery and battery charger with DC distribution board
- Power and control cables
- pumps
- instruments
- DCS
- gear boxes
- integral control and switchgear panels
- valve gear
- castings
- all types of filter and settling media
- all types of process units
- microfilters
- RO membranes
- RO vessels

Where witness tests are not required the test certificates check sheets and curves etc. shall be forwarded to the Engineer within two weeks of the tests being completed.

The Contractor shall not deliver Plant to the site without the Engineer's approval in writing. This permission will not be given unless amongst other things a valid Contractor's test certificate and completed FAT Document for the item of Plant concerned is in the possession of the Engineer.

10.1.3 Inspection and Testing Programme

The Contractor shall submit to the Engineer not later than sixty (60) days prior to the commencement of the first inspection and test during manufacture, a schedule/programme detailing the inspection dates for all equipment/units/plants. Those items of Plant that the Engineer has specifically identified for witness testing, shall be highlighted in the

programme.

The Contractor shall keep the Engineer/ Employer's representative informed of any changes to the programme.

The Engineer/ Employer's representative shall not be requested to inspect an item of Plant until the Contractor has satisfied himself that the equipment meets all requirements of the Employer's Requirements.

The Contractor shall inform the Engineer in writing at least 21 days in advance regarding readiness for carrying out inspection of equipment/material etc. at manufacturer's works or at places of inspection. The programme for inspection shall be finalised by the Engineer after the receipt of the above. In case inspection cannot be carried out due to non-readiness of equipment/material, etc. a subsequent date shall be finalised for carrying out the inspection and all expenses of the Engineer / Employer's representative for such visits shall be incurred by the Contractor. In case equipment/material, etc. is found not to comply with the specification, dates for re-inspection shall be finalised and expenses incurred by the Engineer for such visits shall also be recovered from the Contractor. Contractor's Representatives shall be present during all inspections. The following information shall be given in the inspection call letter mentioned above:

- (a) Name of manufacturer/supplier
- (b) Address of place where inspection is to be carried out
- (c) Proposed date/s and equipment to be inspected
- (d) Name(s) of contact personnel at manufacturer's/supplier's works with their telephone and fax numbers and e-mail address
- (e) Name of Contractor's Representative who will be present during the inspection
- (f) Confirmation that internal testing has been completed
- (g) Testing Procedure with relevant codes and standards
- (h) Confirmation that the testing procedure has been approved

The Contractor shall provide all the necessary instruments to carry out the tests after assembly. All instruments used for such tests shall be calibrated and certified by and approved by an independent testing authority not more than six months prior to the tests in which they are used. Calibration certificates for instruments used for such tests shall be produced for the approval of the Engineer and if necessary, instruments shall be recalibrated before the commencement of the tests.

No material shall be delivered to the Site without inspection having been carried out or unless waived in writing by the Engineer. If during or after testing, any item of Plant fails to achieve its intended duty or otherwise proves defective, it shall be modified or altered as necessary and retested and re-inspected as required by the Engineer at the cost of the Contractor.

10.1.4 Manufacturer's Works Acceptance Tests on Mechanical Equipment

The Contractor shall carry out further specified tests (but not limited to) as follows in

addition to any tests stated or implied by the foregoing sections of this clause.

10.1.4.1 Pumps

Manufacturer's standard test certificates will be acceptable for small centrifugal pumps rated for powers of 20 kW or less.

All other pumps shall be tested individually in accordance with the relevant IS or International Standard. Site conditions shall be simulated as near as possible including the NPSH condition. Pumps shall be tested with their own prime movers. Where it is impractical to include the full length of the connecting shaft, the Contractor shall state the allowances to be made for the losses incurred by its omission and shall demonstrate the accuracy of the allowances to the satisfaction of the Engineer.

Each centrifugal pump shall be tested on the manufacturer's premises individually, in accordance with the provisions of IS 9137/BS EN ISO 9906:2000 with clean, cold water.

Each and every rotating part/assembly/sub-assembly shall be dynamically balanced as per grade G6.3 of ISO 1940/1 - 1986.

Each pump shall be tested at its guaranteed duty point and over its full working range from its closed valve condition to 20% in excess of the specified quantity at minimum head. Tests shall provide information for performance curves to be drawn for: head/capacity, efficiency/capacity and power absorbed/capacity.

Pump casings shall be subject to a pressure test at 2.0 times the pressure obtained with the delivery valve closed. The positive suction head shall be taken into account in determining this pressure. Performance characteristics of motors used during testing shall be furnished prior to commencement of tests.

In addition to confirming the hydraulic performance of the pump set as specified, the test shall demonstrate that vibration is within the specified limits and that the mechanical performance is satisfactory. However, for the purpose of the Performance Guarantee, noise and vibration levels shall be demonstrated at site to be within acceptable limits.

10.1.4.2 Valves

Type test certificates will be acceptable for low pressure valves sized 300 mm diameter or less.

All valve bodies shall be hydraulically tested closed ended to (minimum) 1.5 times the rated pressure and at rated pressure for seat and duration as specified in IS:14846.

Satisfactory operation of manual/motorised and pneumatic actuators with valves shall be demonstrated.

Butterfly valves' body and disk with rubber seats shall be tested to the pressures and duration as specified under IS:13905.

10.1.4.3 Penstocks

Check for smoothness of operation and integrity of seal. Leakage tests shall also be carried out as per appropriate standard. Satisfactory manual and motorised operation of penstocks shall be demonstrated.

10.1.4.4 Pipework

The inspection and testing of all pipework shall be carried out in accordance with the appropriate standards approved by the Engineer.

10.1.4.5 Cranes & Hoists

Cranes shall be completely assembled and tested for all operations in accordance with the relevant international standard. Internal Test certificates shall be furnished.

Hoists and lifting equipment shall be assembled and tested at the place of manufacture in accordance with IS:3938.

Each and every rotating part/assembly/sub-assembly shall be dynamically balanced as per grade G16 of ISO 1940/1 - 1986.

10.1.4.6 Compressors

Tests shall be carried out in accordance with the relevant international standard. All compressors shall be tested with their ancillaries to confirm design performance particularly in respect of flow and pressure. The test shall demonstrate that vibration and noise are within the specified limits and that the pressure relief valve operates correctly.

Air receiver shall be tested in accordance with the relevant section of B.S. 5169. Air dryers shall also be tested as per relevant standards.

All pressure vessels shall be inspected and hydro water tightness tested.

10.1.4.7 Process Plant Items

All process Plant items shall be tested to ensure they meet the Employer's Requirements for quality of workmanship, construction and performance.

10.1.4.8 Chlorine Piping

All items of Plant shall be tested at manufacturer's works and test certificates shall be provided.

All chlorine gas piping from chlorine drums to chlorinator shall be pressure tested with dry air/nitrogen to a pressure of 15 kg/sq.cm.

The chlorine gas piping from the chlorinators up to injectors shall be pressure/vacuum tested with dry air/nitrogen to a pressure/vacuum equal to 1.5 times the maximum pressure/vacuum to be encountered during operation.

The motive water piping shall be hydrostatically tested for a pressure of 1.5 times the

operating pressure or the maximum pump discharge pressure at pump shut off whichever is higher.

After the chlorine system has been completely tested as above, leak proofness tests shall be conducted admitting chlorine gas. Leakages if any shall be identified using ammonia stick. During this test all chlorine leak detectors shall be in place and all safety procedures shall be adhered to.

10.1.4.9 Ventilation system

The ventilation system (fans 400mm and above) shall be tested at manufacturer's works to verify the design flow and pressure. For all other fans MTC's shall be furnished for review.

10.1.5 Manufacturer's Works Acceptance Tests on Electrical Equipment

The Contractor shall carry out further specified tests as follows in addition to any tests stated or implied by the foregoing sections of this clause. The contractor shall submit detailed Quality Assurance Plans for all electrical equipment and items for review and approval be the Engineer prior to start of manufacturing.

10.1.5.1 Switchgear and Motor Control gear Assemblies

Switchgear and control gear shall be witness tested as complete assemblies.

Factory built assemblies of 230kV/110kV/11kV/0.415kV switchgear and control gear shall be tested in accordance with relevant Indian Standards.

Additionally, switchgears and control gear assemblies shall be tested for the following:

- (a) Interchangeability - All components of the same rating and construction, designated as draw out or plug-in shall be demonstrated as being interchangeable.
- (b) Protection and control circuits - For all forms of current transformer protection, the following information, as applicable shall be made available to the Engineer before the time of inspection:
 - current transformer magnetising curve
 - recommended relay setting
 - calculated primary operating current at this setting
 - calculated through-fault stability values where applicable
 - values of any stabilising and setting resistors employed in the system

As far as possible, based on the completeness of the circuits, in the final manufactured form within manufacturer's premises, the satisfactory operation of associated control and protection circuits shall be proved by the following tests as applicable.

- To ensure the correct operation of all relays and coils at the recommended setting by current injection

- To ensure the correct polarity between current and voltage elements of power relays, meters and instruments
- To ensure the correct operation of control circuits at normal operating voltage by operation of local control switches and simulation of operation from remote control positions

Note: Checking the operation of protection relays and control circuits shall be carried out at site with all relevant circuits energized at their normal rated voltage.

The following tests shall be carried out but not limited to:

- Dielectric tests at an approved voltage/s
- Primary injection tests to ensure correct ratings and polarity of current and voltage transformers and of the current operated protection relays and direct acting coils, over their full range of settings
- Tests on auxiliary relays at normal operating voltages by operation of associated remote relays
- Correct operation of sequencing and control circuits at normal operating voltages by operation of local control switches, and simulation of operation from remote control positions
- Correct functionality of the equipment in all modes of control

10.1.5.2 Transformers

Transformers shall be subject to works routine and acceptance tests as defined in the relevant standard. Type test certificates issued within the past three years shall be provided for the following:

- impulse voltage withstand
- temperature rise

10.1.5.3 Capacitor Bank with APFCR

The capacitor bank with APFCR shall be subject to works routine and acceptance tests as defined in the relevant standards

10.1.5.4 Battery and Battery Charger with D.C Distribution Board

The battery and battery charger with D.C distribution board shall be subject to works routine and acceptance tests as defined in the relevant standards.

10.1.5.5 Cables

All cables and armoured cables shall be subject to routine and acceptance tests in accordance with the relevant Indian Standards. Test certificates shall be provided against each drum and/or cable length. The tests carried out on every cable length and/or drum at manufacturer's premises shall include:

- high voltage DC insulation pressure test, between cores, each core to earth, metallic sheath or armour as applicable
- insulation resistance test
- core continuity and identification
- conductor resistance test

10.1.5.6 Motors

The manufacturers type test certificate and an individual motor test certificate shall be provided for all motors. All type test certificates shall have been issued within the past three years.

Electric motors shall be subjected to routine and acceptance tests in accordance with relevant Indian Standards.

It shall be responsibility of the Contractor to select sizes, and types of motors to suit the starting and running characteristics of driven equipment with due consideration for specified margin over the requirement of the driven equipment at duty point. Motors not complying with the above shall be replaced by the Contractor at his own cost by appropriate motors. Replacement motors shall undergo testing and inspection as per the provisions in the contract. Cost of such testing and inspection shall be to Contractor's account.

The motor rotor assembly shall be dynamically balanced as per grade 6.3 of ISO 1940/1-1986.

10.1.6 Manufacturer's Works Acceptance Tests on ICA Equipment

The Contractor shall carry out further 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 control panel containing the PLC and associated equipment in order to demonstrate correct functional operation of the hardware and software systems.

The Contractor shall prepare for the approval of the Engineer a detailed Factory Acceptance Test (FAT) document that shall fully detail the scope of the tests to be carried out and the tests themselves.

The tests shall encompass the normal modes of operation and failure modes and shall demonstrate correct functionality of the system or systems in accordance with the Functional Design Specification (FDS).

The test shall include the following but not limited to:

- Hardware Verification and Functional checks
- Software verification checks and functional checks

- Communication verification and redundancy checks
- Network Loading checks
- Redundancy checks on Hardware and Communications
- DCS Controllers Loading test
- DCS Controllers Functionality checks
- DCS self-diagnostics tests
- 3rd Party Communication and Control interface test
- Stakeholders interface test
- Automation logic checks
- Data Archiving checks
- Response time checks
- Any other functional checks described by the PMC/Employer

The DCS program or programs shall be tested by means of a test rig designed to input and receive digital and analogue signals. Using this test rig it shall be possible to fully simulate the operation of the controlled equipment in order to demonstrate correct functional operation of the hardware and software systems.

The analogue to digital conversion shall be tested by means of a calibrated current source, digital to analogue outputs shall be tested by means of ramping the output channel and measuring the current by means of a calibrated current meter.

All inputs and outputs to the Controller and associated equipment shall be made through the field terminal connections of the control panel containing the Controller and associated equipment.

10.1.7 Manufacturer's Works Acceptance Tests on Uninterruptible Power Supplies

The Contractor shall carry out further 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:

- 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

10.2 Inspection at Site

Detailed Field Quality Plan (FQP) shall be submitted by the contractor to the engineer for

review and approval prior to commencement of work at site. All disciplines of site works shall be covered in the FQP. All site works shall be performed strictly in line with the approved FQP. Any deviations found will be recorded in the form of NCR's or Punch List and shall be corrected as instructed by the Engineer.

During erection of the Plant, the Engineer will inspect the installation from time to time in the presence of the Contractor's Supervisor to establish conformity with the requirements of the Specification. Any deviations found shall be corrected as instructed by the Engineer.

10.2.1 Plant Protection on Site

Factory finished Plant shall be adequately protected both before and during installation against damage to finished surfaces, fitted components, and the ingress of dust. It may be necessary for structural finishing operations to be carried out in the vicinity of installed Plant before it is taken over and the Contractor shall take this into consideration in complying with the requirement of this clause.

10.2.2 Erection Staff

The Contractor shall provide at least two approved senior English speaking working erectors to supervise the erection of all Plant in the Contract.

The Contractor shall also provide sufficient erectors skilled in electrical, mechanical and instrument engineering, with such skilled, semi-skilled and unskilled labour as are necessary to ensure completion of the various sections of the Contract in the time required. The Contractor shall not remove any supervisory staff or labour from the site without the prior approval of the Engineer.

The Contractor shall make all the necessary arrangements to ensure that sufficient Plant has been or is about to be delivered to site, so that there shall be no delay to the start of erection.

It shall be the responsibility of the Contractor to obtain necessary License/Authorisation/Permit for work from the Licensing Boards of the locality where the work is to be carried out. The persons deputed by the Contractor's firm should also hold valid permits issued or recognized by the Licensing Board of the locality where the work is to be carried out.

10.2.3 Erection and Building In

10.2.3.1 General

The installation work shall comply with the latest applicable Standards, Regulations, Electricity Rules and Safety Codes of the locality where the installation is to be carried out. Nothing in this specification shall be construed to relieve the Contractor of this responsibility.

It shall be the Contractor's responsibility to obtain approval/clearance from local statutory authorities including Electrical Inspector, wherever applicable for conducting of any work

or for installation carried out which comes under the purview of such authorities.

The Contractor shall carry out the complete erection of all Plant, including the provision of all necessary skilled and unskilled labour, material, transportation, supplies, power and fuel, Contractor's Equipment and appurtenances necessary, for the complete and satisfactory erection of the Plant.

The Contractor shall have a separate cleaning gang to clean all equipment under erection and as well as the work area and the project site at regular intervals to the satisfaction of the Engineer. In case the cleaning is not up to the Engineer's satisfaction, he will have the right to carry out the cleaning operations and any expenditure incurred by the Engineer in this regard shall be to the Contractor's account.

10.2.3.2 Erectors

The Contractor's employees shall include skilled erection staff in sufficient number, who shall arrive on the site on or before the respective dates set out in the approved work programme and prior to delivery of any item of Plant to the Site. The Engineer will not entertain any claim by the Contractor in respect of delayed erection due to a delay in the delivery of any items of Plant to the Site.

10.2.3.3 Contractor's Equipment, Materials and Appurtenances

The Contractor shall have available on the Site sufficient suitable equipment and machinery, as well as all other materials and appurtenances required by him, of ample capacity to ensure the proper erection of Plant and to handle any emergencies such as may normally be expected in work of this character.

The Contractor shall be responsible if any installation materials are lost or damaged during installation. All damages and thefts of equipment/component parts, after takeover by the Contractor, till the installation is taken over by Engineer shall be made good by the Contractor.

10.2.3.4 Workmanship

Plant shall be erected in a neat and workmanlike manner on the foundation and at the locations and elevations shown on the approved drawings and other engineering documents. Unless otherwise directed by the Engineer, the Contractor shall adhere strictly to the aforesaid drawings and no departures there from shall be permitted.

All Plant shall be correctly aligned, levelled and adjusted for satisfactory operation and shall be installed so that the proper and satisfactory connection can be made readily between the various units and pipework and equipment installed under the Contract. The mounting arrangements for pump sets shall be such that the alignment offset between motors and the driven equipment shall be well within 0.1 mm.

10.2.3.5 Building-in

Before commencing any erection work, the Contractor shall check the dimensions of

structures where the various items of Plant are to be installed, and shall bring any deviations from the required positions, lined or dimensions to the notice of the Engineer and shall take such measures as are necessary for their correction.

The Contractor shall take particular care for the correct positioning and alignment of all puddle pipes which are required through concrete structures prior to, and during the pouring of concrete.

The Contractor shall pin and plug in the holes prepared, all small clips, plugs, screws, nails, sleeves, inserts, etc. required for fixing electric wires and conduits, small pipework and all other apparatus.

The Contractor shall align all equipment and holding down bolts and shall inform the Engineer before proceeding with grouting-in the item or item concerned. The Contractor shall ensure that all equipment is securely held and remain in correct alignment before, during and after grouting-in.

The Contractor shall properly bed in cement grout each item of Plant or its supporting base resting on foundations, and shall grout-in where required holding down bolts placed in the holes prepared in the foundations. The materials and workmanship used in grouting shall be such as will result in a solid anchoring of foundation bolts and complete filling of the gaps between the Plant or its base and the foundations, without shrinkage or cracking.

10.2.3.6 Precautions

The approval by the Engineer of the Contractor's proposals for rigging and hoisting of any item of Plant into its final position shall not relieve the Contractor from his responsibility for avoiding damage to completed structures, parts or members thereof or other installed equipment. He shall at his own cost make good, repair or replace any damaged or injured items whether structural, mechanical, electrical, architectural, or of any other description, promptly and effectively to the satisfaction of the Engineer.

No Plant or other loads shall be moved across the floors of structures without first covering the floors with timber of sufficient size so that applied loads will be transferred to floor beams and girders of steel or concrete. If it is required to reduce bending stresses or deflection, the beam and girders shall be provided with temporary supports. Any movement of Plant and other loads over the floor structures shall be subject to the prior approval of the Engineer.

10.2.4 Inspection after Erection

After the erection of any item of Plant and its associated equipment has been completed, it shall be offered to the Engineer for inspection in its static state prior to commissioning the item.

The mechanical completion of Plant under erection shall be deemed to occur if all the units/systems of the Works are structurally and mechanically complete as noted below :

- a) All rotary, static, structural equipment, piping, electrical/instrumentation and other

equipment under the scope of the Contract have been erected, installed and grouted and are as per the specifications.

- b) All systems have been cleaned/washed/flushed/drained/boxed up where necessary.
- c) All system testing including pressure, hydrotesting, vacuum and nondestructive tests, no load tests and such other tests are completed with safety valves/relief valves set to operating conditions installed in position.
- d) All panels, local control desks erected with power/control cable terminations with all continuity checks, insulation checks and other installation checks are carried out.

Prior to pre-commissioning checks, the Contractor shall erect the entire Plant and ensure readiness of civil works to the satisfaction of Engineer, so that the Works are physically ready to undergo pre-commissioning checks. Pre-commissioning checks shall include checks like no-load running of machinery, checks on instruments and electrics including calibration and loop checks, functional checks, inter-lock checks etc.

At the stage of mechanical completion of erection, the Contractor shall ensure that all the physical, aesthetic and workmanship aspects are totally complete and the Plant is fit and sound to undergo pre-commissioning checks.

The following documentation shall be completed before the Contractor notifies Mechanical Completion of Erection to the Engineer :

- All shop inspection records compiled and bound in 4 (four) copies.
- All erection and commissioning procedures duly approved.
- All instruction manuals in draft form - with each sheet bearing a stamp to indicate "DRAFT FOR REVIEW ONLY" submitted in 4 (four) copies.

Upon achieving mechanical completion, the Contractor shall notify the Engineer of such completion of section/units/systems and readiness for inspection for acceptance of mechanical completion of erection. The Engineer shall proceed with inspection of such sections/units/systems within 10 days of such notice.

Consequent to inspection, the Engineer will inform the Contractor a list of deficiencies mainly on the NCR and Punch list items for rectification and the Contractor shall complete the rectification work within a jointly agreed period prior to start of pre- commissioning tests. The erection period allowed by the Contractor shall include all activities of mechanical completion as noted above.

10.2.5 Site Acceptance Test Document

Sixty (60) days prior to commencement of tests, the Contractor shall supply a Site Acceptance Test (SAT) Document for approval. This shall comprise four copies of the details of the inspection and test procedures to be carried out in testing the Works.

The SAT Plan shall provide comprehensive details of the tests to be carried out, the purpose of each test, duration of test, acceptance limits/criteria, tolerance limits, the equipment to be used in carrying out the test and the methods to be adopted in carrying out the tests. The SAT shall provide space within the documentation for results of the tests to be added and for each test and for the SAT as a whole to be signed off by the Contractor and the Engineer.

The SAT shall categorise tests as follows:

- Pre Commissioning Checks
- Dry Tests
- Wet Tests
 - hydraulic tests
 - process tests (Manual and Automatic)
- Trial runs
- Initial Performance Tests

Dry tests are those tests carried out without process fluid being present.

Wet tests are those tests carried out with raw seawater or product water in order to prove the hydraulic capability of the Works. Process wet tests are those tests carried out with raw water as the feed stock to prove the process capability of the various equipment and Works.

Trial runs are carried out across the Plant for each process areas which verify the completeness of the Plant and to all ancillary equipment, and of no known defects or outstanding works. The trial run tests are also carried out as a whole plant test, which aims at testing the Plant at various load settings and operating conditions, including Starts, Stops, and Switchover for different mode of operation.

Initial performance tests are carried out after Dry and Wet tests and trail runs to check the performance of the complete process of the Plant as a whole. Both water treatment processes and wastewater treatment processes shall be tested. The tests are described in detail below.

All tests shall comply with relevant approved International standards/codes.

It shall be assumed that the co-operation of other contractors in the carrying out of Tests on Completion will not be unreasonably withheld.

10.3 Tests On Completion

The Tests on Completion referred to in Clause 11 of the General Conditions of Contract shall be read in conjunction with the Clause 3.12 of Chapter-3 of Section VI, Part 2. The purpose of Tests on Completion shall be to demonstrate and confirm that the Works can fulfil all the mechanical, electrical and process requirements of the Specification. This includes all commissioning and initial performance tests.

Prior to the commencement of Tests On Completion the Contractor shall submit for approval the following along with all the documents required as given in the Part-2, A3 document:

- Site Acceptance Test Documents
- As-Built Drawings
- Operation and Maintenance Manuals
- Punch List Status

Tests on Completion shall not be commenced until the aforementioned documents are prepared by the Contractor and approved by the Employer.

The initial stocks of oil, grease, chemicals, membrane etc. necessary for Tests shall be kept ready and to be provided by the Contractor. The costs of chemicals, power, spare parts and any other ancillaries used for the Tests shall be met by the Contractor.

The Contractor shall carry out all tests on the Plant and shall supply five hard copies of all test results with one soft copy to the Engineer. The test report shall include recordings of power and chemical consumption and Plant performance/behavior pattern.

All tests shall be to the approval of the Engineer who may require them to be repeated, prolonged or modified as may be necessary to ensure that any or all items of the Plant conform with the Contract. The Engineer shall be permitted to inspect all Plants which are undergoing tests and may himself conduct tests.

Where, it is necessary for the Engineer to make arrangements for the supply chemicals, power, etc., for any testing, the Contractor shall inform the Engineer in writing before at least 3 weeks and not commence the tests until after these arrangements have been made on or after a date agreed by the Engineer and the Contractor shall make no claim for delay to such testing on this account.

If any item of Plant fails during or after testing to achieve its intended duty or otherwise proves defective, it shall be modified or altered or replaced with the capacity/rating of Plant item as necessary and suitable and shall be re-tested and re-inspected as required by the Engineer.

Apart from process performance, the vibration/noise level tests shall be carried out at site which will form basis for acceptance of the equipment. If the Contractor is not in a position to meet the requirements given below as per ISO 10816 – 1995, the equipment may either be rejected or the Contractor shall carry out all necessary modifications to keep vibrations/noise within the acceptable limits specified in table below.

Table 10-1: Noise Level as per ISO 10816

Equipment	Noise Level dBA at 1.86 m from Equipment	Velocity of Vibration mm/sec
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All rotating equipment not having reciprocating parts with motor kW less than or equal to 15 kW	85	1.12
All rotating equipment having reciprocating parts with motor kW more than 15 kW and less than or equal to 75 kW	85	1.8
All rotating equipment not having reciprocating parts with motor kW greater than 75 kW	85	2.8
All equipment having reciprocating parts viz. compressors, dosing pumps sampling pumps	85	-

The Contractor shall have a minimum of four commissioning engineers, two for process and Plant and the other two for electrical/instrumentation works on site during all tests in order to demonstrate the Plant and to correct any faults which may occur.

10.3.1 Pre-Commissioning Checks and Dry Test Requirements

10.3.1.1 General

As a minimum requirement the following checks shall be carried out as a general requirement:

- a general inspection to check for correct assembly and quality of workmanship
- a check on the presence of lubricant, cooling medium, electrolyte, etc.
- a check on adequacy and security of Plant fixing arrangements
- a general check to ensure that all covers, access ladders, water proofing, guard railings etc are in place
- a check on damp-proofing, rust-proofing and vermin-proofing and particularly the sealing of apertures between building structures, chambers etc and the outside

10.3.1.2 Civil and Building Works

As a minimum requirement the following dry tests shall be carried out on the civil engineering and building works:

- check for the presence of foreign bodies in pipework and structures.

10.3.1.3 Mechanical Works

As a minimum requirement the following dry tests shall be carried out on the mechanical systems:

- carry out preliminary running checks as far as permitted by circumstances in order to ensure smooth operation of Plant
- Monitoring and control from remote workstation.
- Automatic switchover from normal power to emergency power, and emergency power to normal power.
- All control functions, both at local system and remote workstation.
- Operation of all monitoring instruments.

10.3.1.4 Electrical Works

As a minimum requirement the following dry tests shall be carried out on the electrical systems:

- check phasing and polarity;
- carry out point to point check on all cables;
- check on security of cable termination;
- check on completeness and adequacy of earthing systems;
- check setting on protection relays, sizes of fuses and motor overload settings;
- carry out checks on cabling systems in accordance with the requirements of the relevant standards;
- check operation of main circuit breakers by secondary injection methods;
- check rotational direction of Plant.

10.3.1.5 ICA Works

As a minimum requirement the following dry tests shall be carried out on the I&C systems:

- check instrument loop integrity, functionality and calibration
- check Plant functionality
- check functionality of the central HMI and its power supply
- check functionality of the plant to other communications interface (3rd party interfaces and stake holder interfaces)

All control sequences shall be fully tested unless there is potential for damage to the equipment. All safety and protection devices (e.g. flow switches) shall be tested to ensure that they operate correctly.

10.3.2 Wet Test Requirements

Wet tests shall be carried out on completion of dry tests and shall comply with relevant approved engineering international standard/code.

Raw seawater or product water (if available) shall be used for hydraulic wet tests. The purpose of the tests is to prove as far as is practical the hydraulic performance of the Works. In order to demonstrate this the Contractor shall ensure that each part of the Works is hydraulically loaded to its rated throughput (including a period of overload if required in order to demonstrate compliance with the Employer's Requirements) for a continuous stable operating period of not less 48 hours.

In order to ensure a sufficient supply of raw water to carry out these tests the Contractor shall provide facilities for the disposal off site in an approved manner not less one third of the Works rated output.

In order to remove doubt, the following tests inter alia shall be carried out:

- pressure testing of all piped systems laid direct in ground in accordance with the relevant standards
- fill all structures and check for leaks
- filling of all storage vessels to check for leaks and distortion
- running of all pumped systems to check for:
 - correct functionality
 - absence of leaks
 - correct running temperatures
 - smoothness of running and the absence of undue vibration or stress
 - check drive running currents
- carry out calibration of instruments where appropriate
- carry out valving, diversions etc. to fully hydraulically load (or where there is a requirement to withstand an over load to overload) each process element
- manual operation and automatic commissioning tests of all the equipment and protection systems
- manual operation and automatic commissioning tests of all the process units including RO system
- alarm initiation
- demonstrate correct functionality of electrical, control and instrumentation systems
- Start-up tests for each process areas of the plant, verify the completeness of the Plant and to all ancillary equipment, and of no known defects or outstanding works.

- All control sequences shall be fully tested unless there is potential for damage to the equipment. All safety and protection devices (e.g. flow switches) shall be tested to ensure that they operate correctly.
- Verification of conformance to the specified or guaranteed performance as far as is practical at the initial loading

The Contractor shall simulate where practical the conditions that will prevail when operating as a process in order to demonstrate the correct functionality of process control loops etc.

During these tests a check on the performance of Plant shall be made, as far as site facilities will allow, to compare its site performance with the factory test data and to identify any constraints on performance due to site conditions.

10.3.3 Safety Audit

After satisfactory completion of wet tests and prior to introduction of process fluid to the Plant a safety audit shall be carried out to ensure compliance with the necessary requirement for safety and for operation of Plant. The safety audit shall be documented. The safety audit document shall be approved by the Engineer prior to commencement of Plant sterilisation.

10.3.4 Plant Sterilisation

On approval of the safety audit document the Contractor shall carry out sterilisation of the wetted parts of the Works. In order to remove doubt this shall also include the wetted surfaces of water treatment chemical storage and dosing systems.

The sterilisation process shall be carried out by completely filling the item or items concerned with water containing not less than 30 mg/L of free chlorine and leaving it to stand for not less than 48 hours. On draining down the Contractor shall demonstrate that the chlorine residual has not fallen below 10 mg/L of free chlorine. If this is not true the sterilisation process shall be repeated until this condition is met.

The Contractor shall be responsible for the disposal of the sterilisation solution. The Contractor shall take the necessary measures to ensure that the free chlorine residual of the solution for disposal is not greater than 1 mg/L before discharge to the environment.

Areas such as the roofs of tanks not easily wetted by filling the vessel with sterilisation solution shall be sterilised using a procedure approved by the Engineer.

The Contractor shall give 2 weeks notice to the Engineer and the Employer of the proposed date for carrying out sterilisation.

The Contractor shall advise the Engineer and the Employer in writing when all wetted parts of Plant and civil structures have been sterilised.

If the Contractor carries out any work that invades a previously sterilised area the

Contractor shall be required to carry out re-sterilisation of that area to the approval of the Engineer.

10.3.5 Punch List

Throughout the Start-up, commissioning and testing phase, the Contractor shall rectify minor Defects identified on a Punch List which shall be updated as items are rectified. Prior to Acceptance of the Plant, the Employer's Representative, PMC Consultant and the Contractor shall agree upon the final Punch List identifying all Defects which must be completed by the Contractor following Provisional Acceptance of the Plant together with a timeframe for completion of each item. The punch list shall be categorized and prioritized.

10.3.6 Trial Run

After completion of the commissioning as per the agreed test program, the RO Plant, including related equipment, systems and facilities, shall be put into a minimum twenty-four (24) hour trial run at various load settings and operating conditions established mutually by the Contractor and Employer's Representative/PMC Consultant. Starts, stops and switching-over to standby equipment shall be included. The Contractor may extend the operating period if it considers this necessary to achieve the quality and stability of operation required for the Initial Performance Test.

However, after successful trial run and commissioning, the Employer at his sole discretion may commence commercial operations of the plant to meet the demand, if so is necessary in his sole discretion. During the said period the Contractor shall pay all the cost of the plant operation and maintenance and it will continue till the successful completion of the proves proving.

10.3.7 Initial Performance Test

On approval of the sterilisation process and trial run, the Contractor shall carry out initial performance tests (test on completion) as per the Clause 9 of GC of Contract. The contractor shall submit a "Initial performance test procedure" with pre-commissioning and commissioning activities for review and approval by the Engineer after which the test shall be carried out starting on an identified date. All the cost of the test including labour, power chemical, membranes etc. shall be borne by the Contractor. The product water during this period may be taken into public supply network depending on the Employer's discretion.

The Contractor shall run the Plant as a whole including RO system and sludge processing units in order to demonstrate the full functionality and performance of the Works at various throughput rates for a continuous period of not less than 15 days.

The activities necessary to complete before start-up of the Plant for the initial performance tests shall include, but not be limited to :

- i. Completion of buildings and civil works to the extent necessary for the safe and proper operation of the Works;

- ii. Successful completion of all tests associated with the civil/building, electrical, Instrumentation and mechanical works and individual process to the satisfaction of the Engineer.
- iii. Testing ventilating and air conditioning units;
- iv. Safety audit;
- v. Pressure testing, leak tests, tightness tests;
- vi. Checking of pipe hangers, supports, guides etc.;
- vii. Pipe and equipment flushing and cleaning;
- viii. Chemical protection of piping systems, if applicable;
- ix. Checking of coating, if applicable;
- x. Testing and adjustment of safety devices;
- xi. Checking and functionally testing of electrical systems according to IEC standards;
- xii. Valid calibration certificate of instrumentation is available, loop checking, functional testing of control equipment, interlocks, protection inputs, etc.;
- xiii. All equipment are in operating condition including the standby equipment as well
- xiv. Start-ups completion of relevant parts of the plant equipment, facilities and systems including automatic changeover of standby facilities
- xv. Operation of equipment for functional test.
- xvi. Process parameters achieved
- xvii. Complete Plant level Automation completed
- xviii. Operating stability verified between Minimum, Nominal and Maximum water output
- xix. Fire Fighting system completed

During the various process tests apart from the online water quality measurement, the Contractor shall take samples and carry out water quality analysis at the specified intervals or more frequent as required necessary by the Engineer in order to demonstrate that the Works is functioning in accordance with the Employer's Requirements. Each sample shall comprise two 1 litre (minimum) quantities and shall be labelled to identify the contents, where taken and time and date. One sample shall be used by the Contractor for his analysis, the other shall be handed over to the Engineer.

The Engineer reserves the right to take additional samples and to carry out his own tests or to check the samples taken by the Contractor.

The Engineer shall be given reasonable access to the premises where analysis is taking place in order to check on working practices and the procedures being adopted.

As much as possible, the pre-treatment and post treatment plant shall be operated with minimum automation for at least 3 days during 15 days initial performance test period. Manual operation shall be required to demonstrate the satisfactory operation of the whole

Plant at all design flow rates whilst using the minimum quantity of automatic control and monitoring equipment. Such equipment shall be at least that required both for the maintenance of safety and for the normal mode of operation of the Plant.

During the test period; if the power supply should fail or other matters interfere outside the Contractor's control, the tests may be repeated or carried out of such number of broken days as the Engineer considers is the equivalent.

The exact date of commencement shall be subject to the approval of the Engineer and shall be dependent on the following conditions having been met:

- all pre-requisite tests satisfactorily completed
- all relevant items of Plant in approved working order
- all items of Plant correctly identified with labels
- The punch list items mutually agreed and closed
- the operation and maintenance manual is submitted and approved

10.3.8 Water Quality Criteria for Passing the Tests On Completion

The Works shall be considered to have achieved the required water quality standards for passing Tests On Completion if all samples taken during a 15 days continuous operational period comply with the criteria set down in Table-2 for the passing of the Tests, including criteria relating to the reliability of the Plant.

Initial performance tests shall not be commenced until all tests associated with the civil/building, electrical and mechanical works and individual process tests have been completed to the satisfaction of the Engineer. The product water during this period may be taken into public supply network depending on the Employer's discretion.

10.4 Process Proving Test

On successful completion of the commissioning with Initial Performance Tests, the Contractor shall carry out the Process Proving Tests for a period of 90 consecutive days. During these tests water produced by the Plant will be supplied to the public supply network. The process proving test conditions shall be read in conjunction of the provisions given in A-3, Section VI, Part-2 of Employer's requirements.

The purpose of this test is to demonstrate the performance of the following Works:

- Intake system
- Pre-treatment system
- RO system
- Post treatment system
- Sludge treatment and disposal system

- RO membrane Cleaning (CIP)
- Power Receiving Station and Switchgears
- All allied units and buildings

Each part of the Works shall be considered separately as far as the tests are concerned.

The Contractor shall inform the Engineer in writing the date of completion of the Test on Completion (commissioning, initial performance test and the proving test). The total time for carrying out the Proving Tests shall not be less than 90 days.

If there is one event of failure, then the remedial action shall be taken and test is continued. If there is second event of failure, then the test will be stopped, and remedial action shall be taken and the rest of the 90 days of test will be completed. If there are more than two events of failure when product water quality and quantity is not maintained as specified in the Contract during the 90 days of operation, the test shall be deemed as failed and the test shall be terminated. The Contractor shall carry out necessary remedial work to the satisfaction of the Engineer before the Employer approves to restart the test again. The event of failure is defined as the 3% reduction in product water quantity or deterioration of product water quality in terms of pH, turbidity, TDS, Boron and other vital parameters in 74 hours.

The Contractor will not be held responsible for interruptions to the desalination process as a result of grid power failures (unless as a result of any fault at the Plant) resulting interruptions in the raw water supply etc. which are out of his control. However, the Contractor shall be required to demonstrate that the Works can cope with these inevitable interruptions in an orderly fashion and recover to a normal operational state with the minimum of manual intervention.

All manpower and consumables needed for operation of the Works during process proving period such as manpower, chemicals, power, membranes, materials, fuel, equipment, transportation of sludge off the site etc. shall be provided by the Contractor. So the Contractor should include the cost of the plant operation during process proving period in the price bid for capital works.

The Contractor shall provide all facilities and equipment not given in the contract and which are deemed necessary for the Employer to carry out and monitor the Tests on Completion. In order to the Employer carrying out any test to validate the performance of the Plant, the Contractor shall be required reasonably to co-operate and co-ordinate his activities with those of the Employer and other subcontractors and bearing all the cost of the tests.

During the tests, the Contractor shall take samples to demonstrate that the Works are performing in accordance with the Employer's Requirements and as per the performance guarantees. The procedure for taking the samples shall follow as described in the Tender specifications elsewhere. Samples shall be taken at locations and intervals detailed in Table below. The results of the Tests on Completion shall be compared and evaluated by the Employer and Contractor. Also test results shall be recorded to demonstrate the power

and chemical consumptions are within the guaranteed limits as committed by the Contractor in the technical schedules.

Table 10-2: Sample Locations and Intervals

Sample	Interval (hours)	Criteria for Passing Code
Raw Seawater at pump station	4	Not applicable
Tube Settler Clarifier effluent from each stream	8	Nr 1
DAF effluent from each stream	8	Nr 2
Filtered water from each stage	8	Nr 3
RO feed water after micro-cartridge filter	8	Nr 4
RO permeate	8	Nr 5
Pump discharge from clear water reservoir	4	Nr 6
Sludge from sludge balance tank	24	Not applicable
Supernatant from thickener	24	Not applicable
Thickened sludge from thickener	24	Nr 7
Belt Filter Press sludge	24	Nr 8
Discharge wastewater in Sea	24	Nr 9

All above sampling and analysis shall be carried out in the laboratory established in the plant and outside agencies for result confirmation.

10.4.1 Criteria for Passing the Test on Completion

10.4.1.1 Water Quality Criteria at Different Process Units

The requirements of the water quality shall be considered to have passed the Initial Performance Test and Process Proving Test if all samples taken during the test period at different process units comply with the criteria set forth in the Table below. Also, the final product water is to meet the criteria given in Part-2 A-1 document and CPHEEO standards for drinking water quality. The water quality criteria are an absolute requirement (i.e. the stated water quality standards must be achieved).

Table 10-3: Performance Criteria Requirement

Passing Code	Performance Requirement in the Effluent
Nr 1	TSS < 15 mg/l TOC < 4 mg/l

Passing Code	Performance Requirement in the Effluent
	Turbidity < 10 NTU Colour < 5 Pt-Co Unit
Nr 2	TSS < 10 mg/l TOC < 3 mg/l Turbidity < 5 NTU Colour < 3 Pt-Co Unit
Nr 3	Turbidity: ≤ 0.2 NTU for 95% readings; and ≤ 0.5 NTU for rest of the time. TSS: 0.0 (Not detectable) TOC: < 2.0 pH: 7.0 to 8.5 Residual Cl ₂ < 0.2 mg/l Colour: < 3 units Pt/Co scale Iron: < 0.05 mg/L
Nr 4	Turbidity: ≤ 0.1 NTU TSS: 0.0 TOC: ≤ 2.0 Residual Cl ₂ 0 mg/l Colour: < 1 units Pt/Co scale Iron: < 0.05 mg/l Manganese < 0.05 mg/l SDI: ≤ 3
Nr 5	TDS: < 330 mg/l Boron: < 1 mg/l
Nr 6	TDS: < 450 mg/l Boron: < 1 mg/l Hardness: ≥ 60 mg/l Faecal Coliforms 0/100 mL (Nil) Total Coliforms 0/100 mL (Nil) Taste and Odour – Unobjectionable
Nr 7	Thickened sludge – 4 to 5 % solids
Nr 8	BFP waste solids – ≥ 25% solid
Nr 9	TSS < 100 mg/l; metal ions as per regulatory norms

10.4.1.2 Product Water Quantity Criteria

The Works shall have fulfilled the product water quantity criteria if the Works have demonstrated that this can provide the quantity of product water detailed in the Contractors Functional Guarantee over a sustained and continuous period of 90 days during the Process Proving Tests.

The product water quality shall be sampled and tested by the Third Party every fortnight for the vital parameters to ensure the water quality meeting the requirements. The third

party shall be NABL accredited laboratory in Chennai. All costs for the sampling and analysing of the product water shall be borne by the Contractor.

10.4.1.3 Sludge Quality Criteria

The sludge treatment plant shall have fulfilled the sludge quality criteria if the dried solids content of the sludge produced is as detailed Table below over a sustained and continuous period during the Process Proving Test. The sludge quality criteria are an absolute requirement (i.e. the guaranteed sludge quality must be achieved).

Table 10-4: Sludge Quality Criteria

Criteria Code	Criteria to be guaranteed
Nr 8	≥ 25 % dried solids
	@ all solids contents in feed

10.4.1.4 Operational Cost Criteria

The Works shall have fulfilled the operating cost criteria if the operating costs determined during the Process Proving Test are in agreement with or less than those detailed in the Contractor's Functional Guarantee. In case of any failure to meet the criteria as discussed in Part-2, Chapter 3 & 10, the liquidated damages and/or penalty shall be levied as per the Contract Conditions (Part-3).

10.4.1.5 Plant Reliability Criteria

Apart from the quality, quantity and operational cost criteria for the test discussed above, a part of the Works shall be deemed to have failed its test if a single item of Plant fails more than twice during the test, or more than four individual Plant items fail. An item of Plant shall be deemed to have failed if manual intervention is required in order to restore the item to its fully operational state (i.e. the failure of a duty drive will be considered as one failure, if the standby drive fails to start that will be considered as a second failure).

Apart from the above, a failure of any single piece of main or auxiliary item should not cause any deterioration in quality and quantity of the plant product water. If any failure leads to a reduction in production or deterioration in product water quality, it shall be deemed as the failure of the test.

10.4.2 Completion of Design-Build

No item of Plant will be certified for completion under Clause 9.12 of the General Conditions of Contract by the Employer unless it has successfully passed the Process Proving Test.

A Commissioning Certificate for Plant shall not be issued unless 7 copies of the instruction manuals for operation and maintenance of that Plant and 7 copies of all completion (As-built) drawings with soft copies of all manual, drawing with civil structures have been received to the satisfaction of the Engineer.

The instruction manual complete including SCADA/DCS system for operation and maintenance of Plants shall be in two parts. Part 1 shall detail operation of entire Plant as a system giving sequence of operation, DO's and DONT's very clearly. The operation manual shall be user friendly so as to guide the operator faultlessly in operating the Plant. The manual shall be customized giving details of important information about operation, maintenance and troubleshooting, and it should not be mere collection of manufacturer manuals.

Part 2 bid document shall deal with maintenance of each component of the system, sub-system etc. in full details giving details of construction, material, manufacturer's item code number, dismantling and assembly procedures, dimensions, routine checks to be carried out, signals and observation by predictive maintenance gadgets that can prompt maintenance, overhauling of sub-systems/systems.

The drawings shall give complete details of the systems, sub-systems like dimensions cross-sectional views, assembly details, etc. Maintenance schedules as specified by the manufacturers for each component of the system and for entire system shall be furnished.

A Commissioning Certificate defines the start of the Extended Operation and Maintenance period but its issue does not relieve the Contractor of his obligation to the defect liability and continued satisfactory performance of the complete Works in all aspects.

10.4.3 Operation and Maintenance Period

The Operation and Maintenance Period of 20 years as defined in the Contract shall commence from the date of issue of the Commissioning Certificate, which will be issued as the Engineer decides appropriate after successful completion of 90 days Proving Period. The detail of the operation and maintenance is provided in the technical requirements Chapter-13, Part-2.

10.5 Performance Certificate

The issuance of a performance certificate is on the discretion of the Employer. The minimum conditions for issuance of a Performance Certificate shall comprise:

- completion of the 20 years operation and maintenance of the Works to the satisfaction of the Engineer
- Operation and Maintenance Manuals have been updated following 20 years of operational experience and as approved by the Engineer.
- all defects identified prior to Taking Over and defects identified during the 20 years operation and maintenance of the Works have been rectified.
- all Tests before Handover have been completed to the satisfaction of the Engineer.
- all training detailed in the Employer's Requirements have been completed.

CHAPTER - 11

11. GENERAL PAINTING AND PROTECTION REQUIREMENTS

11.1 General

This section covers the general requirements related to the cleaning protective coating and painting of equipment, components, and system. Painting and protective coatings shall comply with the requirement of this section. The components and/or equipment shall be mechanically and /or chemically cleaned. The preparation, application and conditions for work shall comply with the recommendations of BS 5493 and BS 6150 or if the protection is of a special nature, in accordance with the manufacturer's directions.

The painting system shall be selected taking into consideration the high atmospheric salinity, humidity and temperature. The painting schemes that are in contact with potable water shall be non-toxic type food grade. The painting system that are not in direct contact with the potable water but that could cause toxicity to the potable water through the process is not allowed. Non-toxicity certificate shall be submitted for all such painting systems from a reputed international agency by the Bidder. The material selection has to be adequate to all relevant process and environmental conditions and has to be sufficient for design life.

Cathodic protection system for preventing galvanic corrosion shall be employed where ever necessary for Seawater applications.

Suitable protection for the Plant equipment and system shall be provided in form of selection and application of coating schemes. All concrete tanks in contact with sea water shall be epoxy screeded to 3 mm.

Color strip indication system should be used for pipes. These strips should be painted on the joint of pipes, entrance, valves of pipe. This pipe without outside protection layer should be marked by some color in whole length. The principal color of field equipment should be determined by the Owner/PMC and contractor during execution stage.

Paints, primers and undercoats shall be obtained from the same manufacturer and except where a definite time is specified between mixing and application, shall be ready mixed for use. They shall be compatible with one another.

Paints shall be delivered in sealed containers bearing the manufacturer's name, batch number, etc. and shall carry a label giving details of quality and instructions for use.

No site painting shall be carried out unless the surface to be painted is prepared and dried, the air temperature above 4°C and the relative humidity less than 85%. The Engineer / Employer's Representative shall approve the methods for removing all dirt, oil, grease, etc, before painting commences. No paints in any coat shall be applied until the Engineer/ Employer's Representative is satisfied that the surface is clean and dry. After cleaning when a surface is approved for painting, it must be painted immediately. 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.

Test plates carrying finishes from the actual coating used may be required by the Engineer for inspection and test purposes.

To facilitate inspection, no consecutive coats of paint shall be of the same shade except in the case of white. Priming to two mating surfaces shall be applied prior to assembly.

All items of Plant shall be delivered to Site with the shop paint finish applied unless specified otherwise. A further coat of final finish paint shall be applied at Site, of sufficient thickness to produce a uniform colour and appearance and also to fix any damage to the painting during transport. Such painting shall be carried out within one month of successful acceptance trials for the Plant.

All paint dry film thicknesses shall be checked using an alkometer or equivalent instrument, supplied by the Contractor, for each layer of paint, to the satisfaction of the Engineer / Employer's Representative.

No paints in any coat shall be applied until the Employer's Representative 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.

11.2 Equipment

All tools, brushes, rollers, spray guns, blast material, hand power tools for cleaning and all equipment, scaffolding materials, shot/sand blasting equipment & air compressors etc. shall be arranged by the Bidder at the site in sufficient quantity at his own cost. Bidder shall arrange at his own cost, for suitable paint thickness measuring instrument like Elkometers acceptable to the Engineer (with calibration facilities). Elkometers shall be provided to the Engineer for measurement of paint thickness. Instruments for surface finish and roughness measurement shall also be provided by the Contractor to the Engineer.

Mechanical mixing shall be used for paint mixing operations in case of two pack systems except that the Engineer may allow the hand mixing of small quantities at his discretion.

All the surface preparation, protective coating, painting of steel structures and equipment shall be suitable for prevailing site condition and particular care shall be taken for site near to or at Coastal and Marine environment condition. Contractor shall submit the surface preparation, Protective coating and painting specification for the Engineer's approval.

11.3 Extent of Works

The scope of work in this specification defines the requirements for surface preparation, selection and application of paints on external surfaces of equipment, vessels, machinery, piping, ducts, steel structures, external & internal protection of storage tanks for all services.

The following surfaces and materials shall require shop, pre-erection and field painting:

- i) All uninsulated equipment like pumps, valves, structural steel, vessels, storage tanks, pumps, compressors, electrical panels and motors etc.
- ii) All uninsulated carbon and low alloy piping fittings and valves (including painting of identification marks), furnace, ducts and stacks.
- iii) All items contained in a package unit as necessary.
- iv) All structural steel work, pipe, structural steel supports, walkways, handrails, ladders, platforms etc.
- v) Identification colour bands on all piping as required including insulated aluminium clad, galvanised, SS and non-ferrous piping.
- vi) Identification lettering / numbering on all painted surfaces of equipment / piping insulated aluminium clad, galvanised, SS and non-ferrous piping.
- vii) Marking / identification signs on painted surfaces of equipment / piping
- viii) Supply of all primers, paints and all other materials required for painting.
- ix) Over insulation surface of equipment and pipes wherever required.
- x) Painting under insulation for carbon steel and stainless steel as specified.
- xi) Repair work of damaged / protection / fabrication shop primer and weld joints at field.

The following surfaces and materials shall not be painted unless otherwise specified:

- i) Uninsulated austenitic stainless steel.
- ii) Plastic and / or plastic coated materials
- iii) Non-ferrous materials like aluminium, galvanised “piping”, “gratings” and “Handrails” etc. except G.I towers.

11.4 Colour Coding and Labelling of Pipes and Equipment

All pipes and equipment shall be colour coded to a schedule to be agreed with the Engineer before any site painting starts, or earlier if necessary, to suit manufacturing procedures. Valves and fittings shall be painted in the same colour as the pipe of which they form a part. Where a pipe enters or leaves a piece of equipment the pipe colour shall extend up to but not including the flange attached to the equipment.

All pipelines shall be identified by stick-on 90 micron thick vinyl film labels showing the name of the material to be carried by the pipeline and an arrow indicating the direction of flow. Letters of titles shall be pre-spaced on carrier tape and the complete title protected by one-piece removable liners. Titles shall be at intervals not less than 8 m, but shall in any case be provided in every space through which the pipe passes. Locations of labels shall be subject to prior approval by the Engineer. Lettering sizes shall be between 16 mm and 75 mm in height depending on the size of the pipe.

Pipes smaller than 22 mm outside diameter shall be labelled by the use of tags instead of labels. Tags shall be made of brass no smaller than 65 mm x 16 mm by 1.5 mm thick, with lettering etched and filled with black enamel. Titles shall also be provided on all equipment in locations and in sizes to be approved by the Engineer.

All paints and painting materials shall be stored only in rooms to be arranged by Contractor and approved by the Engineer for the purpose. All necessary precautions shall be taken to prevent fire. The storage building shall preferably be separate from adjacent building. A signboard bearing the words "PAINT STORAGE - NO NAKED LIGHT - HIGHLY INFLAMMABLE" shall be clearly displayed outside.

11.4.1 Colour Codes and Standards

The IS: 2379: 990 - Indian Standard for Pipeline Identification Colour Code and standards shall be followed for the work covered by this contract.

For identification of pipelines, the colour code as per the table below shall be used.

Table 11-1: Colour Coding Scheme for Pipes, Equipment, Machinery & Structures:

Description	Ground Colour	First Colour Band	Second Colour Band
Product Water	Sea Green	French Blue	Signal Red
Cooling Water	-do-	French Blue	-
Fire Water	Fire Red	Crimson Red	-
Sea Water	Sea Green	White	-
Compressed Air	Sky Blue	Signal Red	-
Plant Air	-do-	Silver Grey	-
Instrument Air	-do-	French Blue	-
CO ₂	-do-	Light Grey	-
Sulfuric Acid	Dark Violet	Brilliant Green	Light Orange
Nitric Acid	-do-	French Blue	-do-
Hydrochloric Acid	-do-	Signal Red	-do-
Caustic	Smoke Grey	Light Orange	-
Chlorine	Canary Yellow	Dark Violet	-do-

The colour code scheme is intended for identification of the individual group of the pipeline. The system of colour coding consists of a ground colour and colour bands superimposed on it.

Ground Colours as given in Table-11.1 shall be applied throughout the entire length for uninsulated pipes, ground colour coating of minimum 2 m length or of adequate length not to be mistaken as colour band shall be applied at places requiring colour bands. Colour band(s) shall be applied at the following location.

- i) At battery limit points
- ii) Intersection points & change of direction points in piping ways.

- iii) Other points, such as midway of each piping way, near valves, junction joints of service appliances, walls, on either side of pipe culverts.
- iv) For long stretch / yard piping at 50M interval.
- v) At start and terminating points.

11.4.2 Identification Sign

Flow direction shall be indicated by an arrow in the location stated above and as directed by the Engineer.

Colours of arrows shall be black or white and in contrast to the colour on which they are superimposed.

Product names shall be marked at pump inlet, outlet and battery limit in a suitable size as approved by the Engineer.

11.4.3 Colour Band

As a rule, minimum width of colour band shall conform to the following table:

Nominal Pipe Size	Width (mm)
3" NB and below	25 mm
Above 3" NB upto 6" NB	50 mm
Above 8" NB upto 12" OD	75 mm
Above 12" OD	100 mm

Note: For insulated pipes, nominal pipe size means the outside diameter of insulation. Nominal pipe size figures are to be in inches.

Colour band(s) shall be arranged in the sequence shown in Table 11.1 and the sequence follows the direction of flow. The relative proportional width of the first colour band to the subsequent bands shall be 4:1; minimum width of any band shall be as per the above table.

Whenever, it is required by the Engineer to indicate that a pipeline carries a hazardous material, a hazard marking of diagonal strips of black and golden yellow as per IS:2379 shall be painted on the ground colour.

11.4.4 Identification of Vessels, Piping etc.

Equipment number shall be stencilled in black or white on each vessel, column, equipment & machinery (insulated or uninsulated) after painting. Line number in black or white shall be stencilled on all the pipe lines of more than one location as directed by the Engineer; Size of letters printed shall be as below:

Column & Vessels	-	150 mm (high)
Pump, compressor and other machinery	-	50 mm (high)
Piping	-	40-150 mm

11.5 Inspection and Testing of Painting Materials

All painting materials including primers and thinners brought to site by Contractor for application shall be procured directly from manufacturers as per specifications and shall be accompanied by manufacturer's test certificates. Paint formulations without certificates are not acceptable.

The Engineer at his discretion may call for tests for paint formulations. Contractor shall arrange to have such tests performed including batch wise test of wet paints for physical and chemical analysis. All costs there shall be borne by the Contractor.

The painting work shall be subject to inspection by the Engineer at all times. In particular, the following stage wise inspection will be performed, and Contractor shall offer the work for inspection and approval of every stage before proceeding with the next stage. The record of inspection shall be maintained in the registers. Stages of inspection are as follows:

- a. Surface preparation
- b. Primer application
- c. Each coat of paint

In addition to above, record should include type of shop primer already applied on equipment. Red oxide zinc chromate or zinc chromate or Red lead primer etc.

Any defect noticed during the various stages of inspection shall be rectified by the Contractor to the entire satisfaction of Engineer-in-charge before proceeding further. Irrespective of the inspection, repair and approval at intermediate stages of work, Contractor shall be responsible for making good any defects found during final inspection / guarantee period / defect liability period as defined in general condition of contract. Dry film thickness (DFT) shall be checked and recorded after application of each coat and extra coat of paint should be applied to make-up the DFT specified without any extra cost to Owner, the extra cost should have prior approval of the Engineer.

11.6 Cleaning and Surface Preparation

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

11.6.1 General

In order to achieve the maximum durability, one or more of the following methods of surface preparation shall be followed, depending on condition of steel surface and as instructed by Engineer. Adhesion of the paint film to surface depends largely on the degree of cleanliness of the metal surface. Proper surface preparation contributes more to the success of the paint protective system:

- i) Manual or hand tool cleaning
- ii) Mechanical or power tool cleaning
- iii) Blast cleaning

Mill scale, rust, rust scale and foreign matter shall be removed fully to ensure that a clean and dry surface is obtained. The use of aromatic solvent prior to surface cleaning will remove all other contaminants, oil, grease etc.

Blast cleaning shall not be performed where dust can contaminate surfaces undergoing such cleaning or during humid weather conditions having humidity exceeding 85%.

Irrespective of the method of surface preparation, the first coat of primer must be applied on dry surface. This should be done immediately and in any case within 4 hours of cleaning of surface. However, at times of unfavourable weather conditions, the Engineer shall have the liberty to control the time period, at his sole discretion and / or to insist on recleaning, as may be required, before primer application is taken up. In general, during unfavourable weather conditions, blasting and painting shall be avoided as far as practicable.

11.6.2 Procedure of Surface Preparation

Parts shall be cleaned prior to testing at the manufacturer's works. Parts subject to hydraulic test shall be tested before any surface treatment. After test all surfaces shall be thoroughly cleaned and dried out if necessary, by washing with an approved dewatering fluid prior to surface treatment.

Bright parts: Bright parts and bearing surfaces shall be thoroughly polished and protected from corrosion by the application of rust preventive lacquer or high melting-point grease, as approved by the Engineer, before the parts are packed. A sufficient quantity of the correct solvent for removal of the protective compounds shall be supplied and packed with each particular part.

Embedded parts: Embedded parts or those parts of an assembly which will be embedded in concrete shall be thoroughly de-scaled and cleaned to the satisfaction of the Engineer and before being packed shall be protected by a cement wash or other approved method. No cast iron or steel work shall be bitumen or tar coated where it is to be cast into the concrete and provision shall be made for cleaning off any portions so coated.

Grit or shot blasted parts: Grit or shot blasting shall be carried out in accordance with BS 7079 to a standard between 'First Quality' and 'Second Quality' after which the maximum amplitude of the surface shall not exceed 0.1 mm.

Cast Iron and Steel pipework: All ungalvanized steel pipework including pump suspension mains, bearing spiders and tunnel tubes shall be prepared internally and externally by grit or shot blasting as specified above and the surfaces primed as specified within four hours of blasting.

11.6.2.1 Blast Cleaning

Air Blast Cleaning

The surfaces shall be blast cleaned using one of the abrasives: Al₂O₃ particles chilled cast iron or malleable iron and steel at pressure of 7kg/cm² at appropriate distance and angle depending on nozzle size maintaining constant velocity and pressure. Chilled cast iron, malleable iron and

steel shall be in the form of shot or grit of size not greater than 0.055" maximum in case of steel and malleable iron and 0.04" maximum in case of chilled iron. Compressed air shall be free from moisture and oil. The blasting nozzles should be venturi style with tungsten carbide or boron carbide as the materials for liners. Nozzle orifices may vary from 3/16" to 3 /4". On completion of blasting operation, the blasted surface shall be clean and free from any scale or rust and must show a grey-white metallic lustre.

Primer or first coat of paint shall be applied within 4 hours of surface preparation. Blast cleaning shall not be done outdoors in bad weather without adequate protection or when there is dew on the metal which is to be cleaned. Surface profile shall be uniform to provide good key to the paint adhesion (i.e. 35 to 50m). If possible, vacuum collector shall be installed for collecting the abrasive and recycling.

Water Blast cleaning

Environmental, health and safety problems associated with abrasive blast cleaning limit the application of Air Blast cleaning in many installations. In such case water blast cleaning is done.

Water Blast cleaning can be applied with or without abrasive and high-pressure water blasting. The water used shall be inhibited with sodium chromate / phosphate. The blast cleaned surface shall be washed thoroughly with detergents and wiped with solvent and dried with compressed Air. For effective cleaning abrasives are used. The most commonly used pressure for high pressure water blast cleaning for maintenance surface preparation is 3000 to 6000 psi at 35-45 litres / minute water volume and pressures up to 10000 psi and water volume of 45 litres / minute provide maximum cleaning.

The water blast cleaned surface shall be comparable to SSPC – SP – 12/NACE No.5. the operation shall be carried out as per SSPC guidelines for water blast cleaning. The indicative values for sand injection is

- i) Air : 300 to 400 Cu.ft/min
- ii) Water : 5-10 litres / min. with corrosion inhibitor
- iii) Sand : 200 – 400 lbs / hr
- iv) Nozzle : 0.5 to 1" dia
- v) Special equipment for water blast cleaning with abrasives now available shall be used.

11.6.2.2 Mechanical or Power tool cleaning

Power tool cleaning shall be done by mechanical striking tools, chipping hammers, grinding wheels or rotating steel wire – brushes. Excessive burnish of surface shall be avoided as it can reduce paint adhesion. On completion of cleaning, the detached rust mill scale etc. shall be removed by clean rags and / or washed by water or steam and thoroughly dried with compressed air jet before application of paint.

11.6.2.3 Manual or hand tool cleaning

Manual or hand tool cleaning is used only where safety problems limit the application of other surface preparation procedure and hence does not appear in the specification of paint systems.

Hand tool cleaning normally consists of the following:

- i) Hand descaling and / or hammering
- ii) Hand scraping
- iii) Hand wire brushing

Rust, mill scale spatters, old coatings and other foreign matter, shall be removed by hammering, scrapping tools, emery paper cleaning, wire brushing or combination of the above methods. On completion of cleaning, loose material shall be removed from the surface by clean rags and the surface shall be brushed, swept, dedusted and blown off with compressed air / steam to remove all loose matter. Finally, the surface may be washed with water and dried for effective cleaning.

11.7 Primer Application

After surface preparation, the primer should be applied to cover the crevices, corners, sharp edges etc. in the presence of inspector nominated by the Engineer.

The shades of successive coats should be slightly different in colour in order to ensure application of individual coats, the thickness of each coat and complete coverage should be checked as per provision of this specification. This should be approved by the Engineer before application of successive coats.

The Contractor shall provide standard thickness measurement instrument with appropriate range(s) for measuring.

Dry film thickness of each coat, surface profile gauge for checking of surface profile in case of blast cleaning. Holiday detectors and pinhole detector and positector whenever required for checking in cast of immersion conditions.

Prior to application of paints on surfaces, the thickness of the individual coat shall be checked by application of each coat of the same paint on M.S. test panel. The thickness of paint on test panel shall be determined by using gauge such as 'Elkometer', the thickness of each coat shall be checked as per provision of this specification. This shall be approved by the Engineer before application of paints on surface.

At the discretion of the Engineer, the paint manufacturer must provide the expert technical service at site as and when required. This service should be free of cost and without any obligation to the Employer, as it would be in the interest of the manufacturer to ensure that both surface preparation and application are carried out as per their recommendations.

Final inspection shall include measurement of paint dry film thickness, Adhesion, Holiday detection check of finish and workmanship. The thickness should be measured at as many points / locations as decided by the Engineer and shall be within +10% of the dry film thickness, specified in the specifications.

The Contractor shall arrange for spot checking of paint materials for Sp. gr., flow time (ford cup) and spreading rate.

11.7.1 Non-Compatible Shop Coat Primer

The compatibility of finishing coat should be confirmed from the paint manufacturer. In the event of use of primer such as zinc Rich epoxy, inorganic zinc silicate etc. as shop coat, the

paint system shall depend on condition of shop coat. If shop coat is in satisfactory condition showing no major defects, the shop coat shall not be removed. The touch up primer and finishing coat (s) shall be identified for application by Engineer-in-charge.

Shop coated (coated with primer & finishing coat) equipment should not be repainted unless paint is damaged.

Shop primed equipment and surfaces will only be 'spot cleaned' in damaged areas by means of power tool brush cleaning and then spot primed before applying one coat of field primer then shop coated primer should be completely removed before application of selected paint system for particular environment.

11.8 Painting and Finishing

This Clause governs the methods for the protective coatings to be applied to structural steel, metalwork and ironwork as corrosion protection systems. Protective coating specified elsewhere for particular works such as pipes and cladding shall firstly be designed in accordance with particular requirements specified elsewhere and secondly in accordance with any requirements herein which are not overridden elsewhere. This specification makes reference to the following standard: BS 5493 "code of practice for the protective coating of iron and steel against corrosion".

The Contractor shall design each protective coating system and shall submit details of each system to the Engineer for approval. Submissions shall where possible be in the format of which examples are given at the end of this part with such additional information and samples as the Contractor may provide or the Engineer may require to enable the system to be assessed.

Protective coating shall be designed in accordance with BS 5493 to have a long life, generally of at least 10 years prior to first maintenance. Protection systems shall be chosen to be easily maintained in the future and to allow non-specialist on-site re-coating where necessary using single part paints.

For the purposes of system design the general environment shall be as specified in BS 5493 Table 3 Part 2 'Exterior exposed polluted inland'. Bulkhead gates and stoplogs shall be assumed to be exposed to a Table 3 Part 8 'Non-saline water' environment unless otherwise approved by the Engineer.

Interior spaces shall be considered to be dry in administration areas open to continuous access and damp or immersed in other spaces. The protective coating of components or structures which are continuously or infrequently immersed shall be designed for the more onerous of these two conditions relevant to the protection system used.

All exterior exposed items to be coated shall have a final coat of good appearance of a colour and type as approved by the Engineer.

The Contractor shall submit to the Engineer details of his proposals for the corrosion protection of each of the items requiring such protection, which will generally fall into the above categories

as follows:

- trash screens, flooring, ladders, access covers and frames, step irons and other components which are inaccessible but subject to abrasion/damage
- structural steelwork (including crane beams, monorails, crane structures and chassis), bulkhead gates, stoplogs, grappling beams, steel tanks and other large items readily accessible for maintenance
- valves and other corrosion-susceptible items which may be buried and are not covered by the provisions of other specifications
- other components not covered by the above for which the contractor may propose a system which he considers to be more suitable for the duty
- electrical switchgear, transformers, control panels etc.

All painting material shall be applied in strict accordance with the paint manufacturer's instructions.

11.8.1 Coating Procedure and Application

Surface shall not be coated in rain, wind or in environment where injurious air-borne elements exist, when the steel surface temperature is less than 5°F above dew point, when the relative humidity is greater than 8% or when the temperature is below 40°F.

Blast cleaned surface shall be coated with one complete application of primer as soon as practicable but in no case later than 4 hours, the same day.

To the maximum extent practicable, each coat of material shall be applied as a continuous film uniform thickness free of probes. Any spots or areas missed in application shall be recoated and permitted to dry before the next coat is applied. Applied paint should have the desired wet film thickness.

Each coat shall be in proper state of cure or dryness before the application of succeeding coat. Material shall be considered dry for recoating when an additional coat can be applied without the development of any detrimental film irregularities, such as lifting or loss of adhesion of the under coat. Manufacturer instruction shall be followed for inter-coat interval.

When the successive coat of same colour have been specified, alternate coat shall be tinted, when practical, sufficiently to produce enough contrast to indicate complete coverage of the surface. The tinting material shall be compatible with the material and not detrimental to its service life.

11.8.1.1 Air Spray Application

Air spray application shall be in accordance with the following:

- i) The equipment used shall be suitable for the intended purpose, shall be capable of properly atomising the paint to be applied, and shall be equipped with suitable pressure regulators and gauges. The air caps, nozzles, and needles shall be those recommended by the manufacturer of

the equipment for the material being sprayed. The equipment shall be kept in satisfactory condition to permit proper paint application.

- ii) Traps or separators shall be provided to remove oil and condensed water from the air. These traps or separators must be of adequate size and must be drained periodically during operations. The air from the spray gun impinging against the surface shall show no condensed water or oil.
- iii) Ingredients shall be kept properly mixed in the spray pots or containers during application by continuous mechanical agitation.
- iv) The pressure on the material in the pot and of the air at the gun shall be adjusted for optimum spraying effectiveness. The pressure on the material in the pot shall be adjusted when necessary for changes in elevation of the gun above the pot. The atomising air pressure at the gun shall be high enough to properly atomize the paint but not so high as to cause excessive fogging of paint, excessive evaporation of solvent, or less by overspray.
- v) Spray equipment shall be kept sufficiently clean so that dirt, dried paint, and other foreign materials are not deposited in the paint film.
- vi) Any solvents left in the equipment shall be completely removed before applying paint to the surface being painted.
- vii) Paint shall be applied in a uniform layer, with overlapping at the edge of the spray pattern. The spray patterns shall be adjusted so that the paint is deposited uniformly. During application, the gun shall be held perpendicular to the surface and at a distance which will ensure that a wet layer of paint is deposited on the surface. The trigger of the gun should be released at the end of each stroke.
- viii) All runs and sags shall be brushed out immediately or the paint shall be removed and the surface repainted.
- ix) Areas inaccessible to the spray gun shall be painted by brush, if not accessible by brush, daubers or sheepskins shall be used.
- x) All nameplates, manufacturer's identification tags, machined surfaces, instrument glass, finished flange faces, control valve items and similar items shall be masked to prohibit coating deposition. If these surfaces are coated, the component shall be cleaned and restored to its original condition.
- xi) Edges of structural shapes and irregular coated surfaces shall be coated first and an extra pass made later.
- xii) If spray gun shows choking, immediately de-choking procedure shall be followed.

Airless spray application shall be in accordance with the following procedure: as per steel structure paint manual Vol.1 & Vol.2 by SSPC, USA. Air less spray relies on hydraulic pressure rather than air atomization to produce the desired spray. An air compressor or electric motor is used to operate a pump to produce pressures of 1,000 to 6,000 psi. Paint is delivered to the spray gun at this pressure through a single hose within the gun, a single paint stream is divided into separate streams, which are forced through a small orifice resulting in atomization of paint without the use of air. This results in more rapid coverage with less overspray. Airless spray usually is faster, cleaner, more economical and easier to use than conventional air spray.

Airless spray equipment is mounted on wheels, and paint is aspirated in a hose that sucks paint from the container, including drums. The unit shall have inbuilt agitator that keep the paint uniformly mixed during the spraying. The unit shall consist of inbuilt strainer. Usually very small quantities of thinning are required before spray. In case of High Build epoxy coatings

(two pack). 30:1 pump ratio and 0.020 – 0.023" tip size will provide a good spray pattern. Ideally fluid hoses should not be less than 3/8" ID and not longer than 50 ft. to obtain optimum results.

In case of gun choking, de-choking steps shall be followed immediately.

11.8.1.2 Brush Application

- i) Brush application of paint shall be accordance with the following:
- ii) Brushes shall be of a style and quality that will enable proper application of paint.
- iii) Round or oval brushes are most suitable for rivets, bolts, irregular surfaces, and rough or pitted steel. Wide flat brushes are suitable for large flat areas, but they shall not have width over five inches.
- iv) Paint shall be applied into all corners.
- v) Any runs or sags shall be brushed out.
- vi) There shall be a minimum of brush marks left in the applied paint.
- vii) Surfaces not accessible to brushes shall be painted by spray, daubers, or sheepkin.

11.8.1.3 Manual Application

Manual application by sling (where 6 O'clock position of pipe is not approachable)

A canvas strip (alternatively a tinplate strip) about 450 mm wide and 1.5 m long is hold under the pipe by two men. Liquid coating is poured on the sling at each side of the pipe. The men holding this sling move it up and down and walk slowly forward while fresh coating is poured on the pipe and they manipulate the sling so that an even coating is obtained all-round the bottom. This work shall be done very carefully and by experienced personnel. There shall not be any formation of "Whiskers" and holes in the coating. The coating film shall be inspected by mirror.

For each coat the painter should know the WFT corresponding to the specified DFT and standardise the paint application technique to achieve the desired WFT. This has to be ensured in the qualification trial.

11.8.1.4 Drying of Coated Surfaces

No coat shall be applied until the preceding coat has dried. The material shall be considered dry for re-coating when another coat can be applied without the development of any film irregularities such as lifting or loss of adhesion of undercoats. Drying time of the applied coat should not exceed maximum specified for it as a first coat; if it exceeds the paint material has possibly deteriorated or mixing is faulty.

No paint shall be force dried under conditions which will cause checking, wrinkling, blistering formation of pores, or detrimentally affect the condition of the paint.

No drier shall be added to a paint on the job unless specifically called for in the manufacturer's specification for the paint.

Paint shall be protected from rain, condensation, contamination, snow and freezing until dry to the fullest extent practicable.

11.8.1.5 Repair of Damaged Paint Surface

Where paint has been damaged in handling and in transportation, the repair of damaged coating of pre-erection / fabrication shall be as given below:

Repair of damaged inorganic zinc silicate primer after erection / welding:

Quickly remove the primer from damaged area by mechanical scraping and emery paper to expose the white metal. Blast-clean the surface if possible. Feather the primer over the intact adjacent surface surrounding the damaged area by emery paper.

Repair of damaged pre-erection and shop priming in the design temperature of –90°C to 500°C.

- Surface preparation shall be done as per procedure given above.
- One coat of inorganic zinc silicate coating (F-9) shall be applied wherever damaged was observed on pre-erection / pre-fabrication / shop primer of F-9. F-9 shall not be applied if damaged area is not more than 5 x 5 cm.

Shop priming / pre-erection priming with F9 or F12 shall be done only on blasted surface and with airless spray. For large flat surface field painting shall be done by airless spray otherwise brush can be used.

11.8.2 Plant Supplied to Site with Final Coating Applied

Cubicles, Cabinets etc.

Before any steel work is painted the steel must be thoroughly cleaned and an approved anti-rusting priming coat applied so that the possibility of rusting or corrosion taking place is negligible. All surfaces should have not less than two undercoats and two top coats or air-drying paint. The undercoats shall be easily distinguishable in shade or colour form the priming and finishing coats. The two final coats shall be in a colour and finish to be advised by the Engineer. The inside surfaces of any cubicles, cabinets, etc. where condensation is liable to occur, shall be coated with an approved anti-condensation composition. The Contractor shall ensure that all component sections of a switch board wherever manufactured shall have a finish of uniform texture and an exact colour match.

Chromium Plated Parts

Where chromium plating is specified or offered by the manufacturer it shall comply with the requirements of BS 1224 including the following provisions. No blistering of any surfaces will be tolerated. The finished appearance shall be bright. Where the base metal is steel, plating shall be applied in accordance with Table 2 of the above code. Other base metals shall be plated in accordance with Tables 3, 4, 5 as appropriate. For all base metals the service condition number 2 (of the above code) shall be used. Small bore pipes, valves and fittings etc., which are sited in architecturally finished areas of the station and selected by the Engineer shall be chromium plated. Damage to chromium plating shall be made good before taking over.

Galvanised Parts

All materials to be galvanised shall be of the full dimensions shown on the approved drawings or specified and all punching, cutting, drilling, screw tapping and the removal of burrs shall be completed before the galvanising process begins. Parts to be galvanised shall be shot blasted as specified above. Such parts shall be galvanised not more than four hours after commencement of shot blasting.

All galvanising shall be done by the hot dip-process. No alternative process may be used without the approval of the Engineer. No components shall be galvanised which are likely to come into subsequent contact with oil.

The zinc coating shall be uniform, clean smooth and as free from spangle as possible. In the case of component parts the zinc coating shall weigh not less than 610 g/sq. m of area covered and shall not be less than 0.090 mm in thickness.

Bolts and nuts shall be standardised. The Engineer may select for test as many components to be weighed after pickling, and before and after galvanizing as he may think fit.

All galvanised parts shall be protected from injury to the zinc coating due to differential serration and abrasion during the periods of transit, storage and erection. Damaged areas of the coating shall be touched up with an approved zinc-dust paint or other approved flake metallic compound.

Cast Iron and Steel Pipework (Internal Surfaces)

The internal surfaces shall have an approved coating. Where a bitumen-based coating is used, it shall be in accordance with Type 2 of BS 4147.

Prior to lining, the pipe shall be grit blasted and primed with an approved primer. The lining shall be in accordance with BS 534. After installation, the internal lining shall be made good and satisfactorily tested with a Holiday detector to 8 kV.

The coating shall be suitable for use in contact with drinking water. The type of coating shall be entered in Schedule L provided and the Engineer reserves the right to call for test plates of the paint. The manufacturer shall at the time of ordering carry out the 'Taste and smell test' (Appendix E of BS 4147) and 'Effects on water test' (Appendix C of BS 3416) and forward 3 copies of the test results to the Engineer for approval.

Where pipe are to be welded after the protective coatings have been applied the pipe surfaces shall be primed and all other coating stopped 250 mm short of the weld preparation. Collars and fillings shall be primed but no other coating applied.

The manufacturer shall supply a sufficient quantity of suitable materials to repair damage occurring during delivery to site and to provide a flush finished internal lining at welded joints. He shall supply sufficient coating to fill in the recesses at internal welds over the previously primed areas. The costs of these materials shall be included in the unit rates for the supply of the pipes and specials. The coating shall be applied in accordance with the manufacturer's

instructions and with Appendices J and K of BS 3416.

Cast Iron and Steel Parts (External Surfaces)

All ungalvanized metal parts which will be immersed in water shall be cleaned by grit blasting and within four hours of blasting given a approved coating. Ungalvanized metal parts exposed in manholes or areas of high humidity shall be cleaned by grit blasting and given two coats of a black bituminous solution.

11.8.3 Plant Forwarded to Site for Final Finishing

Cast Iron and Steel Parts (External Surfaces) Outside Buildings

All ungalvanized metal parts which will be exposed to the outside atmosphere shall be cleaned by grit blasting and provided with two coats of an approved primer.

Cast Iron and Steel Parts Inside Buildings

All exposed metal surfaces which will not be immersed in water or exposed in areas described above shall be rubbed down, cleaned by grit blasting and within four hours of blasting given one coat of an approved primer before packing.

11.9 Painting at Site

Immediately on arrival at the site, all items of plant shall be examined for damage to the paint coat applied at the manufacturer's works, and any damaged portions shall be cleaned down to the bare metal, all rust removed, and the paint coat made good with similar paint.

Steel and cast-iron parts received at site shall be provided with adequate number of further coats of coal tar epoxy polyamine coating or Polyurethane coating as specified & approved, to a total dry film thickness of minimum 275 microns including the primer coats unless specified somewhere else. All sharp edges, nuts, bolts and other items difficult to be painted shall receive a brush coat of specified paint before application of each coat of epoxy-based coal tar paint giving a total dry film thickness of at least 275 microns. In the case of fabricated steelwork this work shall be done after assembly.

Before painting is commenced the Contractor shall submit for the approval of the Engineer, full details of the paints he proposes to use together with colour charts for the gloss finishes.

After erection, such items which are not finish painted shall be finish painted, items finish painted at the Manufacturer's works shall be touched up for any damaged paint work.

The painting work shall conform to the following requirements:

(a) The surface preparation shall be carried out generally in accordance with IS: 1477 Part I and IS: 6005.

(b) After surface preparation, two coats of primer-red oxide zinc chromate with modified

phenolic alkyd base conforming to IS: 2074 shall be applied. Dry film thickness of each coat shall be 25 microns.

- (c) For finish painting, after application of primer as in (b) above, two coats of synthetic enamel conforming to IS: 2932 shall be applied. Dry film thickness of each coat shall be 25 microns.
- (d) Colours shall be selected as per IS: 5

No painting shall be carried out unless the item has been inspected and accepted by Engineer at the Manufacturer's works.

The dry paint film thickness shall be measured by Electrometer or other instruments approved by the Employer. In order to obtain the dry film thickness DFT specified, the Contractor shall ensure that the coverage rate given by the paint manufacturer will enable this thickness to be obtained. Strength of adhesion shall be measured with an adhesion tester and this value shall not be less than 10 kg/cm^2 . Painted fabricated steel Work which is to be stored prior to erection shall be kept clear of the ground and shall be laid out or stacked in an orderly manner that will ensure that no pools of water or dirt can accumulate on the surface. Suitable packings shall be laid between the stacked materials. Where cover is provided, it shall be ventilated.

The painting procedure shall be submitted in the following format for approval:

- (a) Surface Preparation
- (b) Reference Standard
- (c) Conditions of Work
- (d) Type of Materials
- (e) Tests and inspection methods and sequence, thickness (DFT)
- (f) Colour in final coat
- (g) Total thickness of coats (DFT)
- (h) Other necessary data and information

The following items in the plant are required to be painted:

- (a) Outer surfaces of pumps, valves, pipes, fittings, motors etc., not exposed to treated water
- (b) Steelwork exposed to weather, such as outer surface of surge vessel, valves, pipes etc.
- (c) Internal Plant and pipework, cranes, exhaust fans, fire extinguishers and miscellaneous steelwork not exposed to weather
- (d) Steelwork exposed to weather, such as platforms, ladders, hand railing, etc.
- (e) Steelwork exposed to humid weather and requiring hard maintenance and repairs
- (f) Buried steelwork
- (g) Buried pipes and fittings prior to application of wrapping
- (h) Other equipment, as per requirement of employer.

All buried steel pipes and fittings shall be coated and unwrapped with hot or cold applied, self-adhesive, polyethylene in accordance with AWWA C214 or equivalent Standard.

Cast iron or mild steel parts to be built into concrete shall remain unpainted. Immediately before it is cast in-situ, it shall be made perfectly free from dirt, scale, loose rust, paint, oil limewash or any other coating.

No blast cleaning or painting shall be applied to corrosion resistant Materials such as stainless steels. Ni-resist cast iron, bronze and other metals used for seals, bearings, lighting fitting etc.

Machined surfaces such as gear teeth shall be coated with a thick layer of grease. Other mechanical surfaces such as shaft ends or other bright parts shall be coated with two coats of an anti-rust solution which can be removed easily when required. Permanently bolted mechanical interfaces such as flanges shall be coated with a thin coat of anti-rust compound before assembly.

All primers, under coats and finishes shall be applied by brush or airless spray, except where otherwise specified.

Consecutive coats shall be in distinct but appropriate shades. All paints shall be supplied from the store to the painters, ready for application, and addition of thinners or any other Material shall be prohibited. Any instruction given by the paint manufacturer shall be strictly followed.

All painting shall be carried out by the painters under supervision. Paint shall be applied to the dry surface which has been prepared in compliance with the approved procedure.

Paint shall not be applied when the ambient temperature falls below 4°C or relative humidity rises above 90%.

The plant and equipment shall be inspected and reviewed at the various stages of the coating application both at the manufacturer's works and at the site of the Works. Samples may be taken from the paints as delivered and submitted to such tests as are deemed necessary. The completed paint systems shall be tested by instruments to ensure that the protection is of adequate thickness and is free from pinholes and the direct measurement of adhesion shall be checked by the removal of a small section of the coating. The Contractor shall supply all instruments and apparatus required for carrying out such tests required by the Employer.

11.10 Waterworks Finish

A high standard of finish, defined as "Waterworks finish" is required for all Plant as detailed below.

11.10.1 Welding and Flame Cutting

A smooth neat finish, by careful grinding if necessary is required on all exterior welding and flame cutting. All plates and bars used in fabrication shall have smooth surfaces with no pitting or deep slag inclusions.

11.10.2 Castings

Casting surfaces shall be smooth and free from surface blowholes. Stock castings shall be selected with this in mind. All castings shall be shot blasted before machining.

11.10.3 Covers

All covers shall be firmly fixed. Weld mesh shall sit square in its frame. Where panels are placed next to each other the patterns shall line up.

11.10.4 Flanges and Beadings

All bolt holes shall be spot faced parallel with the mating face for good seating of nuts and bolt heads. Surplus jointing shall be removed from mating faces and peripheries.

11.10.5 Items to be Chromium Plated

Name plates, instruction plates, rotation arrows, indicators and pointers, small bore pipework, tundish oil level gauges and fittings, small valves (including air valves), plugs and grease nipples, which are sited in architecturally finished areas of the station and as selected by the Engineer, shall be chromium plated. Damage to chromium plating shall be made good.

All pipes and fittings, etc. shall be fitted in a straight, neat symmetrical manner so as to present a pleasing appearance.

11.10.6 External Screws, Bolt-heads, Nuts and Washers

These shall be chromium plated, sherardised or made in stainless steel.

11.10.7 Gauges

All indicating gauges fitted to any machine assembly shall be of similar appearance and grouped together to present a pleasing aspect. They shall all have chromium-plated cases, bezels, cocks and fittings.

11.11 Guarantee

The Contractor shall guarantee that the chemical and physical properties of paint materials used are in accordance with the specifications contained herein / to be provided during execution of work.

The Contractor shall produce test reports from manufacturer regarding the quality of the particular batch of paint supplied. The Engineer shall have the right to test wet samples of paint at random, for quality of same. Batch test reports of the manufacturer's test for each batch of paints supplied shall be made available by the Contractor.

11.12 Qualification Criteria of Painting Contractor

Painting contractor who is awarded any job for under this standard must have necessary equipment, machinery, tools and tackles for surface preparation, paint application and inspection. The contractor must have qualified, trained and experienced surface preparator,

paint applicator, inspector and supervisors. The Contractor supervisor, inspector, surface preparator and paint applicator must be conversant with the standards referred to this specification. The Contractors capacity, capability and competency requirements for the job shall be quantified in the tender document and shall be assessed by a team appointed by the owner before awarding any job.

11.13 Procedure for Approval of New Coating Materials and Manufacturers

Following procedure is recommended to be followed for approval of new manufacturers.

The manufacturer should arrange testing of the inorganic zinc silicate coating materials as per the list of tests given below from one of the reputed Government laboratories.

Samples of coating materials should be submitted to the Govt. laboratory in sealed containers with batch no. and test certificate on regular format of manufacturer's testing laboratory. The sampling shall be certified and sealed by a certifying agency.

All test panels should be prepared by Govt. testing agency coloured photographs of test panels should be taken before and after the test and should be enclosed along with test report.

Sample batch no. and manufacturer's test certificate should be enclosed along with the report. Test report must contain details of observation and rusting if any, as per the testing code. Suggested Government laboratories are:

- RRL, Hyderabad
- HBTI, Kanpur
- DMSRDE, Kanpur
- IIT, Mumbai/ Madras
- BIS Laboratories
- UDCT, Mumbai
- RITES, Calcutta
- PDIL

Manufacturers should intimate the Company, details of sample submitted for testing, name of Govt. testing agency, date, and contact personnel of the Govt. testing agency. At the end of the test the manufacturer should submit the test reports to the company for approval. The manufacturer(s) shall be qualified based on the results of these tests and other assessment and the Company's decision in this regard shall be final and binding on the manufacturer.

Tests required for evaluation of acceptance of coating materials for onshore application.

<u>Test</u>	<u>ASTM Test Method</u>
Density	D 1475
Dipping properties	D 823
<u>Film Characteristics</u>	
Drying time	D 1640
Flexibility	D 1737 / D 522
Hardness	D 3363
Adhesion	D 2197
Abrasion resistance	D 968 / D 1044

DFT / Coat	As per SSPC Guidelines
Storage Stability	D 1849
<u>Resistance to</u>	
Humidity for 2000 hrs.	D 2247
Salt Spray for 2000 hrs.	B 117
Accelerated Weathering	D 822
% Zn in DFT	G 53

CHAPTER - 12

12. TRAINING AND ADVISORY REQUIREMENTS

12.1 Training Requirements

12.1.1 General

The Contractor shall provide comprehensive training for the different categories of the Employer's operation and maintenance staff. Training shall fall into two main types which are 'off the job' and 'on the job'. Off the job training shall take place in the class room, on the job training shall be carried out at the operating treatment plant.

12.1.2 Off -the Job Training

The Contractor shall prepare formal training documentation for distribution to the trainees. Visual aids shall be used to illustrate the points being made and make the training programme as interesting and enjoyable as possible for the participants. The off the job training shall comprise the following:

12.1.2.1 Off the Job Training Programme for all Trainees

- a) simple chemistry and process principles involved in the operation of the Works
- b) details of the processes involved including comparison with other processes
- c) plant operational procedures and trouble shooting
- d) health and safety
- e) use of the local and central HMI's

12.1.2.2 Off the Job Process Training Programme for Operators

- a) operation of individual items of plant and sections of the Works including automatic operation and manual operation in the event of say automatic control failure
- b) day to day operation of the Works and procedures
- c) comprehensive list of 'what if' scenarios dealing with the actions to be taken in the event of potential process problems, alarms, plant failures, overflows, power failures. etc.
- d) first-line mechanical maintenance
- e) safe methods of work general
- f) safety procedures to be followed in operating, maintaining and cleaning the plant
- g) special precautions to be followed in the event of a chlorine leak

12.1.2.3 Off the Job Training Programme for Electrical Maintenance Staff

- a) configuration, construction and operation of the electrical plant
- b) electrical maintenance requirements of the Works

- c) switching and safety procedures to be followed
- d) safe methods of working
- e) fault finding and repair procedures

12.1.2.4 Off the Job Training Programme for Control and Instrumentation Maintenance Staff

- a) configuration, construction and operation of the plant
- b) control and instrumentation maintenance requirements of the Works
- c) fault finding and repair procedures
- d) safe methods of working
- e) special training on the use of the PLC/SCADA/DCS and associated programming software for fault finding on control systems
- f) special training on the use and performance of the central HMI SCADA/DCS hardware and software and other specialist hardware and software systems used on the plant

12.1.2.5 Off the Job Training Programme for Mechanical Maintenance Staff

- a) routine mechanical maintenance requirements of the Works
- b) lubrication requirements of the Works
- c) fault finding, repair and overhaul procedures
- d) safe methods of working

12.1.2.6 Off the Job Training Programme for Desalination Management Staff

- a) desalination process management techniques
- b) desalination plant cost management
- c) desalination plant laboratory management
- d) safe methods of work general
- e) safety procedures to be followed in operating, maintaining and cleaning the plant

12.1.3 On the Job Training

The Contractor shall utilise the Operation and Maintenance manuals as the primary training aid in carrying out the on-the-job training. Short-comings, omissions and errors identified in the Operation and Maintenance manuals during the training shall be rectified prior to final acceptance of the Operation and Maintenance manuals.

12.1.3.1 On the Job Training Programme for all Trainees

- a) plant familiarisation tour
- b) description of plant process units
- c) understanding of PFD and the PIDs

- d) discuss on the O&M Manual and its use
- e) Understanding of all the critical control points (CCPs)
- f) alarm management protocols
- g) use of the local and central HMIs
- h) plant safety procedures
- i) identify areas where special safety precautions are necessary,
- j) asset management and work-order policies and principles

12.1.3.2 On the Job Process Training Programme for Operators.

- a) operational conditions on the operation of individual items of plant and sections of the Works including automatic operation and manual operation in the event of say automatic control failure,
- b) illustrate by example the day-to-day operation of the Works and procedures,
- c) illustrate by example the actions to be taken in the event of potential process problems, alarms, plant failures overflows, power failures etc. (as identified in the ‘what if’ scenario off the job training)
- d) illustrate by example the first line mechanical maintenance,
- e) illustrate by example safety procedures to be followed in operation, maintenance and cleaning of the Works,
- f) Training on each process unit using a duplicated simulation tool of exact process controls. Operational staff to be tested using this simulator program module to identify any weakness for continuous improvements and reach a minimum pass standards.

12.1.3.3 On the Job Training Programme for Electrical Maintenance Staff

- a) carry out a detailed tour of the electrical plant
- b) illustrate by example the operation of the electrical plant
- c) illustrate by example the electrical isolation and maintenance procedures
- d) illustrate by example fault finding and repair procedures
- e) illustrate by example switching and safety procedures to be followed
- f) illustrate by example safe systems of work

12.1.3.4 On the Job Training Programme for Control and Instrumentation Maintenance Staff

- a) illustrate by example the operation of the Works
- b) illustrate by example the calibration of the instruments and equipment
- c) illustrate by example the control and instrumentation maintenance requirements of the

Works

- d) illustrate by example fault finding and repair procedures
- e) illustrate by example fault finding on DCS based control systems, the central HMI SCADA/DCS hardware and software and other specialist hardware and software systems used on the plant
- f) illustrate by example safe systems of the Works.

12.1.3.5 On the Job Training Programme for Mechanical Maintenance Staff

- a) illustrate by example the routine mechanical maintenance requirements of the Works
- b) illustrate by example lubrication procedures
- c) illustrate by example fault finding, repair and overhaul procedures
- d) illustrate by example safe systems of work

12.1.4 Training Programme

Off the job training shall be carried out prior to the commissioning of the Works or any section of the Works. With the permission of the Engineer and the Employer on the job training shall be carried out prior to the start of the operation and maintenance. On the job training shall be completed as a condition for acceptance of the Works following completion of the Tests After Completion.

The Contractor shall provide a training plan for each category of staff. The training plan shall detail the content and duration of each course. The training plan shall be submitted for the approval of the Engineer at least 120 days prior to the commencement of the training program. The duration of training offered for each category of staff shall not be less than that detailed in the Table below.

Table 12-1: Minimum Duration of Training Courses

Category of Staff	Off the Job (minimum days duration for each course)	On the Job (minimum weeks duration for each course)
All staff	1	1
Operator	5	5
Electrical technician/electrician	3	5
Control/instrument technician	5	10
Mechanical technician/fitter	3	5

Category of Staff	Off the Job (minimum days duration for each course)	On the Job (minimum weeks duration for each course)
Desalination plant operation team	5	(see note)
Desalination plant management	3	(see note)

Note: It is assumed that desalination plant operation/management personnel on the job training will be available throughout the 240 months when the plant is operated by the Contractor.

The training day shall be assumed to be not less than six hours split into two sessions. The off the job training rooms shall be provided by the Employer at the Site in existing buildings. The Contractor shall provide facilities for training which shall include inter alia tables and chairs, projectors, white/black boards, training aids, etc. Where trainees of a given category can all be released from their operational duties simultaneously, they may be trained together. Where this is not possible the Contractor shall repeat the complete course for those who could not attend.

12.1.5 Training Personnel

The Contractor shall provide suitably qualified trainers to carry out the off the job and on the job training. The trainers are to be experienced in desalination plant management, operation and maintenance in their relevant discipline and the training of skilled and unskilled staff. The Contractor shall submit the curriculum vitae of the nominee for the position of training expert to the Engineer for approval 120 days before training is scheduled to commence. The training expert shall be fluent in English, Tamil and Hindi, or the Contractor shall provide the services of an interpreter(s) during the training periods.

12.2 Advisory Requirements

12.2.1 General

The Contractor shall provide personnel to advise in the operation of the Works for a period after Hand Over. The personnel provided shall have proven experience in their intended roles. Those persons provided shall comprise:

- Advisor to the treatment works manager duration 24 months
 - Advisor mechanical maintenance duration 6 months plus 2 months
 - Advisor electrical/control maintenance duration 6 months plus 2 months
 - Advisor process duration 6 months plus 2 months

The electrical/control, mechanical and process specialist visits are split. During the first visit, procedures shall be established and implemented. During the second visit, the procedures shall be monitored and refined. The role of the Contractor's advisory personnel shall be to:

- advise on day-to-day management of the desalination plant
- advise on the development procedures for the ordering and reordering of consumables
- propose and develop systems to monitor the consumption of consumables and power and to advise actions to reduce their usage to a minimum,
- establish analytical procedures within the laboratory and carry out periodic checks to ensure that they are adhered to,
- establish routines for the analysis of water quality in all areas of the plant and to establish procedures for corrective action in the event of quality falling below that expected,
- establish systems for the recording of water quality appropriate to a plant of this type,
- ensure procedures for operation and planned maintenance of the Works as detailed in the Operation and Maintenance manuals are carried out.
- advise on the optimisation of process settings, dosage rates, operating regimes etc.
- provide continuing informal on the job training to the Employers staff (this is in addition to formal training requirements detailed elsewhere)
- update the Operation and Maintenance manuals in line with experience gained during the year's operation.

The Contractor shall be responsible for all costs associated with the provision of his advisory personnel.

12.2.2 Advisory Personnel

The Contractor shall provide suitable personnel to provide advisory services. The advisors shall be experienced in desalination plant management, or operation and maintenance in their relevant discipline. The Contractor shall submit the curriculum vitae of the advisory nominees to the Engineer for approval 120 days before the scheduled assignment. Prior to mobilisation, the advisors shall be fluent in both Tamil, Hindi and English or the Contractor shall provide the services of an interpreter(s) during the advisory period as necessary.

12.2.3 Operation and Maintenance Manual

This Operation and Maintenance manual shall be provided by the Contractor to establish guidelines for plant operators to understand the new desalination plant to operate this system efficiently and successfully. The guidelines will be provided to the training personnel, on how to operate the plant so that they shall be able to manage to treat the water to best quality; with low consumption of energy; with low cost of maintenance; providing a long life of equipment; protection against accident, safe working methods and protecting systems from damages.

The system operation and unit operation of each component will be needed to be adjusted and modify depending on the raw water quality, and the required data are collected during the training program as well as the operation and maintenance period. The Contractor shall train the CMWSSB personnel about Plant operation knowledge, abilities and skill as follows:

12.2.3.1 Capacity Building

Knowledge:

- System flow and unit operation, maintenance, pumps, blowers, other plant equipment and machinery
- Basic Desalination Process
- Basic sludge handling principle and its characteristics
- Basic maintenance period and work sheet
- Basic laboratory techniques to make standardized tests
- Avoiding any chance of an accident
- Basic safety and health

Abilities:

- Make adjustments to the desalination system according to Raw water characteristics and its flow fluctuation, and control
- Make adjustments to control the chemical dosing system
- Adjust the chlorination process, and to lift sacks of chemicals and to read and follow written and oral instructions
- Adjust the dosing system of chemicals. Perform standardized laboratory tests
- Make repairs and/or adjustments to water treatment equipment and to keep records and prepare reports
- Make repairs and/or adjustments to each equipment and to keep records and prepare reports
- Handling safety valves and its pipeline
- Read and interpret gauges and recording devices used in the desalination plant
- Usage of safety equipment in case of Emergency

12.2.3.2 Tasks of Operation and Maintenance Works

- a) Operate water treatment plant under normal conditions such as equipment, machinery and pipe line, including valves, gate, stop-logs, pumps, thickeners, chlorine feeder, chemical tanks, dewatering equipment, chemical preparation and dosing system, reading flow meter; regulate the flow of water, disposing the sludge, etc.
- b) Select the desalination facility or equipment to meet the actual inflow pattern,
- c) Take samples and make standardized laboratory test if required, including tests for temperature, residual chlorine, pH, turbidity and other required items,
- d) Set the system/equipment to adjust timer or operation period to meet the required specified amounts of feeding chlorine solution, chemical solution, air volume, sludge withdrawal, recycling waste wash water
- e) Make minor repairs and adjustments to machinery, equipment, pipes and other

- materials pertinent to the operation of the plant,
- f) Work on troubleshooting including bulk flow control,
 - g) Maintain maintenance and operational records,,
 - h) Cleaning of machinery, equipment and civil tanks, building, loading and unloading of materials and storage of chemicals properly
 - i) Does general maintenance of the plant, including, but not limited to, painting, general custodial work, maintenance of equipment, etc.
 - j) Assist in repairing flow meters and pipeline including valves in inactive time and/or operation time,
 - k) Assist in the inspection of all necessary equipment, of water & wastewater sampling & of pipeline.

12.2.3.3 Information to be covered in the Operation and Maintenance Manual

The Operation and Maintenance Manual shall be prepared in accordance with the information provided in Part-2 A3 works requirements. The manual should include but not necessarily be limited to the following:

- a) Background of project
- b) Plan and design condition
- c) System operation indices and unit operation indices
- d) Water Quality & Quantity (Inlet/outlet):
 - Actual
 - Standard
- e) Outline of system operation (Civil, Mechanical & Electrical):
 - Summary
 - Flow diagrams, plan view, hydraulic profile, Piping isometrics
 - Operation flow diagram
 - Table of facilities
 - (Tag number, Type, Number, Nominal bore, capacity, motor rating, weight)
- f) Outline of component and its aim (Civil & Mechanical):
 - Normal operation
 - Emergency operation
 - Selection of facility
 - Selection of Auto/Manual mode
 - Notice of danger/peril/hazard
- g) Verification items of system operation mode (Civil & Mechanical):
 - Before the start of system operation
 - Start of system operation
 - During regular operation
 - Set value of level sensors and safety pressure on safety devices

- Position of plant/equipment on the selected mode
 - Remove potential danger/peril/hazard
- h) Details of the facility/equipment component (Civil & Mechanical):
- Summary
 - Specification
 - Outside dimension
 - Weight, quality of material
 - Outside drawing
 - Graph, charts, performance curve, table
 - Photo after installation
 - Notice of danger/peril/hazard
- i) Verification items of component operation (Civil & Mechanical):
- Preparation before the operation
 - Starting operation flow
 - Normal operation
 - Set value of level sensors and safety valves
 - Emergency maintenance
 - Notice of danger, peril, hazard
- j) Outline of component and its aim (Electrical):
- Verify incoming power Hz, kWh
 - Verify output from cogeneration Hz, kWh
 - Ordinary line or emergency line operation
 - Detail and full operation procedure
 - Select standby generator
 - Emergency operation
 - Selection of facility
 - Notice of danger/peril/hazard
- k) Verification items of system operation mode (Electrical):
- Before the start of system operation
 - Start of system operation
 - Set value of level sensors and protection
 - Select Auto/Manual mode on the central control panel
 - Remove potential danger/peril/hazard
- l) Detail of facility component (Electrical):
- Summary
 - Specification
 - Single line diagram
 - Panel dimension
 - Weight, quality of material
 - Outside drawing
 - Graph, charts, performance curve, table
 - Photo after installation

- Notice of danger/peril/hazard
- m) Facility verification items (Electrical):
- Preparation before the operation
 - Select Normal operation or Emergency operation
 - Select equipment operation mode/switch by Auto /manual
 - Before the start of system operation
 - Start of system operation
 - Set value of level sensors and protection
 - Remove potential danger/peril/hazard
 - Notice of danger/peril/hazard
- n) Standard:
- Water quality at inlet and outlet
 - Critical control points
 - Compliance with contractual water quality parameters
 - Risk assessment and control procedures
 - Documentations and Hazard analysis and critical control points (HACCP) audits
 - Emission control
 - Noise and vibration
- o) Fire/explosion protection
- p) Dewatered cake sludge handling/disposal
- q) Frequency of sampling, analysis and evaluation:
- Inflow and outflow quality /flow rate
 - Regulated pollutants
 - Operation index
 - Amount of sludge and its density
 - Water/sludge temperature
- r) Maintenance schedule (Mechanical & Electrical):
- Routine work
 - Regular work
 - Manufacturer recommendation
- s) Maintenance schedule(Civil):
- Routine work
 - Regular work
 - Manufacturer recommendation
- t) Calculation sheets:
- Calculation of dosing amount (Alum/Chlorine/Poly/etc.)
 - Calculation of sludge amount
- u) Troubleshooting guide (Phenomenon/action/comments):
- Discharge quality and bulking
 - Process and system control
 - Mechanical equipment

- Electrical equipment
 - Case study or/and previous experiences (Normal troubleshooting)
- v) Operation/test data:
- Operation index
 - Asset management software to meet ISO 55000
 - Mechanical site inspection data
 - Electrical site inspection data
 - Water quality and quantity(inlet/outlet)
 - Regulated pollutants
 - Amount of sludge and its density
 - Amount of cake and its density
 - Noise and vibration
 - Water/sludge temperature
 - Power /chemical consumption
 - Operation cost during the training period
 - Performance test of pressure control valves, pressure reducing valves
 - Consumables, spare parts and its list
 - Photo of inspection (evidence)
- w) List:
- Equipment control
 - Operation record formats
 - Maintenance record formats
 - Material control
 - Inventory
 - Spare parts
 - Safety and Health

CHAPTER - 13

13. OPERATION AND MAINTENANCE

13.1 General

This section applies to the specifications of materials used for operation and maintenance, the workmanship, period for operation and maintenance, specifications for the acceptable quality of product water, maintenance of records, and responsibilities during Operation and Maintenance period. The Contractor shall operate and maintain the desalination plant and sludge treatment systems at Perur, Chennai, the instrumentation system, the communication system, 230kV/110kV/11kV/415 V GIS substations, SCADA/DCS systems, all ancillary buildings and campus area for a period of 20 years. The Operation and Maintenance period shall only commence only after issue of Commissioning Certificate.

13.1.1 Duties and Responsibilities

- The Employer will provide only power up to the guaranteed quantities given in technical schedule for Functional Guarantee, Part-1 during the 20 years of operation and maintenance period. Any cost for extra power consumption at the plant above the functional guaranteed value will be borne by the Contractor. Apart from power, all the remaining responsibilities for operation and maintenance of the plant during O&M period shall lie with the Contractor.
- The obligation of Contractor is to provide product water meeting all the quantity and quality in line with specification requirements.
- The Contractor shall manage plant operations so as to limit power consumption and chemical usage to within the specified functional guarantees.
- The Contractor shall ensure satisfactory operation and maintenance of the Works so that the plant operation provides reliable, consistent performance and is economical at all times.
- The Contractor shall use the Computerized Maintenance Management system for the maintenance.
- The product water quality shall be sampled and tested by the Third Party every month for the vital parameters to ensure the water quality meeting the contract requirements. The third party shall be NAL accredited laboratory in Chennai. All costs for the sampling and analysing of the product water by the third party lab agency shall be borne by the Contractor.

13.2 Definition of Maintenance

Maintenance of the Works covers all the techniques and systems which, by means of regular monitoring of equipment and scheduled maintenance procedures, prevent failures and, in the event of problems, carry out repairs with minimal disruption of the process. Maintenance is therefore a combination of technical, administrative, and management activities. Maintenance consists of preventive and corrective procedures.

13.2.1 Preventive Maintenance

Preventive maintenance consists of all the regular works carried out in order to sustain the conditions necessary for smooth operation of the plant and to keep the performance of the equipment as close as possible to its original and guaranteed performance level. Its purpose is to reduce the probabilities of failure or deterioration of equipment of the plant. In simple terms, preventive maintenance involves the elementary operations such as lubrication, mechanical servicing, and electrical and instrumentation servicing.

13.2.2 Corrective or Remedial Maintenance

Corrective or remedial maintenance of the Works consists of all works needed to re-establish the conditions necessary for an apparatus or set of equipment to operate properly subsequent to failure or deterioration of the results produced by the equipment.

The work may be scheduled for the short or medium term in accordance with the checks carried out as part of the preventive maintenance procedure, the number of hours an apparatus has been operating, or an alarm factor (abnormal noise, repeated cut-out, weakening of the insulation, etc.) or may be dictated by an unexpected breakdown.

13.2.2.1 Maintenance work

The maintenance work consists of inspection work and maintenance work as mentioned below:

- Inspection work, that includes physical appearance, inspection, measurement and testing equipment to verify and survey that the plant performance whether operation is normal or not.
- The inspection work shall be executed daily by each technical specialist as a routine and/or regular inspection and shall be recorded each time. The evaluation on the collected data shall be immediately reviewed by the chief operation engineer to instruct the staff member for operation on the same day and/or make a plan of detail inspection and/or make repair schedule to ensure continuous plant operation without any problem.
- Maintenance work, for which main task-work shall include activities, such as lubrication, overhaul and replacement of parts.

13.2.2.2 Operation work

The operation work is the execution of the plant operation based on the processes and procedures to meet design criteria including set up or adjustment of the operational index or data according to the water quality or demand.

Monitoring work is to confirm the operation data, and readout its measurement value on panels, and check-up the working performance of plant appropriately, as well as maintaining records of the output.

13.2.3 Computerized Maintenance Management System (CMMS)

A computerized maintenance management system (CMMS) is a type of management software that performs functions in support of management and tracking of O&M activities.

CMMS systems automate most of the logistical functions performed by maintenance staff and management.

The typical CMMS functions shall include the following, but not limited to:

- Work order generation, prioritization, and tracking by equipment/component.
- Historical tracking of all work orders generated which shall be sortable by equipment, date, person responding, etc.
- Tracking of scheduled and unscheduled maintenance activities.
- Storing of maintenance procedures as well as all warranty information by component.
- Storing of all technical documentation or procedures by component.
- Real-time reports of ongoing work activity
- Calendar- or run-time-based preventive maintenance work order generation.
- Capital and labor cost tracking by component as well as shortest, median, and longest times to close a work order by component.
- Complete parts and materials inventory control with automated reorder capability.
- PDA interface to streamline input and work order generation.
- Outside service call/dispatch capabilities.

13.3 Specification

The specification of materials used for repairs shall be the same as have been used in the original work. Specifications for any materials which were not used during construction shall be approved by the Engineer prior to commencement of the operation and maintenance period and must be incorporated in the Operation and Maintenance manual. Without being limited by this clause, during Operation and Maintenance period the Contractor shall use appropriate material for repairs even if material required for such repairs has not been approved earlier, and no delay in making such repairs shall be subjected to such limitation. However, subsequent to use of such material the Contractor shall submit proposals for the approval of specifications of such material. The approved material will subsequently form a part of the Operation and Maintenance manual. The comprehensive information as detailed in Table below shall be submitted to the Engineer.

Table 13-1: List of Execution Schedule

Items	Description
Maintenance of plant/facilities	List of unit process, capacity of equipment, method/frequency of maintenance and type of maintenance (On-line or Off-line)

Operation of plant/facilities	List of plant/equipment, items to be monitoring/operation, preparation of chemical, handling sludge, method of system control, data input into computer, operation of backup, period of power failure and generator operation, communication method etc.
Monitoring of product water quality	Scope of monitoring, method of sampling and analysis, place of laboratory and name of authorized personnel.
Countermeasure against accident and risk management	Damage prediction, simulation of public relations, method of recovery, contact address, rescue activity and emergency team
Renewal	Replacement of pipe, replacement of equipment and facilities
Subcontracting	Method of contract out, scope of works, limit of responsibility.
Evaluation and report	Method of data analysis, evaluation of collected data, improvement program, reporting
Organization and administration	Executive organization chart, segregation of duties, list of staff members, experience, health certificate of staff member, type of insurance, criminal record, personnel name of taking record and make soft data, method of data control, operation and maintenance cost.

13.4 Activities during Operation and Maintenance Period

13.4.1 General

Within the framework of the Contractor's responsibilities given above, the Contractor shall carry out the following activities. However, these shall not limit the requirement for other activities which otherwise are required as per term and conditions of Contract or to fulfil the Contractor's responsibilities or are essential as per good practices. The Contractor shall be responsible for, but not limited to, the following:

- a) Providing product water with quality as specified and at the production rates as directed by the Contract

- b) Providing the required staff, but not less than the minimum specified numbers/level, during operation and maintenance period and additional staff as per requirement during periodic maintenance and in emergencies.
- c) Providing all consumables required for functioning of plant and equipment except for power charges up to the guaranteed limit. In case the power consumption is above the guaranteed value, the Contractor shall pay for the excess in accordance with the Contract Data. The Contractor shall arrange for the chemicals and use at the plant. The Contractor will charge the cost of the chemicals to the Employer based on the actual chemical consumption up to the guaranteed quantities. Any excess chemical cost above the guaranteed value shall be borne by the Contractor. The Contractor shall provide the chemical dose rates and other consumption evidence in support of the actual consumption values.
- d) Maintenance of substations, etc., pumping stations, pre-treatment units, RO desalination plant, chemical houses, post treatment units etc. in neat and clean condition.
- e) Entering into AMC contracts with system/equipment suppliers, as necessary. It is mandatory to enter into an agreement for a 20 years maintenance contract with the PLC and DCS/CMMS system suppliers, whosoever has executed the work for this project and on call attendance should at site within 24 hours.
- f) Maintenance of the lighting fixtures and the lighting system of all areas and replacement of all non-functional lighting fixtures within 24 hours.
- g) Maintaining the following:
 - Repair history of all mechanical, electrical and instrumentation control equipment in pumping stations, desalination plant, and communication instruments
 - Logbooks through DCS /CMMS system
 - Daily log of operations of all the important equipment
 - Raw and clear water quality test results on turbidity, residual chlorine levels and other process parameters and sludge quality test results (Refer Part 11, Table 11.2)
 - Daily list of critical alarms (1st Priority) with time tag
 - Logbook format and the data to be included in the logbook shall be decided during commissioning in consultation with the Employer
 - CMMS monthly work order and its completion status
 - Last periodic maintenance done for all equipment/buildings of the system
 - In addition to maintenance of above logbooks, the Contractor is required to maintain one inspection /complaint logbook register and a copy from the CMMS. The complaints entered in the complaint register should be keyed in the CMMS and the complaint must be investigated and remedial measures must be taken immediately.
- h) Providing required spares, special tools and test equipment and maintaining adequate inventory of required accessories or equipment itself for repair of system so that the electrical, mechanical, instrumentation and control system, pipe and the communication system can work efficiently as per the guarantees given or minimum required efficiencies asked for in the Contract, without any additional cost to the Employer. The

Contractor may use spares and tools and tackles supplied with the Contract as required by him. However, at the end of the Contract the Contractor shall hand over the spares, tools and tackles available at the plant for maintenance and also the complimentary spares supplied by the manufacturers along with the equipment and units. If the complimentary spares are used during O&M period, the Contractor shall replenish those with the new spares. The Contractor shall also provide a list of the spare parts required for continuous two years of operation and will help the Employer to procure the items before end of the O&M contract.

- i) Providing manpower for the required repairs of all plant facilities along with the manpower and materials for repair of the roads, buildings and campus area utilities.
- j) Maintaining the drinking water supply facilities at the desalination plant campus and all its units.
- k) Maintaining stores for the electrical, mechanical and instrumentation and control equipment as well as that for the chemicals and laboratory consumables at the desalination plant. The maintenance of stores shall include but not be limited to:
 - Loading/unloading of materials received and issued for works
 - Proper arrangement of material in stores to ensure safety and easy availability
 - Maintaining store areas in a neat and tidy condition
 - Keeping inventory records and accounting for the incoming materials
 - Keeping records and accounting for the consumed materials
 - Updating the inventory data in the CMMS system.

The Contractor shall be solely responsible for the safety and security of the goods in the store and shall be responsible for any loss or damages in stores for any reason. He may opt for insurance cover against the value of the goods to be stored without any additional cost to the Employer.

- l) Periodic routine maintenance of structures/buildings of campus area of the treatment plant and others built in the Contract. Such maintenance must ensure adequate cleanliness, ventilation, illumination and structural safety. In addition to this, the general hygienic standards must be maintained and adequate plantation, horticultural activities must be taken up to maintain the total environment of the campus/buildings pleasant.
- m) Periodic updating and submission of the operation and maintenance manual as defined in this specification for Operation and Maintenance works. The Contractor shall take up all periodic maintenance works provided in the approved Operation and Maintenance manual.
- n) Submission of monthly report – not only limited to the data specified in Section 13.4.15:
 - Co-ordination with other contractors and/or agencies responsible for the execution, operation and maintenance of the product water pumping station.
 - The Engineer shall be entitled to audit any aspect of the system and the Contractor shall ensure remedial action as directed.

- Safety reporting: Brief reports of all accidents and hazardous incidents including descriptions of cause, extent of injuries, action taken, and precautions instituted to prevent repetition of such events.
- o) Insurance: The Contractor shall, without limiting his or the Employer's obligations and responsibilities, ensure:
- The work together with material and plant for incorporation therein, to the full replacement cost (term "cost" in this context shall include profit).
 - The Contractor's equipment and other things brought onto site by the Contractor, for a sum sufficient to provide for their replacement at the site.
 - The insurance shall be in the joint names of the Contractor and the Employer at the Contractor's cost and shall cover the Employer and the Contractor against all losses or damages from whatsoever cause arising from the start of the Operation and Maintenance until the date of completion of Operation and Maintenance in respect of the facility or any section or part thereof as the case may be.
 - Any amount not insured or not recovered from the insurer shall be borne by the Contractor.
- p) The typical main inspection items and some signs of deterioration of plant are presented in Table 13-2, which may be observed during routine inspection or monitoring work. The maintenance works shall be planned together and analyse information to solve the problem.
- Information about raw water quality and product water is necessary to make a decision how to operate plant operation properly, and to check the operational performance whether the water quality meets water quality standards or not. Typical parameters to be sampled and its quality analysis shown in Table 13-3. The other tables are:
- Table 13-4: Typical Operation & Maintenance items in Electrical and Instrumentation Systems
 - Table 13-5 Operation & Maintenance for Mechanical Systems

Table 13-2: Typical Indication of Sign of Plant Deterioration

Parameters	Concrete and Structure	Pipe Line	Mechanical & Electrical	Chemical	Instrumentation
Deterioration of material quality	<ul style="list-style-type: none"> • Appear crack on concrete structure • Water leakage • Scouring • Wear/abrasion • Corrosion (steel, rebar) • Irregular subsidence • Change of shape • Reducing service life 	<ul style="list-style-type: none"> • Appear corrosion (reducing wall thickness/size/bolts) • Electrical corrosion • Water leakage • Damage • Wear/abrasion • Cavitation erosion • Discoloration • Reducing service life 	<ul style="list-style-type: none"> • Stop operation • Heating • Fumes • Oil/water leakage • Voltage reduction • Lower performance • Electricity failure • Malfunction • Wear/abrasion • Noise/vibration • Electric leakage • Decline acid proof/water proof • Mechanical down • Burnout/damage • Corrosion/rust • High pressure gradient across membranes 	<ul style="list-style-type: none"> • Chemical/water/air/CO₂ gas/ Chlorine solution leakage • Insulation deterioration • Corrosion/rust • Wear/abrasion • Zero-point disparity • Increasing in measurement error • Frozen System / Frozen reading • Difficult to adjust accuracy • Failure of total accuracy • Performance defect • Equipment malfunction • Mechanical down • Dosing malfunction • Reducing service life • Discolour 	<ul style="list-style-type: none"> • Insulation deterioration • Corrosion/rust • Wear/abrasion • Zero/point disparity • Increasing in measurement error • Frozen System / Frozen reading • Difficult to adjust accuracy • Failure of total accuracy • Performance defect • System malfunction • Mechanical down • Heating • Fumes • Burn up relays • Reducing service life • Remove puddle/keep dry

Parameters	Concrete and Structure	Pipe Line	Mechanical & Electrical	Chemical	Instrumentation
			<ul style="list-style-type: none"> • Reducing service life • Operation rigidity 		<ul style="list-style-type: none"> • Operation rigidness
Deterioration of water quality	<ul style="list-style-type: none"> • Contamination of water by inflow hazardous/waste material, small animal, higher turbidity and pH • Settlement of floating substance • Deterioration/peel-off of internal coating • Spoil the facility • Algae growing on tank inside wall • Low residual chlorine cause of rising water temperature or stagnant water 	<ul style="list-style-type: none"> • Water contamination • Red/black water • Abnormal water color & smell by algae • Low residual chlorine by water quality or stagnant water • Deterioration of internal coating or pipe/peel-off • Observation of metal color in water (Fe, Mn, Cu, Pd) 	<ul style="list-style-type: none"> • Quality analysis • Observation of small flocks • Accumulate sludge on tank bottom • Increasing flocks carry-over • Clogging surface of filter • Crack on surface of filter media • Poor product water quality • Fall of residual chlorine • Reduction of treatment capacity • High permeate TDS 	<ul style="list-style-type: none"> • Failure of agglutination process due to raw water quality • Failure of disinfection dosing rate or process control (lower or higher residual chlorine) • Feeding rate • Volume, color, smell at feeding points • A number of equipment as operation • Deterioration of stocked chemical • Generation of THM 	<ul style="list-style-type: none"> • Spoil, consummation, damage, dirty on sensor of measuring devices • Inappropriate installation of measuring devices • Malfunction of measuring devices • Calibration Errors • Calibration elapsing • System malfunction • Chut-down plant or stop equipment • On-off emergency alert • Defect of operation mode • Failure of indication & accuracy

Parameters	Concrete and Structure	Pipe Line	Mechanical & Electrical	Chemical	Instrumentation
			<ul style="list-style-type: none"> • Abnormal water color • Stop & adjust number of operation facility 		<ul style="list-style-type: none"> • Remove puddle/keep dry
Reduction of water quantity and pressure	<ul style="list-style-type: none"> • Lack of water tank storage capacity • Water leakage • Lack of water tank elevation • Accumulation of bottom • Settlement • Clogging filter media/under-drain:strainer • Blockage inlet/outlet opening by obstacle 	<ul style="list-style-type: none"> • Reduction of pipe diameter due to corrosion • Scale growing • Increasing head loss • Declining water velocity • Declining water quantity • Accumulation of silt, • Air accumulation • Lack of supplying water quantity • Discoloration • Water hammer 	<ul style="list-style-type: none"> • Amount of receiving raw seawater • Water contamination • Declining production quantity • More filter's back wash or shorter filtration life • Uneven backwash or high initial filter loss head • Increasing pump head loss 	<ul style="list-style-type: none"> • Defect of pumping, mixing, making solution. • Declining chemical dousing rate at points • Lack of storage capacity • Failure of agglutination process • Failure of disinfection • Control plant operation 	<ul style="list-style-type: none"> • System malfunction • Malfunction of measuring devices • Control plant operation • On-off pump operation • Water hammer

Parameters	Concrete and Structure	Pipe Line	Mechanical & Electrical	Chemical	Instrumentation
			<ul style="list-style-type: none"> • Readout of water meters or water level • Number of pumps on duty or On-off operation • Failure of equipment • Service life of facility • Control supply water • Water hammer 		
Decline in plant/system performance	<ul style="list-style-type: none"> • Decline in retention time • Increasing dangerous unit operation • Difficult to repair • Declining facility efficiency • Increasing operation cost 	<ul style="list-style-type: none"> • Required longer repair work • Defect valve/gates operation • Impossible of water flow control 	<ul style="list-style-type: none"> • Increasing frequency of out of order • Increase in frequency of CIP • Longer repair time • Increasing electricity failure 	<ul style="list-style-type: none"> • Increasing frequency of out of order • Longer repair time • Declining operational performance • Poor ventilation & odor • Poor mixing • Increasing third person fault (create ripple 	<ul style="list-style-type: none"> • Unstable system • Increasing frequency of out of order • Longer repair time • Declining operational performance • Missing/lack of operational/maintenance data & record remove puddle/keep dry

Parameters	Concrete and Structure	Pipe Line	Mechanical & Electrical	Chemical	Instrumentation
			<ul style="list-style-type: none"> • Declining operational performance • Poor flash mixing & flocculation • Accumulation of sludge cake in site • Increasing third person fault (create ripple accident by electricity failure) 	accident by chemcial leakage)	<ul style="list-style-type: none"> • Frequent Alarms • Slow Response • Controllers Loading issues • Controller Freeze

Table 13-3: Typical Parameters for Water Analysis

Parameters	Location and Sampling/Analysis Points for Water Quality							
	Raw Water	Lamella Effluent	DAF Effluent	GDMF Effluent	RO Feed	RO permeate	Product Water	
Turbidity	Online	Online	Online	Online	Online	Online	Online	
pH	Online	Online	Online	Online	Online	Online	Online	
TOC	Weekly	Weekly	Weekly	Weekly	Weekly	-	-	
COD	Weekly	Weekly	Weekly	Weekly	Weekly	-	Weekly	
BOD	Weekly	Weekly	Weekly	Weekly	Weekly	-	Weekly	
Alkalinity	Daily	Weekly	Weekly	Weekly	Daily	Online	Daily	
Total Hardness	Daily	Weekly	Weekly	Weekly	Daily	Online	Online	
Total Dissolved Solids	Daily	Weekly	Weekly	Weekly	Daily	-	Daily	
Elec. Conductivity	Online	Weekly	Weekly	Weekly	Online	Online	Online	
Iron	Daily	Daily	Daily	Daily	Online	-	Daily	
Total Coliforms	Daily	Weekly	Weekly	Weekly	Daily	Daily	Daily	
Water Temperature	Online	-	-	Online	Online	Online	Online	
Total suspended solids	Daily	Daily	Daily	Daily	Daily	-	Daily	
Residual Chlorine	Online	Online	Online	Online	Online	-	Online	
SDI	Daily	-	-	Online	Online	-	-	
ORP	-	-	-	-	Online	-	-	
Boron	Daily	-	-	Online	-	Daily	Daily	
Oil & grease	Online	Daily	Weekly	Weekly	Weekly	-	-	
Odour	Daily	Weekly	Weekly	Weekly	Weekly	-	Daily	
Taste	Daily	Weekly	Weekly	Weekly	Weekly	-	Daily	
Colour	Daily	Daily	Daily	Daily	Daily	-	Daily	
Ammonium nitrogen	Weekly	Weekly	Weekly	Weekly	Weekly	-	Daily	
Algae	Daily	Weekly	Weekly	Weekly	Weekly	-	-	
Nitrate	Weekly	Weekly	Weekly	Weekly	Weekly	-	-	

Table 13-4 : Typical Items in Electrical and Instrumentation Systems

Daily		Periodic	
Frequency	Description	Frequency	Description
Transformer	Verification of kVA, V, Am, current protection, oil temperature	Every 6 Months	Verification of oil, abnormal sound, performance
Incoming Panels	Verification of kVA, V, Am, lamp test /replacement, moisture cut heater, current protection, burned smell, remove water	Every 6 Months	Verification of switch On/Off, Fuse, abnormal sound, condenser, relays, protection devices, earthing, wiring and connection
Control Panels	Verification of V, Am, lamp test & replacement, moisture cut heater, overload protection, operation mode, burned smell, remove water	Every 6 Months	Verification of switch On/Off, Fuse, abnormal sound, condenser, relays, protection devices, earthing, wiring and connection
Lighting Panels	Verification of Am, light test & replacement, moisture cut heaters, overload protection, remove water	Every 6 Months	Verification of switch On/Off, Fuse, abnormal sound, condenser, relays, protection devices, earthing, wiring and connection
Meters reading	Verification of V, Am, overload protection	Every 6 Months	Verification of over load protection indication, switch On/Off, accuracy, damage
Motors	Verification of burned smell, heating, vibration	Every 6 Months	Verification of switch On/Off, earthing, insulation resistance, rpm, damage, temperature
System	Verification of system sequence ON/OFF	Every 6 Months	Verification of All system, insulation resistance

Cable line	Verification of short circuit, cable colour, damage	Every 6 Months	Verification of wire droop, degradation, insulation resistance
Instrumentation	Verification on operations of the instrumentation	Every day	Online

Table 13-5 : Typical Items in Mechanical System

Activity	Frequency
Monitoring of Cartridge Filter differential pressure	Online
Monitoring of RO membrane differential pressure	Online
Maintenance on ERI unit	Within 6 hours
Removal of clogged materials from screens	Daily
Cleaning of level sensors	Weekly
Checking vibration and noise level of pump/blower sets	Weekly
Fully closing and opening of sluice gates and valves	Monthly
Replacement of bearings	Within a day of breakdown
Replacement of bulbs, lamps etc	Within a day of breakdown
Tightening of gland	When leakage increases beyond acceptable limit
Greasing, oiling	As per manufacturers recommendation
Preparation of list of spares for satisfactory operation	Semi-annually
Transformer oil sample checking	Semi-annually
Checking of relays/ alarm (through secondary injection)	Yearly
Condition of gasket and replacement (if required)	Yearly
Operation of crane for all motions	Weekly
Submission of report on maintenance to Employer	Monthly

13.4.2 Experience & Qualification of Staff

For all operation and maintenance works, the Contractor shall provide skilled staff, which has adequate qualifications and sufficient experience of similar works. CV of General Manager, Shift-in-charge, Plant Supervisors shall have to be approved from the Employer. The following Table 6 describes the minimum levels of staffing, and their minimum qualifications and

experience in similar works, that the Contractor shall be required to deploy for carrying out the Operation and Maintenance functions:

Table 13-6: Minimum Requirements for Staff and Qualifications

Sr. No	Designation	Qualification	Experience	Shift-1	Shift-2	Shift-3	Reliever	Total Nos.
1.	Plant Manager	Graduate Engineer (Civil/Env/Chemical)	>15 years		General shift 1			1
2.	Sr. Operation Manager	Graduate Engineer (Elec/Mech/Chem)	>10 years	1				1
3.	Operation Manager/ Shift-in-charge	Graduate Engineer (Elec/Mech/Chem)	5 years	2	2	2		6
4.	Maintenance Incharge	Diploma (Elec/Mech/Instr)	5 years	2	2	2		6
5.	Maintenance Personnel	Diploma (Elec/Mech/Instr)	5 years	2	2	2		6
6.	SCADA Operator	Diploma (Engg)/ Science Grad	5 years	2	2	2		6
7.	Field Operator	Diploma (Elec/Mech)/ Science Grad	5 years	8	8	8		24
8.	Admin Staff	Graduate	5 years	2				2
9.	Chemist	B. Sc-Chemistry	5 years	1				1
10.	Lab Assistant	Diploma in Lab Tech.	2 years	3	3	3	1	10
11.	Helpers	10th pass	-	16	10	10	1	37
12.	Safety Officer	Skilled		1			1	2
13.	Security Guards	10th pass	2 years	6	2	2	1	11
14.	Drivers	Skilled	2 years	2	1	1	1	5
15.	Gardener/Cafeteria cleaning	8th pass	2 years	8	4	4	2	18
	Total			14	4	4		136

Notes:

1. The above requirement is minimum only. The Contractor shall arrange extra work force, as and when required, so as to smoothly run the operation and maintenance including preventive maintenance, repairs etc. and general cleanliness of the installations.
2. The above staff strength is exclusive of leave reserve required for different category of staff. The Contractor shall ensure availability of the personnel given in the above table for all seven days in a week.
3. The Contractor shall make appropriate arrangements for maintenance of items like road work, buildings, arboriculture, patrolling and maintenance of civil structures, vehicle operations and other activities defined to fulfil its obligations under Operation and Maintenance Contract.
4. In the event of absence of staff during the Operation and Maintenance, the deduction of payment shall be done on per day basis for the number of days absence. A day salary shall be calculated from the man-month rate quoted by the bidder, considering 30 calendar days in a month.

13.4.3 Safety and Health

a) Chemicals

- All personal who are assigned to work on chemical storage and injection system shall first be trained to understand and follow all aspects of handling and safety procedures.
- Chemical handlers shall be instructed to report any condition that may affect their personal health to their superiors.

b) Electricity

- All the electrical equipment shall be handled and operated by a trained and authorized person only. All the equipment shall be checked for its proper earthing and loose connections prior to start equipment. Naked wire, loose connections and faulty connections shall be repaired immediately prior to start for operation.
- Electrical sockets and switch shall not be touched by bare or wet hands. If there is any live wire found naked or on wet ground, main switch shall be turned off first then the wire shall be repaired or moved.
- For any electrical works proper insulated tools shall be used. Do not try to use tools made for other purpose; it may be hazardous.

c) Fall Protection

- Only authorized person shall work at high place, people working at high level shall be very careful and protect himself from fall and injuries. Protective gears such as gloves, safety belts shall be worn and safety belts shall be tied to proper location prior to start the work. If anybody feels dizzy and drowsy he should not work at high and should come down immediately.

- Whenever possible a ladder shall be used. Ladder shall be in stable condition and proper slope of the ladder is 4 vertical and 1 horizontal and it shall be secured at the base.
- All the openings shall be secured properly by a barrier of a hand rail to avoid unauthorized person getting in. Whenever covers are provided for opening those covers shall be kept closed all the time, except for maintenance type.

d) Entering Tank

- If worker should enter inside of deeper manholes or tanks precautions shall be taken.
- Manholes covers shall be open and wait for fresh air to circulate.
- Prior to enter-oxygen level inside the tank shall be checked otherwise it may be hazardous. If oxygen is not enough a ventilating fan should use to supply fresh air inside.
- Only permitted person shall work inside, while a person is working inside there must be another person watching outside; unless he appoints next person he should not leave from duty. While men working inside manholes must keep open and manholes shall be protected from outsiders to go inside.
- If person inside feels drowsy, dizzy or unusual feeling he should come out immediately. He should take rest and take a fresh air.
- If the worker is collapsing inside, do not immediately enter inside for rescue him as as you may be next victim of accident. Prior to rescue make sure that oxygen is enough inside, report immediately to person in charge. Try to rescue the person from outside.

e) Health Checkup

Water can be scrapped and become a carrier of water borne disease if it is handled by an ill person. That is why personal health is an important factor to keep the water potable. Any person not feeling well shall report to their superior and shall be go through proper health checkups. All workers should go through medical checkup every year, and the result of check up shall be reported to the Engineer.

f) General Hygiene

Persons working for seawater treatment and desalination shall maintain a high level of personal hygiene. This includes clean work clothes, skin, fingernails and hair. They should wash their hands properly by using soap and clean water prior to handle the water treatment works.

g) Uniform

All workers at site work shall wear helmet, safety shoes, regular uniform to avoid any accident by rotating equipment.

13.4.4 Job Description

Plant Manager

The Plant Manager shall be in charge of all aspects linked to the performance of the operations contract. He shall have authority to carry out or have carried out all tasks involved in the smooth operation of the installation he manages. The Plant Manager will:

- Recruit staff
- Organize work
- Order chemicals and local supplies, including negotiation of supply contracts
- Assume full responsibility for ensuring compliance with safety regulations
- Handle the relations with the customer and inspection bodies
- Implement the resources required for compliance with treatment guarantees.

Operation Manager

The Operation Manager shall be directly under the orders of the Sr. Operation Manager. He shall be accountable for the treatment performance of the unit for which he is responsible; and will:

- Coordinate the process teams, who monitor and control the installations,
- Define the operating instruction allot tasks
- Supervise the laboratory, define the program of analysis, and interpret the results
- Draw up plant operation reports
- Inform the maintenance manager, define the modalities for work by maintenance crews.

Operating Staff

- Monitoring, reading and analysing all the operating parameters
- Applying the standardized procedures defined by Management
- Supervising and running the various units in accordance with the operating instructions, in compliance with the treatment objective
- Keeping a log of events in the installation
- Locking units out for servicing operations
- Informing operations Manager any problem in operation of equipment.

13.4.5 Desalination Plant

- a) Operation and maintenance of all the desalination process facilities from Intake system to clear water reservoir and sludge treatment to wastewater discharge to sea through outfall diffusers.
- b) The plant shall be operated continuously at minimum 97% availability. However, the net product water shall be produced at 400 MLD everyday of a month.
- c) Providing required manpower for routine operation of water and sludge treatment units, clear water reservoir and distribution pumps, EHV/LV switchgear room, PLC control, all motors, valves and piping in the system, and laboratory.
- d) Maintaining the PLC, including the hardware, software and all instruments, in good working condition. The downtime of entire control system shall not exceed 2 hours. During the downtime, the Contractor shall continue to operate the desalination plant in manual mode using the local panel controls and the readings from local instruments.

- e) Routine and periodic maintenance of the entire control system and instruments as per the manufacturer's recommendations.
- f) Replacement of damaged controls, communication cables and power supply cables.
- g) Repair or replacement, as required, of all instruments such as flow meters, pressure transmitters, pressure gauges, level sensors/transmitters, float type level switches, on-line pH meters, on-line turbidity meters, on-line residual chlorine meters and laboratory instruments along with all other equipment. The downtime of any individual instrument as referred above shall not exceed 24 hours.
- h) Periodic site calibration of all measuring/metering equipment or as recommended by the manufacturer. The calibration at manufacturer's works shall be done only in case of major failure/ repairs of the instruments.
- i) Preparation and submission of daily and monthly customized reports produced by the local SCADA/DCS system.
- j) Provision and maintenance of all consumables for printing without any additional costs to the Employer.
- k) Weekly lubrication of all gears of reduction motors, motorized valves, gates and other parts of the system.
- l) Periodic operating and checking all valves and gates for their manual and electric operation. Operation of valves must be checked from local control console, switchgear and through PLC system. Any defect observed must be made good.
- m) Ensuring environmentally friendly disposal of sludge at approved site(s), within a radius of 20 kilometers from the plant site. Contractor shall provide the rate for disposal at 20 kms and also beyond 20 km from the plant site.
- n) Operation and maintenance of all circuits and buildings associated with the treatment works.
- o) Breakdown maintenance of all electrical, mechanical and instrumentation equipment.
- p) Routine monitoring of substation equipment and take preventive measures (as required)
- q) Routine maintenance works of lighting and earthing system.
- r) Re-painting of the exposed mild steel components of pipeline, ladders, railings etc. in the desalination plant in every 3rd year of Operation and Maintenance to keep them in good shape.
- s) Maintaining the surrounding areas of the filter plant free from shrubs, weeds, grass and other unwanted vegetation.
- t) Annual cleaning and disinfection of the clear water reservoirs. The raw water shall be used for watering plant and washing.
- u) Providing safety accessories, (e. g. gloves, shoes, first aid box, etc.)
- v) Ensuring fire and safety equipment.

- w) The Contractor shall provide necessary chemicals such as sodium hypochlorite, sulfuric acid, ferric chloride, polyelectrolytes, RO operational and cleaning chemicals, post treatment chemicals etc. The Contractor shall take three quotations from reputed suppliers of required consumables and procure the material from the lowest quoted rate supplier. The Contractor will charge the cost of actual chemical consumption within the guaranteed limit. Minimum 30 days chemical stock shall have to be maintained to ensure that operation is not affected, and quality of water does not suffer. The Contractor shall use chemicals to ensure their most economic consumption and minimize wastage. The maximum consumption of chemicals shall not in any way be more than the guaranteed consumption provided by the Contractor in the Tender document. In case of increase in consumption, the difference in cost of chemicals shall not be payable to the Contractor.
- x) The power consumption shall also not be more than the projected consumption provided by the Contractor in the Tender. In case of increase in consumption, the difference in cost shall be recovered from the monthly payment due to the Contractor.

13.4.6 Lubrication

The Contractor shall furnish a complete schedule of recommended oils and other lubricants in the Operation and Maintenance manual. The number of types of lubricants shall be kept to a minimum. In case of grease lubricated bearings for electric motors, lithium base grease is preferred.

The Contractor shall indicate the brand name of indigenously available equivalent lubricants, with their complete duty specifications, in the Operation and Maintenance manual. The Contractor shall also furnish the schedule of quantities for each fill, frequency of filling and annual requirement in Operation and Maintenance manual.

Where lubrication is affected by means of grease, preference shall be given to a pressure system which does not require frequent adjustment or recharging. Frequent, for this purpose, means more than once in a month. Where more than one type of special grease is required, a grease gun for each special type shall be used. All lubricant systems shall be designed so as not to cause a fire or pollution hazard.

The Contractor shall supply flushing oil for such lubrication system when an item of plant is ready for preliminary running.

13.4.7 Spare Parts

All spare parts required for the maintenance of the plant must be from the manufacturer of the equipment or, if the equipment itself has been made with parts from other manufacturers, the parts must be of the same make as used in the equipment supplied and installed.

All spare parts shall be packed for long storage under the climatic conditions prevailing at the Site. Each spare part shall be labelled on the outside of its packing with its description, number and purpose. If more than one spare is packed in a single case, a general description of the case contents shall be shown on the outside and a packing list enclosed.

13.4.8 Desalination and Ancillary Works

- a) Providing guards in the campus areas round the clock, gardeners and other manpower to maintain the campus area green, neat and tidy.
- b) Maintenance of gardens and plantations in campus area, which will generally involve the following activities:
 - 1. Watering of plants at required intervals
 - 2. Re-plantation without any additional cost in place of dead plants or damaged plants
 - 3. Hoeing and weeding, etc.
 - 4. Pruning, trimming and cutting of old big trees
 - 5. Removing shrubs, weeds, grass and unwanted vegetation after each rainy season from the desalination plant area
- c) Maintenance of roads and lighting fixtures and lighting circuits in the desalination plant campus.
- d) Maintenance of lighting fixtures and lighting circuits, water supply facilities in the desalination plant campus, offices and other residential buildings.
- e) The Contractor shall carry out ordinary repairs to buildings during the Operation and Maintenance period. The repairs may include but not limited to the following items:
 - Easing of doors and windows, monsoon repairs to roofs, attention to drains, rain water spouts, attention to plinth protection.
 - External white or colour wash, external or internal painting, internal distempering, renewal of approach roads within the campus.
 - The frequency of repairs must not be less than as specified in Table below:

Table 13-7: Repair Frequency of Buildings

S. No.	Nature of Repair	Frequency of repair for Residential Buildings	Frequency of repair for other Buildings
1	External finishing (colour washing) after attending minor repairs such as damage to plaster etc.	In 3 rd year of Operation and Maintenance	Every three years
2	Internal finishing (distemper / painting) after attending minor repairs such as damage to plaster etc	In 3 rd year of Operation and Maintenance	In 3 rd year of Operation and Maintenance

- f) Repairs to buildings must be carried out during May to June except for white and colour washing work, which should be done in September and October after monsoon in residential buildings.
- g) Following repairs prior to onset of monsoon are essential:
- Any faults in the electric installation, leakages, earthing, exposed wire ends and any hazards on this account to the users/inmates of the buildings, should be taken care of suitably, wiring, which is damaged or outlived, should be replaced.
 - Damaged sanitary lines should be replaced and choked lines cleared.
 - Proper drainage of the area around the building should be ensured to avoid stagnation of rainwater/house effluent, in order to prevent malarial conditions. Where courtyards exist in the buildings, their drainage into the outer drains should be ensured. Any choked drains should be cleared properly.
 - Leaking roofs should be attended to immediately with suitable repairs/treatment, as the case may be. The rain waterspouts should also be cleared of blockages, etc. The roof should be swept clean of leaves, debris, etc. , if any.
 - The plaster on outer walls of the building, which is exposed to weather, should be repaired before rains in order to prevent dampness inside. Where plinth protection has been provided, it should be checked and the damaged portions, if any, should be repaired before rains.
 - Damaged flooring should be repaired/ replaced as per requirement, in order to prevent dampness inside the rooms, etc. during rains.
 - Periodic repairs of damaged floors, door/window fittings, water taps, water coolers, furniture, desert coolers, electric circuits, must be taken up on complaints using the material of same quality as used during construction.

13.4.9 Restoration of Rain Cuts

Earthwork for restoration of rain cuts in embankment and shoulders shall be made using suitable material and compacting the same. The material used for restoration of rain cuts shall be approved by the Engineer.

The area affected by rain cuts shall be cleared of all loose soil and benched. The width of the benches shall be at least 300 mm and they shall extend continuously for a sufficient length. The height of the benches shall be in the range of 150-300 mm.

Fresh material shall be deposited in layers not exceeding 250 mm loose thickness and compacted so as to match with the benching at moisture content close to the optimum. Compaction shall be carried out using suitable equipment such as plate compactors and rammers or by suitable implements handled manually. The finished work shall conform to alignment, levels and slopes.

13.4.10 Maintenance of Earthen Shoulder

The work of maintenance of earthen shoulder shall include making up the irregularities/loss of material on shoulder to the design level by adding fresh approved soil and compacting it with appropriate equipment, or stripping excess soil from the shoulder surface, as required.

The material to be added to the shoulder, if required, shall be the selected soil as specified for shoulder works. Wherever extra earth is required to be added, the earthen shoulder shall be stripped and loosened to receive fresh soil. The deficiency of thickness shall be made up in layers of loose thickness not exceeding 250 mm. Water shall be added, if required, to attain the optimum moisture content and the layer compacted by 80 to 200 kN smooth wheel roller, vibratory roller, hand roller, plate vibrator or hand rammer to obtain at least 90% maximum dry density in accordance with IS: 2720 (Part 8). The finished surface shall have the specified cross slope and line in accordance with the drawing. The side shall be trimmed to the required slope with the help of grader or manual methods using hand tools.

Wherever the earth is required to be excavated from the shoulder, this shall be done either using equipment like grader or by manual means using hand tools. The resulting surface shall be uniform and have a field density of at least 90% maximum dry density obtained in accordance with IS:2720 (Part 8). If the surface is not uniformly compacted, it shall be excavated to a depth of 150 mm and the soil mixed with water if required and compacted at moisture content close to the optimum to achieve 90% of maximum density as stated above.

13.4.11 Wireless Communication System

- a) Maintaining of a wireless communication system to ensure reliable and easy communication within to and from desalination plant at Perur, Chennai.
- b) Replacement of batteries, faulty sets and all other non-functional equipment to ensure trouble free communication.

13.4.12 Operations and Maintenance Manual

The Operation and Maintenance manual shall establish guidelines for successful desalination plant systems operation by the plant operator. The guidelines shall also provide basic idea on how to operate the desalination plant and its pipe line so as to manage to steady water supply and the best water quality; less consumption of energy; less cost of maintenance expenses; a long life of equipment; protection against accidents and damage of system. The operators have to be well conversant with the manual and the guidelines stipulated therein.

In practice, the system operation and unit operation of each component needs to be continuously adjusted and modified depending on water demand and raw water quality.

The comprehensive manual shall be submitted before the commencement of operation and maintenance period, as specified for review and approval by the Engineer. It shall be periodically updated to incorporate the “best practices” experience gained while carrying out the Operation and Maintenance activities, broadly on the principles listed in Table below.

Table 13-8: Operation and Maintenance Manual

Items	Description
1. General	<ul style="list-style-type: none"> 1) plan and design condition 2) quality & quantity of raw water 3) quality & quantity of product water 4) planned desalination capacity 5) design pressure(pipe line) 6) component of the system (item, specification, quantity, remark) 7) detail of facilities (name of facility, units, no. structure, capacity, remarks) 8) detail of mechanical & electrical (name, specification, s. no./tag no., quantity, remarks) 9) detail of pipe line route (flow diagram including valves/gates s. no. /tag no. , specification, quantity, remarks)
2. System operation (Mech./Elec./ Inst)	<ul style="list-style-type: none"> 1) system drawings (plan view of desalination plant, hydraulic profile, flow diagram, single line diagram, electrical operation/control flow diagram, location /depth of water level sensor, flow control sensor system, others) 2) outline of main facility 3) concept of operation 4) concept of selection of facility 5) operation procedure (photograph with explanation) including operation of RO system. 6) preparation before start operation 7) starting of system operation 8) during regular operation 9) emergency operation 10) Intake pipe pigging for cleaning 11) CIP and flushing of RO skids 12) back washing of sand filter system (when back wash timing schedule, back wash condition, restoring, stopping of filter for long time) 13) sludge handling system (sludge withdrawing, dewatering, chemical feeding, cleaning)

Items	Description
3. Component detail & full operation (Mech./Elec./Inst)	<ul style="list-style-type: none"> 1) outline of all components 2) concept of selection of component 3) concept of auto-manual operation 4) preparation before start of operation 5) starting of operation 6) during regular operation 7) emergency operation
4. Equipment details (Mech./Elec.)	<ul style="list-style-type: none"> 1) outline of all equipment 2) specification, dimensional drawings, performance curve, dimension of water level sensor 3) concept of selection of facility 4) preparation before start of operation 5) starting of system operation 6) during regular system operation 7) emergency system operation
5. Quality of water	<ul style="list-style-type: none"> 1) water quality standards with the authorized certificates of water analysis
6. Maintenance work summary	<ul style="list-style-type: none"> 1) inspection (system, facility, unit operation, others) 2) maintenance (system, facility, unit operation, others) 3) replace/repair(system, facility, unit operation, others) 4) modification(system, facility, unit operation, others) 5) troubleshooting(photograph with explanation)
7. List of data sheet/chart(for daily &/or periodic report)	<ul style="list-style-type: none"> 1) operational schedule (including sludge control valves, filter backwash, slope plates cleaning, jar test, water analysis, sludge disposal, staffing/shift etc.) 2) operational chart (description/number of workers/ allocation) 3) calculation method of dosing of coagulant/chlorination dosage 4) instruction manual for equipment 5) record of pump operation (pressure, q, time, rotation, noise) 6) record of water quality 7) record of water quantity control 8) record of facility control (including filter backwash, sludge control valves)

Items	Description
	9) record of equipment control (including generators, sludge collectors) 10) record of chemical inventory(coagulant/hypochlorite) 11) record of sludge control (including dewatering, sludge handling, hopper) 12) record of material control 13) list of analytical instrumentation & reagent 14) list of accessory/spare parts 15) list of manufacture/supplier 16) list of contractor/subcontractors 17) emergency control (accident/water contamination etc.) 18) list of key control
8. Safety & Health	1) acidification 2) coagulant 3) chlorination 4) electricity 5) fall protection 6) entering inside tank (lack of oxygen/being filled with gas poisoning) 7) health checkup (staff member/workers) 8) general personnel's cleaning 9) uniform 10) site cleaning 11) security control

- a) Updating any changes in the procedures set out in the Operation and Maintenance manual, as deemed necessary based on any limitations observed during the maintenance period, including incorporating additional procedures for maintenance of other repairs/break downs not incorporated in the maintenance manual but faced during Operation and Maintenance period.
- b) Procedures for repair of leaks/burst in different types of pipes must be provided, with supporting drawings. The Operation and Maintenance manual must be updated if any difference is observed during Operation and Maintenance period.
- c) Frequency of spares used in maintenance of valves (air-valve, sluice valves and butterfly valves), expansion joints, equipment installed for surge protection and protection against corrosion must be recorded for updating the contents of the manual.
- d) Records of troubleshooting points and details of events causing trouble (breakdowns) during maintenance of mixing and distribution chamber, flocculators, clarifiers, filters,

RO system, limestone filters, CO₂ storage and dosing system, product water tanks, clear water reservoir and distribution pumps, sludge thickener and pump houses for thickened sludge feed, thickened sludge transfer and belt filter press wash water unit and any other parts of the plant must be maintained and used for updating the contents of the manual.

- e) Records of troubleshooting points and details of events causing troubles (break downs) during maintenance of pumps/motors/measuring equipment(s)/electric panel and accessories there in must be maintained and used for updating the contents of the manual.
- f) Records of trouble shooting points and details of events causing trouble (breakdowns) during maintenance of sub-station, must be maintained and used for updating the contents of manual.
- g) Records of Inventory used must be maintained and the relevant portion of Operation and Maintenance manual must be updated to list out the inventory requirements for maintaining the system for 240 months.
- h) Records of the raw water quality, as monitored during very day of the Operation and Maintenance period, must be maintained and handed over after the expiry of Contract period. The chemical requirement in the worst conditions of operation must be identified and incorporated in the manual. Record keeping must be sufficient so as to assist in forming a relationship between the chemical dosages required for treatment with respect to the raw water input quality.
- i) The provisions in the manual must incorporate every aspect of good industrial practices even if not elaborated here or in other parts of the bid document. The provisions in the approved operation and maintenance document shall be valid and binding for both the parties during operation and maintenance along with the additions and deletions made.
- j) The manual so prepared must be updated after the end of every year of operation and maintenance, giving effect to the experience gained and the observations made by the Employer during the maintenance period.
- k) At the time of handing over after completion of Operation and Maintenance period, all the equipment, including standby equipment, must be in good working order.

13.4.13 Quality of Product Water

Water will be provided within the permissible chemical and bacteriological parameters and, in general, there should be no lapse in it. The product water will be checked for important parameters at the critical points as mentioned in the Part-2, Chapter-3 and Chapter 10 instrumentation and control documents. The product water must meet the quality and quantity as specified in bid documents Part-2 Chapter 1 Project requirements (Table 1 & 2). In case the permissible parameters are not achieved, the liquidated damage shall be applied as per the particular conditions of the contract Part-3 Clause 22 Functional Guarantees.

13.4.14 Facilities to Contractor

The Contractor will be permitted to use the premises developed under the Contract for use by his staff during the operation and maintenance period to the extent agreed and approved by the Engineer.

13.4.15 Format

The Contractor has to prepare a Report (Daily/ Monthly) regarding the Works performance, operations and maintenance. The report should include data pertaining to performance compliance with Applicable Permit requirements, Performance Standards, Potable water and Raw Seawater, and any other information stipulated in this O&M section. The Monthly Report shall also include a description of operating parameters, maintenance activities, trouble shootings and emergency services performed. Apart from these, the report shall include minimum the following:

- a) Monthly average Potable water quantity delivered to each of the points of delivery of potable water and potable water (MLD).
- b) Monthly Average Source water quantity (MLD)
- c) Compilations of the daily flow records with respect to quantities of source water treated and Potable water delivered to the distribution system.
- d) A summary of all tests performed, and reports prepared during the month with respect to source seawater quality characteristics and parameters specified in this Schedule.
- e) A summary of all tests performed, and reports prepared during the month with respect to Potable water quality characteristics and parameters as specified in Attachment 3.
- f) A projection of the Potable water capacity for both process water and for source seawater of the Works for the current month.
- g) A description of recommended Works or unit shutdowns for maintenance and repairs during the current month and anticipated during the following month.
- h) Description of unscheduled repairs.
- i) A list of significant preventive maintenance activities performed on major pieces of equipment and Works during this month and similar activities anticipated for the following month.
- j) Any anticipated adverse condition that may affect the ability of the Works to receive and treat source water and deliver Potable water to the points of connection to the water distribution system.
- k) The results of any inspections conducted by governmental regulatory authorities during the current month, including recommended follow-up actions by the Bidder.
- l) The quantities (units) of electricity used during such month.

- m) Information on any utility (power, water or other) outages that have occurred during the current month that have an impact on the ability of the Bidder to perform its obligations under this agreement.
- n) A description of all incidents wherein the Potable water quality standards and / or quantity standards were not met, including the follow-up actions recommended by the Bidder to taken to eliminate or reduce the likelihood of re-occurrence.
- o) A description of any incidents (hazardous materials emergencies, security breaches, etc.) that adversely impacted Works operations and Bidder ability to fulfil its obligations under this agreement.
- p) Summary of Bidder worker claims filed, third party claims filed, and updates on the status of existing claims.
- q) Semi-annually, an update of the spare parts inventory.
- r) CMMS report on Scheduled / completed maintenance report
- s) Any other data or information as mutually agreed by the Parties.

Suggested formats to be followed for proper recording of pumping and plant operations are given below. The format can be finalized during execution stage with the consent of the Engineer. The format is an example for format only as it does not include complete parameters.

Format 1**Daily Report on Operation and Maintenance**

Prepared by: [Name of Contractor] Report For: [Date]

A. Consumption Records						
Sr. No.	Item Consumed	Meter Reading or other records		Daily Quantity	Average per m ³ of raw water	Remarks
		At 6:00 hrs of reporting day	At 6:00 hrs of previous day			
A.1	Raw seawater quantity received at plant inlet (comm Reading - ML)					
A.2	Coagulant					
A.3	Liquid Polymer					
A.4	Sodium Hypochlorite					
A.5	Electrical Power					
A.6	Product Water quantity produced at plant outlet (comm Reading - ML)					
B. Quality Records						
Raw Water						
		6:00 hrs	12:00 hrs	18:00 hrs	24:00 hrs	Average
B.1	Turbidity					
B.2	Temperature					
B.3	pH					
B.4	Residual Chlorine					
B.5	Conductivity					
		Daily Once at 12. 00 hrs				
B.6	Colour					
B.7	TSS					
B.8	Alkalinity					
		Weekly Once at 12. 00 hrs				
B.9	BOD					
B.10	COD					
B.11	TOC					

B.12	Ammonia						
B.13	NO ₃						
Seawater after RO Feed Tank							
		6:00 hrs	12:00 hrs	18:00 hrs	24:00 hrs	Average	Remarks
B.14	Turbidity						
B.15	Temperature						
B.16	pH						
B.17	Residual Chlorine						
B.18	ORP						
		Daily Once at 12. 00 hrs					
B.19	SDI						
B.20	TOC						
Product Water							
		6:00 hrs	12:00 hrs	18:00 hrs	24:00 hrs	Ave.	
B.21	Res. Chlorine						
B.22	Turbidity						
B.23	pH						
B.24	Conductivity						
		Daily Once at 12. 00 hrs					
B.25	Colour						
B.26	TSS						
B.27	Boron						
		Weekly Once at 12. 00 hrs					
B.28	BOD						
B.29	NO ₃						
B.30	Ammonia						
B.31	Hardness						
C. Operational Downtime							
Sr. No.	Unit	From hrs.	To hrs.	Total time	Remarks		
C.1	Unit (identify)						

Signed by: _____

Designation:

On behalf of Contractor: _____

Format 2**Monthly Report on Operation and Maintenance**

Prepared by: [Name of Contractor] Report For: [Month]

Sr. No.	Item Consumed	Reading on last date of month	Maximum Reading of month	Average Quantity per day	Remarks
A.1	Raw seawater quantity received at plant inlet				
A.2	Liquid Polymer –1				
A.3	Liquid Polymer –2				
A.4	Hypochlorite				
A.5	Electrical Power				
A.6	Product Water quantity produced at plant outlet (comm Reading – ML)				
B. Quality Records					
Particulars		Average during month	Maximum during month	Minimum during month	Remarks
Raw Water					
B.1	Turbidity				
B.2	Temperature				
B.3	pH				
B.4	Residual Chlorine				
B.5	Conductivity				
B.6	Colour				
B.7	TSS				
B.8	Alkalinity				
B.9	BOD				
B.10	COD				
B.11	TOC				
B.12	Ammonia				

B.13	NO3				
B.14	SDI				
Product Water					
B.15	Res. Chlorine				
B.16	Turbidity				
B.17	pH				
B.18	Conductivity				
B.19	Colour				
B.20	TSS				
B.21	Boron				
B.22	BOD				
B.23	NO3				
B.24	Ammonia				
B.25+ ++++	Hardness				

C. Quantity of Sludge (by storage measurement)				
	Total during month	Average daily	Average per MLD of product water	Remark
Thickener				
Thickened Sludge (%)				
Belt Filter Press Solids (%)				
D. Operational Downtime				
Sr. No.	Unit	Total time during month	Average daily	Remark
D.1				

Signed by: _____

Designation: _____

On behalf of Contractor: _____

13.5 Operation and Maintenance Practices for Instrumentation Control and Automation

13.5.1 General

A comprehensive maintenance program is critical to attaining long-term reliable performance of SCADA/DCS/ICA systems. The aid of Computerized Maintenance Management System (CMMS) shall be envisaged for the O&M. Periodic device calibration, preventive maintenance, and testing allow potential problems to be identified before they can cause failure. Prompt corrective maintenance assures reliability by minimizing downtime of redundant components. The EPC or Turnkey contractor has to enter into AMC contracts with system/equipment suppliers, as necessary. It is mandatory to enter into an agreement for minimum 5 years maintenance contract with the instrumentation, PLC and SCADA/DCS system supplier or the authorized system integrator, whosoever has executed the work for this project.

13.5.2 Preventive Maintenance

The SCADA/DCS system shall be included in the preventive maintenance (PM) program for the facility. The table below provides a list of recommended maintenance activities and frequencies for SCADA systems and their components. Preventive maintenance schedules for SCADA components and subsystems should be coordinated with those for the mechanical/electrical systems they serve to minimize overall scheduled down time.

Table 13-9: List of Recommended Maintenance for SCADA System

Activity	Frequency
Pneumatic Systems/Components/Instruments	
Check Regulators and Filters	Monthly
Inspect Tubing and Piping	Monthly
Actuate Pressure Switches	3 months
Calibrate Switches and Sensors	Yearly
Calibrate Pressure Gauges	Yearly
Calibrate Level Transmitters	Yearly
Calibrate Flow Transmitters	Yearly
Calibrate Pressure Transmitters	Yearly
Calibrate Thermometers/Temperature transmitters	Yearly
Calibrate Analytical Instruments/Online Instruments (pH, Turbidity Residual chlorine, etc.)	6 Months
Change Sampling solution of Analytical Instruments	As required
Electronic Systems	

Activity	Frequency
Lamp Test/Verify Indicators	Monthly
Inspect Enclosures for Dirt, Water, Heat	Monthly
Run PLC Diagnostics	3 Months
Calibrate Sensors and Transmitters	Yearly
Calibrate Meters	Yearly
PLC Communication Modules	Monthly
PLC Batteries	Yearly
Test Automatic control Sequences	Monthly
Verify Alarms	Weekly
Software Maintenance and Patching	3months
Anti-virus Definition Updates	Monthly
Inspect Wire, Cable and Connections	Monthly
Inter site Communication Network	Weekly
Dead Bus Relays	3 Months
UPS setting with SCADA	Weekly
PLC Redundant Power back up	Monthly
SCADA Redundancy	Monthly
Network Redundancy	Weekly
PLC Hot-Standby	Monthly
Historian Package(Capacity)	Monthly
Data Archiving	Monthly
System Upgrade	When available

Many components of DCS/SCADA systems, such as dead-bus relays, are not required to function under normal system operating modes. For this reason, the system should be tested periodically under actual or simulated contingency conditions. These tests should approach as closely as possible the actual off-normal conditions in which the system must operate. For example, DCS/SCADA for Dual Redundant system should be tested by interrupting the utility source as far upstream of the normal service as possible.

Periodic system testing procedures can duplicate or be derived from the functional performance testing procedures.

The DCS/SCADA software maintenance should include timely updates of any new versions from the supplier and testing to verify proper installation on the DCS/SCADA computer. In addition, software antivirus updates should be maintained. This should be performed any time after the computer is connected to the Internet or the antivirus patch should be downloaded as and when the updates are available. Normal operation requires that the DCS/SCADA computer not be connected to the Internet.

Faulty Instruments, sensors, transmitters, communication modules, computer hardware should be replaced with new components. Repair of the failure items would not be accepted. Instruments, modules would have to replace with a new instruments and components.

13.5.3 Concurrent Maintenance

Concurrent maintenance is defined as testing, troubleshooting, repair or replacement of a component or subsystem while redundant component(s) or subsystem(s) are serving the load. The ability to perform concurrent maintenance is critical to attaining the specified reliability/availability criteria for facilities and must be designed into the DCS/SCADA system. Where DCS/SCADA components are associated with equipment that has redundancy and therefore are not themselves redundant, their maintenance should be scheduled to occur during maintenance of the associated equipment. DCS/SCADA components and controllers that are redundant must be capable of being taken out of service, repaired or replaced and tested without interfering with the operation of the redundant component.

13.5.4 Reliability Centred Maintenance

Reliability-Centred Maintenance (RCM) is an approach for developing an effective and efficient maintenance program based on the reliability characteristics of the constituent parts and subsystems, economics, and safety. RCM provides a logical, structured framework for determining the optimum mix of applicable and effective maintenance activities needed to sustain the operational reliability of systems and equipment while ensuring their safe and economical operation and support. This shall be aided by the use of the Computerized Maintenance Management System.

A significant byproduct of the application of DCS/SCADA systems to the control of facilities is the large amount of operational data made available through the trending and data storage features of the DCS/SCADA. This operational data can be used for automated performance monitoring of mechanical and electrical systems that can support an RCM approach.

13.5.5 Operation and Maintenance Documentation

The contractor should perform an Operation and Maintenance analysis to determine the Operation and Maintenance data required to support maintenance of the ICA/DCS/SCADA system. This analysis should be coordinated with CMWSSB to determine maintenance parameters and Operation and Maintenance data that are available. Typical Operation and Maintenance data requirements include the following items:

- System documentation as defined in FDS, FAT & SAT documents

- Minimum spare parts list.
- Recommended spare parts list.
- Recommended onsite test equipment.
- Recommended Operation and Maintenance training.
- Recommended Operation and Maintenance to be performed by the Contractor.

13.5.6 Spare Parts Stocking

An adequate on-site stock of spare parts is essential to obtaining high availability of ICA/DCS/SCADA systems. All spare parts used for the equipment in the maintenance of the system must be from the manufacturer of the equipment or, if the equipment itself has been made with parts from other manufacturers, the parts must be of the same make as used in the equipment supplied and installed.

All spare parts shall be packed for long storage under the climatic conditions prevailing at the Site. Each spare part shall be labelled on the outside of its packing with its description, number and purpose and, if more than one spare is packed in a single case, a general description of the case contents shall be shown on the outside and a packing list enclosed.

- a) Minimum recommended stocking levels include the following. These quantities may need to be increased for components which are used in large numbers in the facility:
 - Manufacturer's recommended spare parts list.
 - One each of all line replaceable boards or modules.
 - Six each power and control fuses used in the system.
 - Tools required to terminate coaxial or fibre optic cables.
- b) Automation:
 - Laptop computer loaded with software required to access controllers. Licenses for all software installed on the system.
 - Permission to modify program code.
 - Spare cables for connecting computer to controllers.
 - PLC CPU, Power supply module, 1 DI, DO, AI, AO modules, Communication module, protocol converter, etc. .
 - PLC batteries, fuses, etc.

13.5.7 Utilities & Consumables

The Contractor shall provide consumables for printers e.g: Ink cartridges (colour & B/W), A4, A3, A1 size of paper, dot-matrix print paper for the complete operation and maintenance period. Downtime of the above system should not exceed more than 2 hours.

13.5.8 Technical Support

The Contractor should specify functional areas of the operating system and/or equipment where a Technical representative will be furnished by the manufacturer for training, test, checkout, validation, or pre-operational exercises.

Ongoing operation and maintenance of DCS/SCADA system software may require technical support from the system vendor or from agency technical personnel not located at the facility. Commercial DCS/SCADA software typically has provisions for remote modem access that permit this type of support from the vendor's location or an agency central engineering group.

Such remote access provisions represent a vulnerability to "hacking" and must be used with great caution. They should be monitored when in use and physically disconnected when not in use. Password protection policies for all DCS/SCADA systems, including PLC's, shall be in compliance with Established policies and to be agreed with the Employer's representative.

These policies require that the default password that came from the control supplier be changed when placed into operation at the facility.

CHAPTER - 14

14. HAND OVER

14.1 General

This section applies to procedures for transferring the 400 MLD desalination plant at Perur, Chennai after 20 years of operation and maintenance by the Contractor to the Employer. The specifications of the Plant is the complete plant including seawater pre-treatment, RO desalination and post-treatment processes with sludge treatment facilities, the instrumentation and control system, the communication system, 230kV/110kV/11kV/433V substations, DCS systems, all ancillary buildings and campus area. The procedure for Hand Over shall be processed only after the final examination by the Engineer. A Contract Completion Certificate shall be issued after the submission of all the approved completion documents before the Contract deadline and the successful final examination.

14.2 Duties and Responsibilities

All costs for the examination/test/training, and preparation of any documents shall be the Contractor's responsibility.

14.2.1 Official Certificate

All units and equipment shall be tested and verified for their satisfactory performance and test certificates shall be issued by the testing team/agency. A number of units/equipment as essential shall be tested by an outside authorised agency. All test certificates will be issued by the authorized organization by the qualified personnel with his signature.

14.2.2 Conduct First Training

The Contractor shall provide first the training program to Perur plant staff member for six months before conducting joint inspection. The typical training program is as follows:

- Basic process engineering
- Study of Operation and Maintenance manual
- Operation skill/technology (mechanical and electrical) including normal and emergency operation
- Maintenance and repair skill/technology (mechanical and electrical)
- Water analysis
- Record keeping and maintenance of records
- SCADA/DCS systems
- Safety & Health
- Visits to existing water treatment plants
- Evaluation of the program (examination)
- Others requested by the Engineer.

14.2.3 Joint Inspection

To verify the plant condition and its performance before the completion of 20 years of operation and maintenance, joint inspection will be carried out using updated Operation and Maintenance manual. Not less than two years prior to the expiry date of the O&M period, a joint inspection of the Works shall be conducted. Within 28 days of the completion of the joint inspection, the Contractor shall submit a report on the condition of the Works identifying maintenance works, replacements and other works required to be carried out to satisfy the requirements of the O&M plan after the Contract Completion Date.

The Contractor shall submit a programme for carrying out such works over the remainder of the O&M period.

The typical inspection items are shown in the table below.

Table 14-1: Typical Items to be examined at the end of the Operation Service Period

Item	Description
1. Appearance test /Visual examination (Damage/crack, differential settlement, soil settlement, peel off paint, missing/lost, leakage of water/solution/gas, corrosion, decolonization, condition of maintenance, others)	<ul style="list-style-type: none"> • All civil structures, building including interior/exterior, fence/gate, stairs, others • All mechanical & electrical equipment/accessories, others • All pipe line valves and gates, others • All instrumentation and control equipment, others • All water quality analysers, others
2. Performance examination (Selection of operation mode, selection of facilities, flow/water level, overflow, leakage of water/solution/gas, heating, vibration/noise level, speed of rotation, smoothness, gap/spaces, accuracy, setting value, condition of maintenance, others)	<ul style="list-style-type: none"> • Check the sequence, or manual operation including water level sensors/protections, others • Check the specification of all processes facilities, others • Check the specification of all mechanical equipment including pressure gauges, pressure relief valves, others • Check the specification of all electrical equipment, others • Check the specification of all pipe line including valves, gates, others • Check the specification of all accrual condition after troubleshooting, others • Check performance (flow, pressure, noise, vibration, other conditions etc.) of all equipment and units.

Item	Description
3. Verification of rectified works (System, leakage, crack, damage, soil settlement, corrosion, others)	<ul style="list-style-type: none"> • Checklist of all defect items, history, tendency, repeating, others • Checklist of all miss operation and maintenance items, others • Check all factors of defect/miss operation, others • Verification of action on the take measures, others • Verification of all rectified works with the reports and photo, others • Check emergency works and its factor, action plan, others • Check actual condition after rectified works, others
4. Operation skill (Staff member, others)	<ul style="list-style-type: none"> • Review of daily report and a summary report on Operation and Maintenance activities • Check time and motion of staff member, others • Interview operator regarding troubleshooting, others • Paper test (basic knowledge, calculation of chemical dosing, safety, others) • Field test (using/put on the safety gear, drill of chlorine leakage accident, others)
5. Water analysis (Sampling and analysis, others)	<ul style="list-style-type: none"> • Location of sampling and time, and date • Raw water and treated water • Process wise • Authorized certificate
6. Spare parts and others	<ul style="list-style-type: none"> • Check inventory list (parts, chemical, reagent, others) • Check the quantity of inventory, others • Check maintenance tools and equipment, vehicles, others

14.2.4 Tests Prior to Contract Completion

Upon satisfactory completion of the items identified above, the Contractor shall submit the program and procedures for the tests prior or the contract completion. After the review of the submission and revision of the program as needed, the Employer's representative shall instruct the Contractor to commence the Tests Prior to Contract Completion.

14.2.5 Submission of Completion Documents

The Contractor shall submit the completion documents after passing the final examination before the Contract deadline. The typical report consists of relevant documents for the request for issue the Contract Completion Certificate of 20 years Operation and Maintenance period. Typical completion documents are shown in the table below. These data shall be provided in soft and hard copies in proper professional format as approved by the Employer's Representative..

Table 14-2: Typical Completion Documents to be Handed Over at the End of the Operation and Maintenance Period

Contents	Description
1. Outline	<p>Outline</p> <ul style="list-style-type: none"> • Summary of the project, scope of work, location of the project, main component with the specification, others
<p>2. Completion Photographs (At acceptance complete inspection, completion inspection and final inspection)</p>	<p>Photographs with a short description</p> <ul style="list-style-type: none"> • Civil (structural, buildings, others) • Mechanical and Electrical (equipment, facility, others) • Piping works
<p>3. Inspection summary (At acceptance complete inspection, completion inspection and final inspection)</p>	<p>Appearance test/visual/performance examination</p> <ul style="list-style-type: none"> • Table of summary of daily and monthly test activities • List of type of test, date, inspector, evaluation, comments • Civil (name of the structure, drawing No., drawings, design dimension, previous dimension, actual dimension, photograph with short description others) • Mechanical (name of facility and equipment, Tag. No., quantity, others) • Electrical and ICA (name of facility and equipment, Tag. No., quantity, others)
4. Main inspection data during construction	<p>Summary of data with graphic /chart</p> <ul style="list-style-type: none"> • Civil (plate load bearing test, compressive strength test, water retaining test, compaction field test, road restoration works, road construction works, hydrostatic test, others) • Mechanical (disinfection test, control of filter and filter media quality others) • Electrical (earthing resistance test, others)

Contents	Description
5. Inspection record (At acceptance complete inspection, completion inspection and final inspection)	<ul style="list-style-type: none"> • Appearance test /visual/ performance examination • Performance examination • Verification of rectified works (refer to Table 15.1) • Civil • Mechanical • Electrical and ICA
6. Training and commissioning record (At first and second training program)	<ul style="list-style-type: none"> • Summary (schedule of training and commissioning, attendance rate, impression on training program) • Training attendance list (participants, trainings date, others) • Commissioning daily record (water flow rate of designed and actual, tested water flow, name of the operated facility, list of measurement and its time and reading value, raw and treated water quality, value of V/Am/kW of each equipment, others) • Photographs with a short description
7. Water quality certification data (At acceptance complete inspection, completion inspection and a final inspection)	<ul style="list-style-type: none"> • Location of sampling and time, and date • Raw water and treated water • Each process (Refer to Section 14.5, Table 14.3) • Issued from Authorized certificate
8. Operation/maintenance manual (Civil, mechanical, electrical, ICA)	<p>Update</p> <ul style="list-style-type: none"> • Refer to Section 14.5.12
9. Spare parts list	<ul style="list-style-type: none"> • Mechanical (name of parts, Tag. No., quantity, location of stock, others) • Electrical (name of parts, Tag. No., quantity, location of stock others) • Pipe & fittings (name of parts, Tag. No., quantity, location of stock others) • Valve & gates (name of parts, Tag. No., quantity, location of stock others) • Others (name of parts, Tag. No., quantity, location of stock others)
10. Key list with boxes	<ul style="list-style-type: none"> • Name of key, location, Tag. No., quantity

Contents	Description
11. Manufacture produced catalogue (Civil, mechanical, electrical, ICA)	<ul style="list-style-type: none"> • Civil (all related material: sand filter media, bar, round bar, cement, cement paste, asphalt, chemical admixture, water reducing agent, pozzolan, vibrator, water-tightness sheet, construction equipment, manhole, fence-gate, pipe, water-resistant coating, paint, coating agent, windows, door, lock & key, others) • Mechanical (all related equipment; pumps, fine screens, manual screen, mixer, blower, control valve, sludge collectors, dewatering, conveyor, hopper, tanks, chorine dosing equipment, coagulant dosing equipment, safety equipment, pipe, valve, gate , pressure gauge, safety valves, flow meter, coating painting, others) • Electrical (all related equipment: electric wire, electric conduit, manhole , motor, control panel, relay, transformer, heater, generator and silencer, timer, breaker, light/lamp, switch, street light, earthing, measurement equipment, air condition, communication equipment, electric pole, coating painting, ventilation fan, air duct, others) • ICA (All instruments, DCS etc.) • Safety equipment • Others
12. Instruction manual (Civil, mechanical, electrical & ICA)	See above
13. Factory inspection record or quality assurance (Civil, mechanical, electrical & ICA)	<ul style="list-style-type: none"> • Civil (all related material: sand filter media, bar, round bar, cement, aggregate, sand, gravel, asphalt, crushed stone, chemical admixture, water reducing agent, pozzolan, water-tightness sheet, construction equipment, manhole, pipe, water-resistant coating, paint, windows, door, others) • Mechanical (all related equipment; pumps, fine screens, manual screen, mixer, blower, control valve, sludge collectors, dewatering, conveyor, hopper, tanks, chorine dosing, safety equipment, pipe, valve, gate, pressure gauge, safety valves, flow meter, coating painting, others)

Contents	Description
	<ul style="list-style-type: none"> • Electrical (all related equipment: electric wire, electric conduit, manhole, motor, control panel, relay, transformer, heater, generator and silencer, timer, breaker, light/lamp, switch, street light, earthing, measurement equipment, air condition, communication equipment, electric pole, coating painting, ventilation fan, air duct, others) • ICA (All instruments, DCS etc.) • Safety equipment • Others
14. Photograph (during Construction, at joint completion inspection, at defect liability) (Civil, mechanical, electrical & ICA)	History of construction Replacement of defect liability <ul style="list-style-type: none"> • Civil: construction site before starting construction, earthwork, the arrangement of the bar, rust, cleaning before placing, formwork, concrete mixing work, placing, violator, curing, remove of formwork, backfill, compaction, all field inspection and lab test, others • Mechanical: inspection at factory, receiving inspection, completion inspection, all field inspection and lab test, others • Electrical: inspection at factory, receiving inspection, completion inspection, all field inspection and lab test, others • ICA (All instruments, DCS etc)
15. Production samples (Civil, mechanical, electrical & ICA)	All samples for technical approve <ul style="list-style-type: none"> • Attach Tag. No., and its name, approved sign of the Engineer.
16. Report	<ul style="list-style-type: none"> • Monthly and annual report • Others

14.3 Specifications

The specification of materials used for repairs shall be the same as that have been used in the original DB Works. The Engineer should approve specifications for any materials that were not employed during construction before repair work prior to the Hand Over. In spite of being restricted by this clause, in an emergency the Contractor may use an appropriate material for repairs even if the Engineer has not approved material required for such repairs. However, subsequent to the use of such material, the Contractor shall submit proposals for the approval of specifications of such materials at the earliest within two-week time duration.

14.4 Check List of Contractor's Responsibility

14.4.1 General

Within the framework of the Contractor's responsibilities, the Contractor shall carry out the following activities. However, these shall not limit the requirement for other activities that otherwise are required as per terms and conditions of the Contract or to fulfil the Contractor's responsibilities or are essential as per the good industry practices. The Contractor shall hand over the components of Works in good working condition for, but not limited to the following items:

- a) All process units in good working condition with replaced wear and tear parts to the satisfaction of the Engineer. All MS equipment and structures shall be buffed, cleaned and painted with the appropriate paint and specified specifications.
- b) All civil works intact without any evidence of crack, peeling of plaster or surface finish. All civil building shall be painted with the appropriate paint and of the specified specifications.
- c) All electrical equipment such as 230kV/110kV/11kV/415V transformers, GIS, LT switchgear/MCCs, control stations, cables, earthing, AMF Panel, battery, etc. at the water treatment plant, etc. (all works constructed under this Contract) in neat and clean condition.
- d) All consumables required for the functioning of the plant with the inventory of materials.
- e) AMC contracts with system/equipment suppliers, as necessary for PLC and SCADA system supplier or the authorized system integrator as executed the work for this project.
- f) Lighting fixtures and the lighting system of all areas and replacement of all non-functional lighting fixtures.
- g) Records for:
 - Repair history of all mechanical, electrical and instrumentation control equipment in the water treatment plant, and communication instruments
 - Logbooks through the DCS system
 - Daily log of operations of all the important equipment such as mixing and distribution chamber, chemical feed system, flocculators, clarifiers, filters, chlorination systems, electrically actuated valves, etc., with a time tag
 - Hourly readings water production
 - Raw seawater and product water quality test results on turbidity, residual chlorine levels, etc.
 - Daily list of alarms with a time tag
 - Logbook format and the data to be included in the logbook
 - Last periodic maintenance done for all equipment/buildings of the system
- h) All available spares, special tools and test equipment and adequate inventory of required accessories or equipment for repair of electrical, mechanical, instrumentation and control system, pipe and the communication system. At the end of the Contract, the

Contractor shall hand over the full spares, machines, equipment, tools and tackles (as detailed in Part-2 for workshop, Spare Parts, Accessories and Tools") as supplied with the Contract by replacing the used/dilapidated items with fresh supplies of the same specifications.

- i) Repair of the roads, buildings and campus area utilities
- j) Drinking water supply facilities at desalination plant campus and all its units
- k) Record of stores for the electrical, mechanical and instrumentation and control equipment as well as that for the chemicals, membranes, and laboratory consumables at the plant. The records shall include but shall not be limited to:
 - Loading/unloading of materials received and issued for works;
 - Proper arrangement of material in stores to ensure its safety and easy availability;
 - Maintaining store areas in a neat and tidy condition;
 - Keeping records and accounting for the incoming materials;
 - Keeping records and accounting for the consumed materials.
- l) Structures/buildings of campus areas of the treatment plant and others built in the Contract must ensure adequate cleanliness, ventilation, illumination and structural safety. In addition to this, the general hygienic standards must be in acceptable condition and adequate plantation, horticultural activities must be well maintained to give the pleasant environment of the campus/buildings.
- m) Updated Operation and Maintenance manual as defined in specifications for operation and maintenance works.

14.4.2 Plant in Good Working Condition

The Contractor shall hand over all components of the Works in good working condition for the following, but not limited to:

- a) All the process unit facilities from intake works to clear water tank and sludge/sewage treatment facilities including mechanical, civil, electrical works and ancillary equipment and instruments such as laboratory equipment, analysers, computer system, etc. as built.
- b) DSC including all the hardware, software and all instruments, in good working condition.
- c) Entire control system and instruments as recommended by the manufacturer.
- d) Replacement of damaged controls, communication cables and power supply cables.
- e) Repair or replacement, as required, of all instruments such as flow meters, pressure transmitters, pressure gauges, level sensors/transmitters, float type level switches, on-line pH meters, on-line turbidity meters, on-line residual chlorine meters and laboratory instruments along with all other equipment.
- f) Calibration of all measuring/metering equipment or as recommended by the manufacturer. The calibration at the manufacturer's workplace shall be done only in case of major failure/ repairs of the instruments.
- g) Submission of daily and monthly customized reports produced by the local

SCADA/DCS system in hard copy and soft copy.

- h) Provision of all required consumables for printing.
- i) Repair of damaged moving parts, steel structures, and the reinforced concrete structures. Repairs, cleaning and disinfection shall be done.
- j) Repair or replacement of all leaking or malfunctioning ERDs and associated items.
- k) Lubrication of all gears of reduction motors, motorized valves, gates and other parts of the system.
- l) Check all valves and gates for their manual and electric operation. Operation of valves must be checked from the local control console, switchgear and through the PLC system. Any defect observed must be made good.
- m) Ensuring environmentally friendly disposal of sludge at the approved site(s), within a radius of 20-60 kilometers from the water treatment plant.
- n) Make good all circuits and buildings all electrical, mechanical and instrumentation equipment, substation equipment, lighting, DG Set and earthing system associated with the treatment works including replacement, if any (as required).
- o) Painting of the exposed mild steel components of pipeline, ladders, railings etc. in the filter must be in good shape.
- p) Make good surrounding areas of the filter plant free from shrubs, weeds, grass and other unwanted vegetation.
- q) Ensure availability of safety accessories, (e.g. gloves, shoes, first aid box, etc.)
- r) Ensure availability of fire and safety equipment.
- s) The Contractor shall provide necessary chemicals such as ferric chloride, acid polyelectrolyte etc. for a stock of at least one month period.

14.4.3 Lubrication

In the Operation and Maintenance manuals, the Contractor shall furnish a complete schedule of recommended oils and other lubricants. The number of types of lubricants shall be kept to a minimum. In case of grease-lubricated bearings for electric motors, lithium-base grease is preferred.

The Contractor shall indicate the brand name of indigenously available equivalent lubricants, with their complete duty specifications, in the Operation and Maintenance manual. The Contractor shall also furnish the schedule of quantities for each fill, frequency of filling and annual requirement in the Operation and Maintenance manual. Where lubrication is affected by means of grease, preference shall be given to a pressure system which does not require frequent adjustment or recharging. Frequent, for this purpose, means more than once in a month. Where more than one type of special grease is required, a grease gun for each special type shall be used.

All lubricant systems shall be designed so as not to cause a fire or pollution hazard. The Contractor shall supply flushing oil for such a lubrication system when an item of plant is ready for preliminary running.

14.4.4 Spare Parts

All spare parts used for equipment in the maintenance of the system must be from the manufacturer of the equipment or, if the equipment itself has been made with parts from other manufacturers, the parts must be of the same make as used in the equipment supplied and installed.

Any balance available spare parts may be handed over to CMWSSB.

All spare parts shall be packed for long storage under the climatic conditions prevailing at the Site. Each spare part shall be labelled on the outside of its packing with its description, number and purpose and, if more than one spare is packed in a single case, a general description of the case contents shall be shown on the outside and a packing list enclosed.

14.4.5 Electrical System

The Contractor shall hand over the following at the end of the Operation and Maintenance period:

- a) Revised As built drawings based on all modifications during the Operation and Maintenance period. All electrical drawings like Single Line Diagrams, Control Circuits Equipment Layout, Cable Layout, and Cable Schedules, Earthing Layouts shall be maintained and shall be handed over.
- b) Details of protective relay settings and time relay settings, including any changes done during the Operation and Maintenance period, details of oil changes/filtration of transformers, records of any changes made in the system during the Operation and Maintenance period, etc. shall be maintained.
- c) Equipment wise maintenance record during Operation and Maintenance period, as per daily checking out/inspection and regular (every 6 months or 12 months).
- d) Motor wise power consumption details and over-all power consumption detail of plant. Details of IR test of all equipment like HT/LT panels, HT/LT motors, generators, transformers.
- e) Switchgears and cables, etc., shall be maintained.
- f) Logbook showing details electrical faults that have occurred in the plant and record of corrective actions taken during Operation and Maintenance period.
- g) Equipment wise technical data given by equipment supplier, documents showing Bill of Materials and Operation & Maintenance Manual (hard copy and soft copy).
- h) List of mandatory spares that are to be maintained at stores and their actual availability in the plant, if it is below, the same shall be replenished.
- i) Details of measurement of earth resistance, earth pit wise and overall values during the Operation and Maintenance period.
- j) Details of illumination levels during the Operation and Maintenance period along with details of changes, if any, effected during the Operation and Maintenance period.

14.4.6 Electrical Checks to be Done During Hand Over

- a) Contractor to provide a test schedule & format to be approved by Engineer before commencing any test.
- b) Checking of all electrical equipment, items etc., as per bill of materials. visual checking and tracing out the circuit based on revised as-built drawings.
- c) Visual operational checks of all equipment & protections have to be done.
- d) If transformer oil samples are not tested in the last 6 months, the same shall be done during Hand Over.
- e) Earth resistance of individual, combined pits for substations shall be checked during Hand Over.

14.4.7 Instrumentation, Control and Automation System

The Contractor shall hand over the following documents/drawings/manuals/programs at the end of the Operation and Maintenance period:

- a) Revised As built drawings approved by the Employer's Representative based on all modifications during the Operation and Maintenance period. All ICA Drawings like P&ID, system configuration diagram (PLC & DCS architecture), instrument installation drawings, instrument cable schedule, and cable layouts shall be maintained and shall be handed over.
- b) Handing over document/manuals shall include a minimum five sets of soft copies and five sets of hard copies. The hard copies shall be spiral bounded clearly indicating the version/revision submitted. All the contents shall be indexed. The contents of handing over document/manual shall be clearly legible and shall include the original manufacturer's literature on a minimum, and in-corporate any changes as per site conditions. Suitable Asset Management software tool may be adopted by the contractor for the purpose.
- c) Detailed drawing and manual of the DCS installed. Manual shall include the PLC series installed along with complete details on I/O modules, Ethernet switch, relay modules, and converters (if any).
- d) A complete manual shall be provided which shall include operating instructions and troubleshooting techniques of the DCS and accessories installed illustrated with examples. This shall be provided along with the standard manufacturer's literature.
- e) A complete manual shall be provided, which shall include operating instructions and troubleshooting techniques of the DCS and accessories installed, illustrated with examples. This shall be provided along with the standard manufacturer's literature.
- f) A complete manual shall be provided, which shall include operating instructions and troubleshooting techniques of the ODMS installed illustrated with examples. This shall be provided along with the standard manufacturer's literature.
- g) A complete manual shall be provided, which shall include operating instructions and troubleshooting techniques of the interface control panel, where applicable. This shall be provided along with the standard manufacturer's literature.

- h) Interoperability testing tool/software shall be provided along with relevant manuals and operating instruction with examples.
- i) Latest PLC program back-up, DCS software back-up with license, DCS database backup, reports and alarm back-up, Historical archived data containing reports and alarms, and ODMS data and configuration set-up shall be provided.
- j) All software's used under ICA shall be handed over along with their original licenses.
- k) Complete list of database/addresses shall be provided clearly indicating the spare tags for DCS/SCADA and ODMS software's.
- l) List of mandatory spares that are to be maintained at stores for complete ICA package and their actual availability in the plant shall be provided.
- m) Any password's set to access the internal PLC program; an interface control panel shall be provided and demonstrated.
- n) All passwords (PLC, Interface control panel & DCS and other software/hardware) shall be provided in a sealed envelope and addressed to the Engineer.
- o) DCS, PLC, and ODMS package shall be updated with the latest software version/patch before handing over. The same shall be demonstrated to the Engineer.
- p) Latest licensed version of Windows operating system along with MS Office or equivalent software which is prevailing at that point in time shall be installed on SCADA machines and other machines installed and integrated with the SCADA and ODMS package. The same shall be demonstrated to the Engineer.
- q) The Contractor shall conduct a training session for the Employer's personnel which shall include PLC/DSC configuration, troubleshooting techniques, SCADA configuration and troubleshooting techniques, ODMS configuration and troubleshooting techniques, diagnostic techniques and troubleshooting techniques for wireless technology employed for communication.
- r) The training session shall be conducted for the duration indicated elsewhere in the specification documents.
- s) Manufacturer's literature/manuals for flow meters, level transmitters, switches, pressure transmitters etc and analytical instruments installed.
- t) Instrument wise, DSC and ODMS maintenance record during the complete Operation and Maintenance period shall be provided.
- u) A complete and updated list of all manufacturers/system integrators/contractors of ICA with contact numbers shall be provided. The same shall also be made available on site for ready reference.
- v) The latest versions of all drawings of ICA, which shall include cable termination details, I/O mapping, database details etc., shall be provided in PDF format and editable format and loaded in the operator machine available on site. The same shall be demonstrated to the Engineer.

14.4.8 ICA Checks to be Done during Hand Over

- a) Contractor to provide a test schedule and format to be approved by the Engineer before

commencing any of the tests.

- b) Functional checking of all laboratory instruments/equipment and ICA equipment, including online analyzers, flow meters, pressure and level instruments, vibration monitoring instruments, and wireless equipment being used for communication.
- c) Loop checks will be conducted.
- d) All instrument cabling shall be inspected for continuity. If found faulty, the same shall be replaced and demonstrated.
- e) All instrumentation cable conduits shall be checked for damage. If found faulty, they shall be rectified or replaced and sealed to the satisfaction of the Engineer
- f) Visual operational checks of PLC panel, DCS system and interface control panel.
- g) Licensing feature of PLC, DCS software and hardware, ODMS software and other hardware shall be demonstrated.
- h) Functional check of set points changes at HMI and it's downloading to PLC's concerned.
- i) Hot-standby feature of PLC and hot swappable feature of I/O modules shall be demonstrated. If found to be faulty/non-operational, shall be rectified and, if required replaced to normal working condition and demonstrated to the Employer.
- j) Dual-redundant server feature of DCS shall be demonstrated. If found to be faulty/non-operational, shall be rectified and if required replaced to normal working condition and demonstrated to the Employer.
- k) Functional check of ODMS software in conjunction with DCS shall be conducted.
- l) Functional check of data received/transmitted from remote stations shall be conducted in conjunction with DCS.
- m) Historical archiving of all data shall be demonstrated.
- n) Availability of memory for the smooth operation of DCS and ODMS machines shall be demonstrated. If found to be inadequate, the same shall be rectified/archived and demonstrated.
- o) If any instruments and automation equipment are found to be faulty during the above tests, the same shall be rectified or replaced as necessary.

14.4.9 Plant Ancillary Works

- a) Make gardens and plantation in the campus area green, neat and tidy with the removal of shrubs, weeds, grass and unwanted vegetation and make pruning, trimming and cutting of old big trees from the Plant Area along with.
- b) Reinstate the roads and lighting fixtures and lighting circuits in the water treatment plant campus to its original state.
- c) Make good and working conditions for lighting fixtures and lighting circuits, water supply facilities in water treatment plant campus, offices and other residential buildings.
- d) The Contractor shall carry out ordinary repairs to buildings. The repairs shall include but not limited to the following items:

- Easing of doors and windows, monsoon repairs to roofs, attention to drains, rainwater-spouts, attention to plinth protection.
- External white or colour wash, external or internal painting, internal distempering, renewal of approach roads within the campus.
- Repairs to administrative and other buildings must be carried out during fair season after monsoon. The building shall be fully renovated as needed at the Hand-Over.

Following repairs before the onset of the preceding monsoon are essential:

- a) Any faults in the electric installation, leakages, earthing, exposed wire ends and any hazards on this account to the users/inmates of the buildings, shall be taken care of suitably, wiring, which is damaged or outlived, shall be replaced.
- b) Damaged sanitary lines shall be replaced and choked lines cleared.
- c) Proper drainage of the area around the building shall be ensured to avoid stagnation of rainwater/house effluent in order to prevent malarial conditions. Where courtyards exist in the buildings, their drainage into the outer drains shall be ensured. Any choked drains shall be cleared properly.
- d) Leaking roofs shall be attended to immediately with suitable repairs/treatment, as the case may be. The rain waterspouts shall also be cleared of blockages, etc. The roof shall be swept clean of leaves, debris, etc., if any.
- e) The plaster on the outer walls of the building, which is exposed to weather, shall be repaired before rains in order to prevent dampness inside. Where plinth protection has been provided, it shall be checked and the damaged portions, if any, shall be repaired before rains.
- f) Damaged flooring shall be repaired/replaced as per requirement, in order to prevent dampness inside the rooms, etc., during rains.
- g) Repairs of damaged floors, door/window fittings, water taps, water coolers, furniture, desert coolers, electric circuits, must be taken up on complaints using the material of the same quality as used during construction.

14.4.10 Restoration of Rain Cuts

Earthwork for the restoration of rain cuts in embankment and the shoulders shall be made using suitable material and compacting the same. The material used for the restoration of rain cuts shall be approved by Engineer and in general shall be as specified for earth work in specifications elsewhere.

14.4.11 Maintenance of Earthen Shoulder

The work of maintenance of earthen shoulder shall include making up the irregularities/loss of material on shoulder to the design level by adding fresh approved soil and compacting it with the appropriate equipment, or stripping excess soil from the shoulder surface, as required.

14.4.12 Wireless Communication System

Make good a wireless communication system to ensure reliable and easy communication to and from Desalination Plant at Perur, to CMWSSB, Chennai. Replacement of batteries, faulty sets and all other non-functional equipment to ensure trouble-free communication, if required.

14.4.13 Operation and Maintenance Manual

The comprehensive Operation and Maintenance manual (seven sets) shall be submitted at the end of the Operation and Maintenance period as specified. It shall be updated based on the Engineer's comments. These manuals shall be made available during training sessions conducted by the Contractor. A soft copy of the same shall also be submitted.

14.4.14 Quality of Product Water

Water shall be provided within the permissible chemical and bacteriological parameters. The product water quality shall be as per BIS 10500 standards.

14.4.15 Payments

The Contractor, at the time of tendering, shall ensure the completeness and adequacy of his Tender Price to fulfil the entire responsibilities as described in specifications. His Tender Price for operation and maintenance, as quoted on a yearly basis in the Schedule of Prices, shall include all costs for Hand Over.

14.4.16 Format

For proper recording of desalination plant operations, the formats are provided in Operation and Maintenance Specifications in Volume 2, Part 13. All the operation and maintenance records shall be submitted in hard and soft editable form.

14.5 Completion Certificate

Notwithstanding the foregoing, other services to be performed by the Contractor must be completed before the Contractor will be entitled to receive the Contract Completion Certificate. Pre-conditions that must be fulfilled by the Contractor before the Contract Completion Certificate will be issued have been discussed above and specifically are:

- (a) Inspection and tests of all the Works
- (b) Remedy defects found during tests and inspection;
- (c) All activities in accordance with the above Clause 14.4;
- (d) Updating Operation and Maintenance manuals providing performance records and data; and

A joint inspection shall be arranged by the Contractor to assess the condition of civil structure, mechanical and electrical equipment and instrumentation. Based on this inspection, a list of remedial repair and replacement for the components will be prepared by the Engineer. The Contractor shall carryout such remedial works at his own cost. Again, the joint inspection shall

be arranged by the Contractor for certification of completion of remedial work as well as condition of all civil work to its original appearance. The Contractor shall submit the entire required document to the Engineer / Employer's Representative for review and comments. The Contractor shall resubmit the document incorporating any comments.

The Employer shall issue a Contract Completion Certificate to the Contractor on his request within 30 days after the take-over of the plant subject to the above documents and obligation are met by the Contractor before 90 days prior to Hand Over.

CHAPTER - 15

ENVIRONMENTAL AND SOCIAL MANAGEMENT PLAN

The Bidder shall provide his Environmental and Social Management Plan (ESMP) in detail so as to demonstrate the procedures that will be used to ensure that the environmental and social concerns and requirements.

After award of contract and before the start of work, Contractor shall review the available Environmental and Social Management Plan (ESMP) for the project available below with CMWSSB. The contractor shall duly update the ESMP to ensure compliance with all applicable legislation and regulations of State/ Central Government and also with JICA Environmental and Social guidelines. The ESMP shall incorporate the requirements stipulated in the Project's EIA Report and conditions of approval from State/ Centre Regulatory agencies. The ESMP shall also clearly define roles, responsibilities, reporting requirement and budgetary allocations for implementation of mitigation measures. The revised ESMP shall be submitted by the Contractor to CMWSSB for necessary approval before initiating any groundwork.

The ESMP shall identify the potential environmental and social impacts from the various construction and operations and maintenance activities to be undertaken in the Contract and set out in detail the approach he will adopt in mitigating these impacts to ensure that the residual impacts are minor and confined to a short period.

While preparing the proposed ESMP, the Bidder shall consider but not be limited to the following:

- The Bidder shall pay attention to the methods of materials delivery, storage, usage and disposal; equipment usage; and site activities to ensure they have minimal impact on the environment, workforce and community,
- The Bidder shall propose only environmentally safe products and practices in performing his works, and
- The Bidder shall comply with all the statutes regarding environmental and social impacts.

The Bidder shall provide separate descriptions of its proposals for minimizing any adverse environmental and social impacts/ effects during the construction phase and the subsequent operations and maintenance phase.

15. ENVIRONMENTAL MANAGEMENT PLAN

15.1 Project-related activities, issues, and mitigation measures

15.1.1 Pre-Construction Stage

S No.	Project-related Issues	Mitigation Measures to be taken	Responsibilities	
			Planning and Execution	Supervision/ Monitoring
A.	Pre-Construction Stage			
A.1	Assure compliance with relevant construction field legislation	<p>All clearances required and Environmental and social aspects from other departments shall be ensured and made available before the start of work. Acquire construction permit and Provide Water management guidelines.</p> <p>The project requires Consent to Establish (CtE) under the Water and Air Act from the Tamil Nadu State Pollution Control Board.</p>	CMWSSB/ Contractor	CMWSSB
A.2	Utility Relocation	<ul style="list-style-type: none"> • Identify the common utilities that would be affected, such as telephone cables, electric cables, electric poles, water pipelines etc., • Affected utilities shall be relocated with prior approval of the concerned agencies before construction starts. • Alternate temporary arrangement for crossing over shall be provided. 	Planning - CMWSSB Execution - Contractor	CMWSSB
A.3	Supply of Material and resources	<p>Procurement of construction material only from permitted sites and licensed/ authorized quarries.</p> <p>Identify locally available resources/ materials and eco-friendly materials.</p>	Contractor	CMWSSB
A.4	Water	The Contractor will be responsible for arranging an adequate supply of water of the required quantity for the entire construction period. Groundwater extraction not permitted in the area. The contractor will minimize the wastage of water during construction.	Contractor	CMWSSB

S No.	Project-related Issues	Mitigation Measures to be taken	Responsibilities	
			Planning and Execution	Supervision/ Monitoring
A.5	Appointment of Environment Health & Safety Officer	The contractor will appoint qualified and experienced Environmental Engineer, who will dedicatedly work and ensure implementation of EMP, including Occupational health and safety issues at the camp, construction work sites.	Contractor	CMWSSB
A.6	Other Construction Vehicles, Equipment and Machinery	All vehicles, equipment and machinery to be procured for construction/ protection work will conform to the relevant Bureau of Indian Standard (BIS) norms/ CPCB standards. The discharge standards promulgated under the Environment Protection Act, 1986 and Motor Vehicles Act, 1988 will be strictly adhered to. Soundproof DG set as per regulations will be used at the project site. The contractor will maintain records of Pollution Under Control (PUC) certificates for all vehicles used during the contract period, which will be produced to the Project Implementation Unit for verification whenever required.	Contractor	CMWSSB
A.7	Risk Assessment and preparation of management plans ²	Risk and hazards associated with different construction activities shall be identified by the contractor, and accordingly, management plans shall be prepared for implementation on-site such as <ul style="list-style-type: none"> • Construction Labour Management Plan; • Traffic Management Plan; • Health and Safety Management Plan; • Construction material Management Plan; • Air pollution control Plan; 	Contractor	CMWSSB

S No.	Project-related Issues	Mitigation Measures to be taken	Responsibilities	
			Planning and Execution	Supervision/ Monitoring
		<ul style="list-style-type: none"> • Construction Waste Management Plan; • Spillage Management Plan; • Marine environment Management Plan; • Tree plantation Programme; • Environmental Monitoring Plan including marine water and sediment quality monitoring; • Emergency Response Plan; and Construction Demobilization Plan. 		
A.8	Disaster Management Plan ¹	<p>The CMWSSB shall identify the key risks associated with each component/ activities for entire project life cycle (construction, operations, & decommissioning) and shall prepare Disaster Management Plan (DMP) for the proposed plant.</p> <ul style="list-style-type: none"> • Further, the DMP for the plant should be synchronized with the district Disaster Management Plan (DMP) for off-site emergencies. • Contractor shall ensure the availability of required resources for the implementation of DMP at the site and incapacitate local communities in handling disaster and emergency response 	Contractor	CMWSSB

S No.	Project-related Issues	Mitigation Measures to be taken	Responsibilities	
			Planning and Execution	Supervision/ Monitoring
A.9	Land Acquisition/ Resettlement & Rehabilitation (R&R)	<p>R&R issue is not involved in the proposed land. However, the site has Casuarina tree plantation, which needs to be cleared.</p> <p>These trees to be cleared in accordance with the provisions given under Government order (G.O.157) dated 29.4.2016</p> <p>The plan is to be prepared for clearing the trees, i.e. cutting Schedules, coordination with the Forest Department and/ or, TN-Newsprint and Papers, Total value of the trees, Budget allocations, compensation to the landowner, auction systems and management of tree cutting for pulps, waste management, construction vehicle and equipment managements etc., for Perur DSP site.</p>	CMWSSB/ Prospective Tree cutting contractor	CMWSSB

15.1.2 Construction Stage

Sr. No.	Project Activity	Relevant Environmental components likely to be impacted	Nature of Impact	Likely Impacts and their significance in the absence of Mitigation Measures	Proposed Mitigation Measures	Responsibilities		
						Planning	Execution	Monitoring
B	Construction Phase							
B.1	Trenching for Intake and outfall pipelines	Marine water quality	Short Term, Localised, Reversible	<ul style="list-style-type: none"> - Increase in turbidity affecting the Photosynthetic process affecting the aquatic productivity. - Suspended Particles will affect the filter feeders, and adult fish will migrate from the site of impact - Change in marine water quality due to aqueous discharges (oily waste, sanitary 	Check turbidity levels with baseline levels as a reference during the entire monitoring programme Use of good engineering tools like cutter suction dredger for trenching to be used Controlled method of dredging with the latest technology which will limit the plume generation Discharge of waste into the sea will be prohibited Oil Spill control measures will be adopted Ensure slop tanks will be provided to barges/ workboats for collection of liquid/ solid waste & Marine	Contractor	Contractor	CMWSSB

Sr. No.	Project Activity	Relevant Environmental components likely to be impacted	Nature of Impact	Likely Impacts and their significance in the absence of Mitigation Measures	Proposed Mitigation Measures	Responsibilities		
						Planning	Execution	Monitoring
				wastes) from dredgers, barges and workboats	<p>environmental monitoring program</p> <p>Silt fences (Pollution Control Equipment) are utilized for controlling turbid water during the construction of trenches for the pipelines</p> <p>To complete the trenching works in the shortest duration.</p> <p>Environmental education on the marine ecosystem as well as the habitat of sea turtles to workers, labourers, and surrounding villagers.</p> <p>Preparation of reports of Sea turtle sightings in and around the seashore in Perur to relevant official entities and NGOs.</p> <p>Avoidance of installations of intake/ outfall pipelines during the sea turtles egg-laying seasons.</p>			
		Marine ecology	Short Term Localised Reversible	<ul style="list-style-type: none"> - Trenching will disturb the sea bed resulting in loss of seagrass beds and associated benthic communities - Boat movement and fishing activity will be restricted - The decrease in DO levels - Increase in noise levels - Removal of benthic communities 				

Sr. No.	Project Activity	Relevant Environmental components likely to be impacted	Nature of Impact	Likely Impacts and their significance in the absence of Mitigation Measures	Proposed Mitigation Measures	Responsibilities		
						Planning	Execution	Monitoring
				<ul style="list-style-type: none"> - Increase in species diversity and density in areas adjoining dredging site - Smothering or blanketing of sub-tidal communities. 	<p>Actions to be taken in cases where sea turtles are observed in and around the seashore in Perur such as to contact to relevant NGOs and official entities handling sea turtle conservations and monitoring for getting necessary instructions.</p> <p>Temporary suspension of the constructions for DSP.</p> <p>Announcement of the existence of sea turtles to the contractor(s), construction workers/labourers and surrounding communities.</p>			
B.2	Seawater Intake head	Mangrove area	Long Term Localised Non-Reversible	<ul style="list-style-type: none"> - Impact on nearby mangrove 	<p>No mangroves were observed at the proposed project site</p> <p>The impact is not envisaged</p>	Contractor	Contractor	CMWSSB
		Entrapment of fishes and other organisms	Continuous	<ul style="list-style-type: none"> - Impact on Fish and Fish larvae 	<p>Deep Water Intake having velocity cap and screen is proposed.</p>	Contractor	Contractor	CMWSSB

Sr. No.	Project Activity	Relevant Environmental components likely to be impacted	Nature of Impact	Likely Impacts and their significance in the absence of Mitigation Measures	Proposed Mitigation Measures	Responsibilities		
						Planning	Execution	Monitoring
		Entrainment of smaller organisms such as fish larvae.			<ul style="list-style-type: none"> – The intake velocity is limited to 0.12 m/s – The bar screen of 0.1 m width is to be installed <p>Above are the design consideration included in the project</p>			
B.3	Fishing	Fishermen and fishing travellers	Short Term Localised Reversible	<ul style="list-style-type: none"> – Impact on fishing due to Construction works – During the trenching for laying the submarine pipeline, the fisherman will not be allowed to cross over the areas where trenching is being done. This is a 	<p>Proposed construction is planned within CMWSSB areas near Approach Channel and at existing Anchorage areas where fishing activities are not permitted; however, the following measures are suggested:</p> <p>Signboards will be placed at the construction site to make fishermen aware of ongoing activities</p> <p>Necessary marker buoys will be installed</p>	Contractor	CMWSSB	CMWSSB

Sr. No.	Project Activity	Relevant Environmental components likely to be impacted	Nature of Impact	Likely Impacts and their significance in the absence of Mitigation Measures	Proposed Mitigation Measures	Responsibilities		
						Planning	Execution	Monitoring
				short term impact and completely reversible as there will not be any prohibition of fisherman crossing the areas above the path where the submarine pipeline is laid	<p>Interactions will be initiated with a fishing community prior to commencement of construction</p> <p>Construction shall be limited to as per development plan.</p> <p>Proper Planning execution of offshore construction activities to ensure the completion of construction as per schedule</p> <p>Ensure slop tanks will be provided to barges/ workboats for collection of liquid/ solid waste</p> <p>Trenching will be done only in small stretches, and so fishing activities can continue as normal in all other areas except where the active trenching/ laying of the pipeline is being done. There will not be any prohibition of fisherman crossing the areas above the submarine pipeline are laid below the seabed.</p>			

Sr. No.	Project Activity	Relevant Environmental components likely to be impacted	Nature of Impact	Likely Impacts and their significance in the absence of Mitigation Measures	Proposed Mitigation Measures	Responsibilities		
						Planning	Execution	Monitoring
B.4	Outfall diffuser	Marine water quality	Continuous	- Increased Salinity	Faster dilution of moderately high salinity levels to ambient levels. Brine diffuser with high brine diffusion efficiency has been proposed. Monitoring of marine water quality for timely action during exceedance of the specified value more than 1% increase in salinity at 400m radius from the brine diffuser position.	Contractor	Contractor	CMWSSB
		Chlorine concentration		- Chlorine concentration to be maintained below 0.2 ppm at the outfall.	Chlorine dosing rate to intake seawater is designed for the elimination of marine growth at intake and inside the pipeline. Residual Cl ₂ concentration will be approximately 0.2 ppm at the outlet of the pre-treatment system by consuming Cl ₂ in the intake and pre-treatment processes.			

Sr. No.	Project Activity	Relevant Environmental components likely to be impacted	Nature of Impact	Likely Impacts and their significance in the absence of Mitigation Measures	Proposed Mitigation Measures	Responsibilities		
						Planning	Execution	Monitoring
					To protect the RO membrane from chlorine attack, Sodium Bisulphite (SBS) is injected for removing Cl ₂ at the inlet of the RO membrane. Accordingly, the brine has no chlorine as calculated in the above equation. RO reject contains an excess SMBS which can reduce the Cl ₂ concentration in the discharge. During regular operation, the Cl ₂ concentration of the discharge from DSP can be maintained less than 0.2 ppm.			
B.5	Vehicle movement	Air quality	Short Term Localised Reversible	Negative Impact of Air quality	Periodic inspection of exhaust gases of dump trucks, other trucks and heavy equipment to be used; Water spraying for heavy vehicles, equipment and trucks operation on-site in the dry season to avoid dust uplift and air pollution;	Contractor	Contractor	CMWSSB

Sr. No.	Project Activity	Relevant Environmental components likely to be impacted	Nature of Impact	Likely Impacts and their significance in the absence of Mitigation Measures	Proposed Mitigation Measures	Responsibilities		
						Planning	Execution	Monitoring
					<p>Trucks carrying construction material/ demolition debris to be adequately covered to avoid dust pollution and to avoid the material spillage;</p> <p>The contractor shall ensure that the batching plant has closed belt conveyor;</p> <p>DG set shall have adequate stack height as per TNPCB requirement;</p> <p>Excavated soil shall be covered to avoid dust emissions.</p>			
B.6	Manpower for Construction works	Water Quality	Short Term Localised Reversible	Negative Impact of water quality	Construction office will be provided with an adequate number of toilets as per labour laws and connected with a septic tank or modular STP for treatment of wastewater.	Contractor	Contractor	CMWSSB

Sr. No.	Project Activity	Relevant Environmental components likely to be impacted	Nature of Impact	Likely Impacts and their significance in the absence of Mitigation Measures	Proposed Mitigation Measures	Responsibilities		
						Planning	Execution	Monitoring
					Once the construction is over, Septic tank to be removed and closed.			
B.7	Noise and Vibration	Noise Quality	Short Term Localised	Negative Impact of noise quality	PPEs to be provided to all labours working at the site. Servicing of all vehicles and machinery shall be done regularly as per the manufacturer's guidelines, and during routine servicing operations, the effectiveness of exhaust silencers will be checked and if found defective will be replaced. Batching plant shall be located minimum 1 km away from the nearby settlement, and noise barriers shall be provided around batching plant in case of nearby settlement is located much closer to the batching plant site; DG set shall have an acoustic enclosure.	Contractor	Contractor	CMWSSB

Sr. No.	Project Activity	Relevant Environmental components likely to be impacted	Nature of Impact	Likely Impacts and their significance in the absence of Mitigation Measures	Proposed Mitigation Measures	Responsibilities		
						Planning	Execution	Monitoring
					<p>Maintenance of vehicles, equipment and machinery shall be regular and up to the satisfaction of the Engineer to keep noise levels at the minimum.</p> <p>The contractor should maintain the proper records for all the constructions vehicles and have a valid fitness certificate, NOC, insurance etc.</p> <p>The construction activities shall be carried out in a planned manner restricting high noise-generating construction activities only during daytime;</p> <p>Acoustic measures to be provided to reduce noise propagation to noise-generating machinery during operations.</p> <p>Regular monitoring shall be conducted at site during operations.</p>			

Sr. No.	Project Activity	Relevant Environmental components likely to be impacted	Nature of Impact	Likely Impacts and their significance in the absence of Mitigation Measures	Proposed Mitigation Measures	Responsibilities		
						Planning	Execution	Monitoring
B.8	Solid waste management	Soil Quality	Short Term Localised Reversible	– Impacts due to disposal of solid waste	Periodical de-sludge activities for toilets in construction sites by the use of public services or by the service providers. Waste oil (from hydraulic systems, etc.) collection and treatment by solid waste collection companies. Storage at DSP site to be provided with secondary containment (Dike) for avoiding any spillages. Surplus soil management by back-filling. Being a greenfield project, Construction waste and debris waste generation is minimal. The minor quantity generated will be utilized within the DSP for various construction works	Contractor	Contractor	CMWSSB
B.9	Handling of Hazardous Waste	Human safety and property loss	Short Term Localised	– Fire accidents due to hazardous material handling	Hazardous materials such as lubricants, paints, compressed gases, varnishes etc., will be stored and disposed of as per the	Contractor	Contractor	CMWSSB

Sr. No.	Project Activity	Relevant Environmental components likely to be impacted	Nature of Impact	Likely Impacts and their significance in the absence of Mitigation Measures	Proposed Mitigation Measures	Responsibilities		
						Planning	Execution	Monitoring
					<p>Hazardous Wastes (Management, Handling) Rules 2016 India</p> <p>Hazardous wastes will be disposed of through approved TNPCB/ CPCB authorised recycler/ disposal agency. Copy of the agreement should be maintained with inventories.</p> <p>Regular audit of hazardous waste generated and records and records</p> <p>A suitable site should be identified for the safe storage and handling of chemicals and other hazardous materials with a paved surface and proper display of requirements and marking as a protected area.</p> <p>Secondary containment shall be provided for hazardous chemicals such as diesel, lubricants, paints</p>			

Sr. No.	Project Activity	Relevant Environmental components likely to be impacted	Nature of Impact	Likely Impacts and their significance in the absence of Mitigation Measures	Proposed Mitigation Measures	Responsibilities		
						Planning	Execution	Monitoring
					etc. Material safety data sheets (MSDS) of all the hazardous chemicals shall be properly displayed at storage areas as well as handling areas.			
B.10	Transportation of Construction material and mobilization of construction machinery and vehicular movement within site ⁴				Contractor shall ensure that traffic management plan for onsite and offsite vehicular movement is in place to the satisfaction of the CMWSSB Engineers; Routes for use by construction traffic within site to be planned with proper signage to minimize encountering of construction workers with vehicles. The routes for the movement of heavy machinery shall be designated to avoid the soil compaction in other areas;	Contractor	Contractor	CMWSSB

Sr. No.	Project Activity	Relevant Environmental components likely to be impacted	Nature of Impact	Likely Impacts and their significance in the absence of Mitigation Measures	Proposed Mitigation Measures	Responsibilities		
						Planning	Execution	Monitoring
					<p>All vehicles deployed at the site shall be pollution under control (PUC) certified;</p> <p>Holding area shall be provided within site for vehicles waiting to deliver loads at the site so as to avoid queuing outside the site;</p> <p>Proper clearance to be obtained from the concerned authorities and sent to the CMWSSB before the commencement of works;</p> <p>Modern machinery such as JCBs, backhoes etc., shall be used to increase work efficiency and minimize the construction period.</p> <p>Regular maintenance shall be done.</p>			
B.11	Barricading site			—	<p>Contractor shall ensure that the construction area is barricaded properly.</p> <p>The construction site should be barricaded at all time in with</p>	Contractor	Contractor	CMWSSB

Sr. No.	Project Activity	Relevant Environmental components likely to be impacted	Nature of Impact	Likely Impacts and their significance in the absence of Mitigation Measures	Proposed Mitigation Measures	Responsibilities		
						Planning	Execution	Monitoring
					<p>adequate marking, flags, reflectors etc. to isolate it from other operating areas.</p> <p>Barricading the onshore pipeline route prior to construction activities.</p>			
B.12	Site preparation-excavation and levelling				<p>Disturbance to land surface contours to be kept to a minimum. Contractor shall try to maintain the natural drainage pattern existing onsite;</p> <p>Adequate drains and slopes to be laid across the proposed Project site prior to the start of excavation work to ensure adequate cross drainage.</p>	Contractor	Contractor	CMWSSB
B.13	Top Soil Protection				Topsoil removed prior to commencement of construction activities shall be stored separately, protected and reused	Contractor	Contractor	CMWSSB

Sr. No.	Project Activity	Relevant Environmental components likely to be impacted	Nature of Impact	Likely Impacts and their significance in the absence of Mitigation Measures	Proposed Mitigation Measures	Responsibilities		
						Planning	Execution	Monitoring
					<p>for landscape development within the project area.</p> <p>Land disturbance shall be restricted to the footprint of the Project components, and the remaining area will be kept undisturbed to the extent possible.</p> <p>All excavations should be closed before the start of the rainy season.</p>			
B.14	Storage of construction material				<p>Contractor shall identify designated covered area for storage of construction material with proper marking and measures to avoid dust emissions.</p> <p>Construction material stored in open shall be covered in order to avoid wind-blown dust emissions.</p>	Contractor	Contractor	CMWSSB
B.15	Removal of temporary construction structures and demobilization				Contractor to prepare site restoration plans, the plan is to be implemented by the contractor prior to demobilization.	Contractor	Contractor	CMWSSB

Sr. No.	Project Activity	Relevant Environmental components likely to be impacted	Nature of Impact	Likely Impacts and their significance in the absence of Mitigation Measures	Proposed Mitigation Measures	Responsibilities		
						Planning	Execution	Monitoring
	of construction machinery				On completion of the works, all temporary structures will be cleared away, all rubbish cleared, excreta or other disposal pits or trenches filled in and effectively sealed off and the site left clean and tidy, at the contractor's expenses, to the entire satisfaction of the engineer			
B.16	Compliance to Permits			—	Contractor shall ensure all compliance conditions given in CRZ clearance, Consent to Establish are compiled, and compliance monitoring reports are submitted to agencies on a regular basis.	Contractor	Contractor	CMWSSB
B.17	Chance found archaeological property			—	All fossils, coins, articles of the value of antiquity, structures and other remains or things of geological or archaeological interest discovered on the site shall be the property of the Government	Contractor	Contractor	CMWSSB

Sr. No.	Project Activity	Relevant Environmental components likely to be impacted	Nature of Impact	Likely Impacts and their significance in the absence of Mitigation Measures	Proposed Mitigation Measures	Responsibilities		
						Planning	Execution	Monitoring
					<p>and shall be dealt with as per provisions of the relevant legislation.</p> <p>The contractor will take reasonable precautions to prevent his workmen or any other persons from removing and damaging any such article or thing. He will, immediately upon discovery thereof and before removal, acquaint the Engineer of such discovery and carry out the SC's instructions for dealing with the same, waiting which all work shall be stopped.</p> <p>The Engineer will seek direction from the Archaeological Survey of India (ASI) before instructing the Contractor to recommence the work at the site</p>			

Note : PMC will be assisting CMWSSB in monitoring during construction phase.

Sr. No.	Project Activity	Relevant Environmental components likely to be impacted	Nature of Impact	Likely Impacts and their significance in the absence of Mitigation Measures	Proposed Mitigation Measures	Responsibilities		
						Planning	Execution	Monitoring
C	Operation Phase							
C.1	Product water production	Water Quality	Localised Reversible	Impact on offshore water quality	Periodical maintenance of Screens, Lamella, DAF, DMF, Membrane, CIP systems of DSP operation, filter backwashing, Belt filter press washing and Sewage Treatment Plant (STP) based on relevant O&M manuals and instructions of such facilities.	O&M Contractor	O&M Contractor	CMWSSB
		Noise Quality	Localised Reversible	Due to the operation of Blowers, DG sets	Provision of acoustic enclosures for equipment Personal Protecting Equipment (PPE).			
		Ecosystem	Localised Reversible	—	Chlorine from DSP shall be maintained less than 0.2 ppm at diffuser of the outfall. Implementation of environmental education on the marine ecosystem as well as the habitat of sea turtles			

Sr. No.	Project Activity	Relevant Environmental components likely to be impacted	Nature of Impact	Likely Impacts and their significance in the absence of Mitigation Measures	Proposed Mitigation Measures	Responsibilities		
						Planning	Execution	Monitoring
					<p>to workers and labourers in DSP, and surrounding villagers.</p> <p>Preparation of reports of Sea turtle sightings in and around the seashore in Perur to relevant official entities and NGO.</p> <p>Collaboration and consultation with other plants in the vicinity for conservation activities as directed by Government authorities time-to-time.</p>			
C.2	Compliance to Permits			—	Contractor shall ensure all compliance conditions given in CRZ clearance, Consent to Operate is compiled, and compliance monitoring reports are submitted to agencies on a regular basis.	Contractor	Contractor	CMWSSB

The approvals and permits are also needed during operations and decommissioning phase; therefore, CMWSSB needs to ensure the required compliance.

15.2 Environmental Monitoring Plan (EMoP)

The environmental monitoring plan helps in signalling the potential problems resulting from the proposed project activities and will allow for prompt implementation of corrective measures. The environmental monitoring will be required during both construction and operational phases. The following parameters are proposed to be monitored by the Contractor.

- Terrestrial Water Quality (Groundwater and Surface water)
- Air Quality
- Noise Intensity
- Soil Quality
- Marine Water Quality
- Marine Ecological Monitoring
- Marine Sediment Quality

Environmental monitoring during the pre-construction phase is important to set up the baseline data and to predict the deviation from baseline data and adverse impacts during construction and operations phases.

Pre-construction phase baseline monitoring for all the aforesaid monitoring parameters is required to be carried out by the contractor for 3 month duration.

The results of monitoring will be required to be provided to JICA every quarter during the construction phase and biannually during the operation of the desalination plant until the two years after the completion of the project.

15.2.1 Details of Environmental Monitoring Plan

Environmental Item	Monitoring Item	Location	Frequency	Responsible Organization
Construction Phase				
Air Pollution*	<ul style="list-style-type: none"> • Visual inspection of discharge conditions of exhaust gases (such as black smoke) of dump trucks, other trucks and heavy equipment and maintenance of the inspection logbook. 	Construction site	Daily	Contractors

Environmental Item	Monitoring Item	Location	Frequency	Responsible Organization
	<ul style="list-style-type: none"> Visual inspection on soil dust diffusions in the dry season for water spraying. 	Construction site	Daily (Dry Season only)	Contractors
Water Quality	<ul style="list-style-type: none"> Visual inspection of sewage water leakage (overflow), bad odour, the emergence of vector flies and de-sludge activities for the on-site toilets 	Construction site	Once/month	Contractors
	<ul style="list-style-type: none"> Checking Turbidity levels with baseline levels turbid water in the sea during installations of intake/outfall pipelines 	Intake/ outfall installation sea areas	Daily for the installation period	Contractors
Wastes	<ul style="list-style-type: none"> Waste composition, quantity, transportation and treatment methods 	Construction site	Once/month	Contractors
Soil Contamination	<ul style="list-style-type: none"> Visual inspection of leakage conditions of oil and fuel leakages (from Engine, hydraulic power units and fuel tanks) of dump trucks, other trucks and heavy equipment 	Construction site	Daily	Contractors
Noise and Vibration*	<ul style="list-style-type: none"> Visual inspection (common) 	Construction site	Daily	Contractors

Environmental Item	Monitoring Item	Location	Frequency	Responsible Organization
	sensation) of silencer conditions of dump trucks, other trucks and heavy Equipment			
Ecosystem	<ul style="list-style-type: none"> · Visual inspection on turbid water in the sea during installations of intake/outfall pipelines 	Intake/outfall installation sea areas	Daily for the installation period	Contractors
	<ul style="list-style-type: none"> · Implementation of environmental education on the marine ecosystem and sea turtles. 	Construction site and surrounding communities	Twice/year	Contractors/ CMWSSB
	<ul style="list-style-type: none"> · Information on Sea turtle sightings in and around the seashore in Perur 	Construction site	In the event of Sightings	Contractors/ CMWSSB
	<ul style="list-style-type: none"> · Actions on sea turtle sighting (construction suspensions periods, records of the announcements and relevant entities contacted) taken by CMWSSB 	Construction site and surrounding communities	In the event of Sightings	CMWSSB
Land Acquisition/ /Resettlement	<ul style="list-style-type: none"> · Implementation of tree cutting action plan (Per-Construction Stage) 	Construction site	Once/week	Contractors/ CMWSSB
Living and Livelihood	<ul style="list-style-type: none"> · Checking Turbidity levels with baseline levels turbid water 	Intake/ outfall installation sea areas	Daily for the	Contractors

Environmental Item	Monitoring Item	Location	Frequency	Responsible Organization
	in the sea during installations of intake/ outfall pipelines <ul style="list-style-type: none"> · Pipelines installation schedules · Installation (Construction) Management 		installation period	
Social Infrastructure and Services	<ul style="list-style-type: none"> · Implementation of construction vehicle management plans · Implementation of meetings with communities 	Construction site Construction site and surrounding communities	Daily Where necessary	Contractors CMWSSB/ Contractors
Risk of infectious diseases such as HIV/ AIDS	· Implementation of Health and Sanitation education on STD.	Construction site and surrounding communities	Once/ year	
Working Conditions/ Work Safety	Visual inspection on the utilization of PPE by workers/labours	Construction site	Daily	CMWSSB/ Contractors
Accidents	Implementation of Traffic safety education	Construction site and surrounding Communities	Once/ year	CMWSSB/ Contractors
General Environment [#]	Site conditions	Construction site and the coast	Every year	CMWSSB
Operational Phase				
Water Quality	Water quality of Raw seawater and Product water in DSP	DSP	Daily	DSP Operator

Environmental Item	Monitoring Item	Location	Frequency	Responsible Organization
	Concentration of Brine diffusion	Seawater at the nearest beach	Daily	DSP Operator
	<ul style="list-style-type: none"> · Visual inspection of sewage leakage (overflow), bad odour, the emergence of vector flies of Sewage Treatment Plant (STP) 	DSP	Once/month	DSP Operator
	<ul style="list-style-type: none"> · Operational Inspection in accordance with instructions on the STP as suggested by the STP construction sub-contractor including Inlet and outlet quantity and quality monitoring 	DSP	Daily	DSP Operator
Ecosystem	<ul style="list-style-type: none"> · Implementation of Meetings on environmental education. 	DSP and surrounding communities	Once/ year	DSP Operator/ CMWSSB
	<ul style="list-style-type: none"> · Information on Sea turtle sightings in and around the seashore of Perur 	DSP and surrounding communities	In the event of Sightings	DSP Operator/ CMWSSB
	Actions (Records of the announcements and relevant entities contacted) taken by CMWSSB	DSP and surrounding communities	In the event of Sightings	CMWSSB

Note # - A close and continuous monitoring during the construction phase through reputed intuitions such as NCSCM, Anna University, Chennai/ NIOT, Chennai/ IIT Madras to review the mitigation measures periodically and to take mitigation measures in the event of any adverse impacts to the coast.

It stipulates the post-clearance monitoring, which is required to be submitted half-yearly compliance reports in respect of the stipulated terms and conditions of the clearance to regulatory authorities, i.e., MoEF & CC and TNPCB. The monitoring activities specified in CRZ clearances are furnished in tables below:

15.2.2 Monitoring Activities requested by CZMAs

CZMA	Monitoring Activity	Frequency
Kancheepuram District (KDCZMA)	Marine quality including water quality and biological characteristics	Continuous
	Marine biodiversity	Twice in a year
	The concentration of toxic trace metals in the reject water	Periodical
	A moored data buoy shall be maintained in the vicinity of the effluent discharge to continuously monitor the changes in the selected physicochemical parameters (salinity, temperature, DO, current, etc.).	Periodical during the construction and operation phases
	The high salinity rejected water may be periodically monitored for the physiochemical and toxic trace metal contents through appropriate standard procedures.	Periodical
Tamil Nadu State (TNSCZMA)	Marine water at the outfall area	Every Quarter
	Periodical report on the site conditions to take mitigation measures on the event of any adverse impacts on the coast	Every Year
	Impact on the corals*, marine organisms, Turtle nesting etc. should be evaluated and monitored through experts (ecologists).	Not specified

15.2.3 Marine Environmental Monitoring proposed in the EIA Report

Marine environmental monitoring activities of Seawater & Sediment Quality, Marine Benthic Fauna, and Intake Seawater outfall have been proposed as shown in Table below

Monitoring	Purpose	Parameter	Frequency
Seawater & Sediment Quality	To monitor impacts on seawater and sediment quality	Measurements of levels of nutrients and heavy metals in water and sediment samples collected from sides at risk of pollution	Each season: April (Fair Weather), July (SW monsoon) and November (NE monsoon)
Marine Benthic Fauna	To determine the composition and distribution of major groups of fauna	Benthic fauna composition in the water outfall region	Each season as indicated above
Intake	To determine the incidence of entrapment and mortality of marine fauna	Screens on pump stations and the effectiveness of management measure	Each season as indicated above
	To determine the impact of entrainment within and external ponds/storage sump/well to assess the loss of fishery	Record an abundance of fauna within the pond/storage sump/well Video recording near intake heads	Each season as indicated above Bi-annual
Seawater outfall	To determine the effect of increased temp/salinity on the plankton	Monitor abundance and distribution of both phytoplankton and zooplankton near the outfall.	Each season as indicated above
		Monitor abundance and distribution of benthic animal communities near the outfall	Each season as indicated above
		Video recording to elucidate the distribution of planktons may be conducted.	Bi annual

15.3 Environmental Sampling and Analysis Programme

The following Environmental sampling program shall be carried out as a minimum requirement by the Contractor before the commencing construction activity. Bidder to submit the Approach and methodology of environmental monitoring to the Employer's representative for review and approval. The Contractor shall submit results of the Sampling program to the Employer's representative for approval. The initial environmental monitoring shall be carried for a duration of three months. Thereafter during the construction period, monthly reports to be submitted to the Employer's

representative. The consolidated reports are required to be submitted to JICA and to MoEF & CC and TNPCB as part of regulatory compliance.

15.3.1 Sampling Program – Part A

A1. Ambient Air Quality

Parameters	No. of Locations	Frequency of monitoring per week (days)	Total Samples per week	Total samples per Month	Method
SO ₂ (24 hrly)	5	2	10	40	West and Gaeke
NO _x (24 hrly)	5	2	10	40	Arsenite modified J and H
RSPM 10μm (24 hrly)	5	2	10	40	EHVS
PM 2.5μm (24 hrly)	5	2	10	40	HVS with cyclone
CO (8 hourly)	5	2	10	40	As per MOEF Guidelines
Volatile organic compounds (VOCs) 24 hourly	5	2	10	40	As per MOEF Guidelines
Hydrocarbon (HC) 24 hourly	5	2	10	40	Gas Chromatographer

A2. Meteorology

Parameter	No. of Location	Frequency	Days	Total samples per Month	Method
- Wind speed - Wind direction - Relative humidity - Temperature, - Rainfall	1	1 hourly continuous	Monthly	1	Automatic weather station and as per IMD specification & MoEF Guidelines

A3. Noise Level

Parameters	No. of locations and Frequency	Minimum no. of sample per month
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Equivalent noise level (Leq) for day time and night time (Ld, Ln, and Ldn).	5 locations & hourly intervals at each location	5
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A4. Water Quality

Parameters	No. of Location	Frequency	Minimum No. of samples per month
(As per IS 10500) Colour, Odour, Temp, pH, turbidity, Total Hardness (Mg & Ca), TDS, total alkalinity, chloride, sulphate, nitrate, fluoride, Na, K, Calcium, Magnesium, phenolic compounds, Mineral oil, Cyanides, Anionic detergents, Residual chorine, Boron, Cadmium, Arsenic, Copper, Lead, Manganese, Iron, Chromium VI, Selenium, Zinc, Aluminium, Mercury, Pesticides, Total coliform, E-coli	2 groundwater + 3 surface water	5	5

A5. Soil Quality

Parameters	No. of Location and Frequency	Frequency	Total No. of samples per month
Bulk density, Salinity, Porosity, Texture Class (Percent wise silt, clay & sand), pH, Electrical conductivity, Cation exchange capacity, Sodium, Potassium, Nitrogen, Magnesium, Phosphorous, Sodium Absorption Ratio (SAR), Water holding capacity, Iron, Copper, Zinc, Manganese, Nickel, Permeability, physiochemical analysis and relevant metals.	5	Monthly	5

Note: Soil samples shall be collected from three different depths, i.e., 30 cm, 60 cm and 90 cm and homogenized samples to be used for analysis.

15.3.2 Sampling Program – Part B

B1. Marine Water Quality:

Sl. No.	Parameters	Number of Locations	Minimum Number of Samples per month
1.	Salinity	5	5
2.	Electrical Conductivity		
3.	Temperature		
4.	Turbidity		
5.	Suspended Solids		
6.	pH		
7.	Dissolved Oxygen (DO)		
8.	Biological Oxygen Demand (BOD)		
9.	Nitrates as NO ₃ -2		
10.	Ammonical Nitrogen		
11.	Nitrites as NO ₂ -2		
12.	Total Nitrogen		
13.	Inorganic Phosphate		
14.	Total Phosphate		
15.	Silicates		
16.	Phosphates as PO ₄ -2		
17.	Chlorides as Cl-		
18.	Sulphates as SO ₄ -2		
19.	Total Nitrogen		
20.	Heavy Metals		
20.1	• Zinc		
20.2	• Mercury		

Sl. No.	Parameters	Number of Locations	Minimum Number of Samples per month
20.3	• Cadmium		
20.4	• Lead		
20.5	• Copper		
20.6	• Iron		
21.	Oil and Grease		
22.	TOC/DOC		
23.	Petroleum Hydrocarbons		

B2. Sediment Quality:

The sediment samples will be collected using a suitable grab. After collection, the samples shall be sieved and subjected to Physico-chemical analysis. The samples collected will be tested for the following parameters:

Sr. No.	Parameters	Number of Locations	Minimum Number of Samples per month
1.	pH	4 & 1 from dredged material during project construction	5
2.	Texture		
3.	Oil & Grease		
4.	Petroleum Hydrocarbons		
5.	Organic Matter		
6.	Total Volatile Solids		
7.	Chlorides as Cl-		
8.	Phosphates as PO ₄ -2		
9.	Nitrites as NO ₂ -2		
10.	Nitrates as NO ₃ -2		

Sr. No.	Parameters	Number of Locations	Minimum Number of Samples per month
11.	Sulphates as SO ₄ -2		
12.	Sodium		
13.	Potassium		
14.	Magnesium		
15.	Total Kjeldahl Nitrogen		
16.	Heavy Metals		
16.1	Zinc		
16.2	Nickel		
16.3	Cadmium		
16.4	Copper		
16.5	Lead		
16.6	Mercury		
16.7	Iron		

B3. Biological Parameters:

The marine water and sediment samples shall be collected as analyzed for the following biological parameters:

B3.1 List of Biological Parameters for Marine Water Samples

Sr. No.	Parameters	Number of Locations	Minimum Number of Samples per month
1.	Primary Productivity		
2.	Chlorophyll -a	5	5
3.	Phaeophytin		

Sr. No.	Parameters	Number of Locations	Minimum Number of Samples per month
4.	Total Biomass		
5.	Oxidizable particulate organic carbon		
6.	Phytoplankton		
6.1	Abundance		
6.2	Number and name of groups		
6.3	Total number and name of the species of each group present		
6.4	Density (total numbers of individual species present)		
6.5	Total biomass		
7.	Zooplankton		
7.1	Abundance		
7.2	Number and name of groups		
7.3	Total number and name of the species of each group present		
7.4	Density (total numbers of individual species present)		
8.	Bacteriological parameters		

B3.2 List of Biological Parameters for Sediment Samples

Sr. No.	Parameters	Number of Locations	Minimum Number of Samples per month
1.	Benthic Organisms	5	5
2.	Meio fauna		

Sr. No.	Parameters	Number of Locations	Minimum Number of Samples per month
3.	Microfauna		
4.	Macrofauna		
5.	Abundance		
6.	Number and name of each group present		
7.	Total number and name of species of each group present		
8.	Density (total numbers of individuals of each species)		

15.4 Proposed Monitoring Forms

The template of Environmental Monitoring Forms which are required to be used during the pre-construction stage, Construction stage and Operation phase of the project are furnished in Tables below.

15.4.1 Pre-Construction Phase (Tree cutting) Monitoring Forms

The latest results of the below-monitoring items shall be submitted to the lenders as part of the Progress Report throughout the pre-construction phase.

15.4.1.1 Air Pollution

- Exhaust Gases

Date	Type of Construction Vehicles/ Equipment	Fleet/ Registration Number	Exhaust Gases Discharge Conditions				Frequency
			Items	Yes	No	If Yes, Measures Taken	
(Day, Month, Year)			Black Smoke				Daily
			White Smoke				
			Others (Specify)				

Logbook: to be prepared and recorded by the contractor(s) which is submitted to CMWSSB monthly.

If any problem arises, such vehicles and equipment to be sustained to use or be replaced by appropriate ones.

- Soil Dust (Dry Season only)

Date	Location	Dust and dried sandy soil stirred up by construction activities				Frequency
(Day, Month, Year)	Construction Site including access roads	Items	Yes	No	If Yes, Measures Taken (such as water supplying)	Daily
		Dust				
		Dried Sandy Soil				
		Others (Specify)				

Log Book: to be prepared and recorded by the contractor(s) which is submitted to CMWSSB monthly.

15.4.1.2 Land Acquisition/ Resettlement (Progress of the tree cutting)

Items	Implementation (as of)			Frequency
Cutting Schedule	1. As scheduled ()	2. Delayed (months)	3. Postponed ()	Once/ week
Total Value of Trees	1. Decided (Rs)	2. Under evaluation ()	3. No action ()	
Budget Allocation	1. Allocated by ()	2. Under discussion ()	3. No action ()	
Compensation to Landowner	1. Compensated ()	2. Under preparation ()	3. No action ()	
Auction for tree cutting	1. Conducted (when)	2. Under preparation ()	3. No action ()	
Waste Management	1. Properly Managed ()	2. Under preparation ()	3. No action ()	

Progress of the preparation and implementation shall be submitted to CMWSSB monthly

15.4.2 Construction Phase Monitoring Form

The latest results of the below-monitoring items shall be submitted to the lenders as part of the Quarterly Progress Report throughout the construction phase

15.4.2.1 Air Pollution

- Exhaust Gases

Date	Type of Construction Vehicles/ Equipment	Fleet/ Registration Number	Exhaust Gases Discharge Conditions				Frequency
			Items	Yes	No	If Yes, Measures Taken	
(Day, Month, Year)			Black Smoke				Daily
			White Smoke				
			Others (Specify)				

Log Book: to be prepared and recorded by the contractor(s) which is submitted to CMWSSB monthly. If any problem arises, such vehicles and equipment to be sustained to use or be replaced by appropriate ones.

- Soil Dust (Dry Season only)

Date	Location	Dust and dried sandy soil stirred up by construction activities				Frequency
(Day, Month, Year)	Construction Site including access roads	Items	Yes	No	If Yes, Measures Taken (such as water supplying)	Daily
		Dust				
		Dried Sandy Soil				
		Others (Specify)				

Log Book: to be prepared and recorded by the contractor(s) which is submitted to CMWSSB monthly.

15.4.2.2 Water Quality

- On-site toilets

Date	On-site Toilet Number/location	Sewerage water Conditions				Frequency
(Day, Month,		Items	Yes	No	If Yes, Measures	Daily

Date	On-site Toilet Number/location	Sewerage water Conditions			Frequency
Year)				Taken	
		Black (sewage)water leakage			
		Bad odour			
		Emergency of Flies			
		Others (Specify)			

Log Book: to be prepared and recorded by the contractor(s) which is submitted to CMWSSB monthly.

- Turbidity (Seawater Turbidity during the installation of intake/outfall pipelines)

Date	Location of installation of Intake/ Outfall (GPS position)	Turbid water Conditions			Frequency	
(Day, Month, Year)	Intake () Outfall ()GPS Position	Items	Yes	No	If Yes, Measures Taken	Daily
		Silts				
		Sea sands				
		Bottom sediments				
		Others (Specify)				

Log Book: to be prepared and recorded by the contractor(s) which is submitted to CMWSSB monthly.

15.4.2.3 Soil Contamination

- Oil and Fuel leakage (spill)

Date	Type of Construction Vehicles/ Equipment	Fleet/ Registration Number	Oil/Fuel Leakage Conditions			Frequency	
(Day, Month, Year)			Items	Yes	No	If Yes, Measures Taken	Daily

			Engine oil				
			Hydric power unit oil				
			Fuel				
			Others (Specify)				

Log Book: to be prepared and recorded by the contractor(s) which is submitted to CMWSSB monthly. If any problem arises, such vehicles and equipment to be sustained to use or be replaced by appropriate ones.

15.4.2.4 Wastes

- Construction Wastes and Debris

Waste Composition	Waste Quantity (ton/month)	Transportation, Disposal/Treatment Methods (Specify: ex. Registered Service Provider, Officially final disposal site, registered treatment facility (or company))				Frequency
		Transport	Disposal	Treatment	Remarks	
Construction Debris						
Surplus Soil						
Toxic and Chemical Waste						
Other (specify)						

15.4.2.5 Noise and Vibration

- Noise from Construction Vehicles and Equipment

Visual Inspection Date	Type of Construction Vehicles/Equipment	Fleet/Registration Number	Condition of Silencer equipped with construction vehicles/Equipment				Frequency
(Day, Month,			Items	Yes	No	If Yes, measures	Daily

Visual Inspection Date	Type of Construction Vehicles/Equipment	Fleet/Registration Number	Condition of Silencer equipped with construction vehicles/Equipment				Frequency
Year)						are taken (such as water sprinkling)	
			Properly Equipped				
			Damaged				
			Large noise discharge				
			Others (Specify)				

Log Book: to be prepared and recorded by the contractor(s) which is submitted to CMWSSB monthly. If any problem arises, such vehicles and equipment to be sustained to use or be replaced by appropriate ones.

15.4.2.6 Ecosystem

- Turbidity

Date	Location of installation of Intake/outfall (GPS position)	Turbid water Conditions				Frequency
(Day, Month, Year)	Intake () Outfall () GPS Position	Items	Yes	No	If Yes, measures are taken	Daily
		Silts				
		Sea sands				
		Bottom sediments				
		Others (Specify)				

- Environmental Education on Marine ecosystems and Sea Turtles

Date	Venue	Agenda	Lecturer	Number of Participants	Materials paraded	Frequency
(Day, Month, Year)				Community ()		Twice/year
				Worker/ Labor ()		
				Others (Specify)		
				Total ()		

Participant list and educational materials shall be attached

- Sea Turtles Sightings

Item	Sighting Report					Frequency
Sea turtles	Time/ Date	Place (In or around Perur DSP construction site)	Sighted by whom (ex, Villager, Worker/labour, rumour and others)	Description of the Sighting	Actions were taken to the sightings	In the event of sighting*
					See the Actions on Sea Turtle	

*During the egg-laying season of sea turtles, hearing survey on the sighting shall be done in the surrounding communities twice of the season

- Actions on Sea Turtle Sightings

Item	Sighting Report			Frequency
Actions on Sea turtle sighting	Construction Suspension Periods	Records of the announcements	Relevant entities contacted	In the event of Sighting

15.4.2.7 Living and Livelihood

- Seawater Turbidity during the installation of intake/outfall pipelines

Date	Location of installation of Intake/outfall (GPS position)	Turbid water Conditions	Frequency

(Day, Month, Year)	Intake () Outfall ()GPS Position	Items	Yes	No	If Yes, Measures Taken	Daily
		Silts				
		Sea sands				
		Bottom sediments				
		Others (Specify)				

- Pipelines installation schedules and Installation (Construction) Management

Date	Location	Management				Compens ation budget and status (Specify)	Frequency
		Type Space used (1. Paddy Field, 2. Farmland, 3. Others)	Area (m ²)	Duratio n of use	Conditi on of Space		
(Day, Month Year)							Daily during the installation

15.4.2.8 Social Infrastructure and Services

- Road Traffic

Date	Location	Construction Vehicle Management				Frequency	
		Traffic Control (Specify the details)					
		Time Restriction	Avoidance of Rush Hour	Avoidance of Rush Hour	Others (Specify)		
(Day, Month, Year)							

Log Book: to be prepared and recorded by the contractor(s) which is submitted to CMWSSB monthly.

- Commercial Activities (for the transmission pipelines installations)

Date	Location	Management				Frequency	
		Traffic Control (Specify the details)					
		Diversion Route	Time Restriction	No Control	Others (Specify)		
(Day, Month, Year)						Daily during the installation	

- Meetings with surrounding Communities (for the transmission pipelines installations)

Date	Location / Community	Meeting Venue	Number of Participants	Agenda	Opinions Requests	Countermeasures	Frequency
(Day, Month, Year)			Community ()				Where necessary
			Officials ()				
			Others (Specify)				
			Total ()				

Participant list and meeting minutes shall be attached.

15.4.2.9 Risks of Infectious diseases such as HIV/AIDS

- Health and Sanitation Education

Date	Venue	Agenda	Lecturer	Number of Participants	Materials paraded	Frequency
(Day, Month, Year)				Community ()		Once/year
				Worker/Labor ()		
				Others (Specify)		
				Total ()		

Participant list and educational materials shall be attached.

15.4.2.10 Working Conditions/Work safety for the Construction

- Personnel Protective Equipment (PPE)

Date	Monitoring Item	If any problems, measures are taken	Frequency
(Day, Month, Year)	PPE: such as Helmet, Gloves, Masks, shoes) -		Daily

Log Book: to be prepared and recorded by the contractor(s) which is submitted to CMWSSB monthly.

15.4.2.11 Accidents

- Meetings with surrounding Communities

Date	Venue	Agenda	Lecturer	Number of Participants	Materials paraded	Frequency
(Day, Month, Year)				Community () Worker/Labor () Others (Specify) Total ()		Once/year

15.4.3 Operation Phase Monitoring Form

The latest results of the below-monitoring items shall be submitted to the Employer on a biannual basis.

15.4.3.1 Water Quality

- Seawater and Product Water

Sl. No.	Constituents	Seawater	Product Water	Frequency
1	Silt Density Index	✓		Daily
2	pH	✓	✓	Daily
3	Total Dissolved Solids	✓	✓	Daily

4	Temperature	✓	✓	Daily
5	Electrical conductivity	✓	✓	Daily
6	Turbidity	✓	✓	Daily
7	Residual chlorine	✓	✓	Daily
8	Boron content	✓	✓	Daily
9	Langelier index	-	✓	Daily
10	Oxidation-reduction potential	✓	-	Daily
11	Alkalinity	✓	✓	Daily
12	Chloride	✓	✓	Daily
13	Hardness	✓	✓	Daily

Operational Monitoring Report on the Seawater and Product Water monitored at DSP can be attached.

- Brine Concentration

Date	Sampling Location	Brine Concentration (ppt)	Remarks	Frequency
				Daily

- Domestic Wastewater (Sewage Treatment Plant)

Monitoring Item	Method	If any negative results measures – Action to be taken	Frequency
Bad Odor	Visual Inspection (Common sensation)		Once/month
Water Leakage	Visual Inspection		
Generation of flies	Visual Inspection		

Monitoring Item	Method	If any negative results measures – Action to be taken	Frequency
	Other necessary actions to be monitored as per the instruction and manuals on the operation and maintenance of aerated sewage treatment facilities (STP) is to be installed.		Once/month (or instructions of the Contractor of STP)

15.4.3.2 Ecosystem

- Environmental Education on Marine Ecosystems and Sea Turtles

Date	Venue	Agenda	Lecturer	Number of Participants	Materials paraded	Frequency
(Day, Month, Year)				Community () Worker/Labor () Others (Specify) Total ()		Once/year

Participant list and educational materials shall be attached.

- Sea Turtles Sightings

Item	Sighting Report					Frequency
Sea turtles	Time/ Date	Place (In or around Perur DSP site)	Sighted by whom (ex, Villager, Worker/labour, rumour and others)	Description of the Sighting	Actions were taken to the sightings	In the event of Sighting*
					See the Actions on Sea Turtle Sightings (specified below)	

*During the egg-laying season of sea turtles, hearing survey on the sighting shall be done in the surrounding communities twice of the season.

- Actions on Sea Turtle Sightings

Item	Sighting Report			Frequency
Actions on Sea turtle sighting	Construction Suspension Periods	Records of the announcements	relevant entities contacted)	In the event of Sighting

15.4.4 Monitoring Format for EIA And CZMAS Recommendations

15.4.4.1 Construction Phase

Environmental Items	Monitoring Items	Parameters	Frequency	Recommended by	Monitoring Results
General Environment	Site conditions	Any adverse impacts on the coast	Every Year	Tamil Nadu State CZMA	

15.4.4.2 Operation Phase

Environmental Items	Monitoring Items	Parameters	Frequency	Recommended by	Monitoring Results
Water Quality	Seawater & Sediment Quality	Nutrients and heavy metals	Each season: April (Fair Weather), July (SW monsoon) and November (NE monsoon)	EIA Report	
Ecosystem	Marine Benthic Fauna	Benthic fauna composition	Each season as indicated above	EIA Report	
Ecosystem	Intake entrapment of marine fauna	Screens on pump stations and Effectiveness of management	Each season as indicated above	EIA Report	

Environmental Items	Monitoring Items	Parameters	Frequency	Recommended by	Monitoring Results
		measure			
Ecosystem	Entrainment of marine fauna	Abundance of fauna within the pond/storage sump/well	Each season as indicated above	EIA Report	
Ecosystem	Seawater outfall	Abundance and distribution of both phytoplankton and zooplankton	Each season as indicated above	EIA Report	
Ecosystem		Abundance and distribution of benthic animal communities	Each season as indicated above	EIA Report	
Water Quality/ Ecosystem	Post-project marine quality	Marine quality, including water quality and biological characteristic.	Continuous	Kancheepuram District CZMA	
Ecosystem	Marine biodiversity	Not specified	Twice in a year	Kancheepuram District CZMA	
Water Quality	Reject water	Concentration of toxic trace metals	Periodical	Kancheepuram District CZMA	
Water Quality	Changes in the selected physicochemical parameters	Salinity, temperature, DO, current etc.	Periodical during the construction and operation phases	Kancheepuram District CZMA	

Environmental Items	Monitoring Items	Parameters	Frequency	Recommended by	Monitoring Results
Water Quality	The high salinity reject water (maybe monitored through appropriate standard procedures)	Physiochemical and toxic trace metal contents	Periodical	Kancheepuram District CZMA	
Water Quality	Marine water	Parameter is not specified/ to be monitored at the outfall area	Every Quarter	Tamil Nadu State CZMA	
General Environment	Site conditions	Any adverse impacts on the coast	Every Year	Tamil Nadu State CZMA	
Ecosystem	Impact on marine organisms, Turtle nesting etc.	Marine organisms, Turtle nesting etc.	Not specified (to be monitored by experts)	Tamil Nadu State CZMA	

CHAPTER - 16

16. SOCIAL MANAGEMENT PLAN

Social safeguard interventions play a major role in bringing understanding and harmony while addressing the impact of infrastructure development which is meant for the greater interest of the society and the people embedded. Hence, the objective of social safeguard intervention is to adhere to JICA's guideline, ISO and the international standards during construction and operation of the Chennai Perur 400 MLD Desalination Plant.

16.1 Scope of Social Safeguard Intervention

The scope of work shall include but not be limited to the following:

16.1.1 Social Management Strategies, Plan and Execution

- After award of the contract and before the start of work, the Contractor shall review the Social Management Plan (SMP) for the project available with CMWSSB. The contractor shall duly update the SMP to ensure compliance with all applicable legislation and regulations of State / Central Government, JICA's Guidelines and IFC Performance Standards on Social Sustainability. The SMP shall incorporate the requirements stipulated in the Project's SIA (Social Impact Assessment) Report and conditions of approval from State/Centre Regulatory agencies. The SMP shall clearly define roles, responsibilities, reporting requirement and budgetary allocations for the implementation of mitigation measures. In case of any revision to SMP shall be submitted by the Contractor to CMWSSB for necessary approval before initiating any groundwork.
- Separate Social Management Plans for Construction, maintenance and Operations Stages shall be prepared to address the impacts associated with construction, maintenance and operation activities on the workforce engaged and surrounding communities. These plans shall incorporate the requirements stipulated in the Project's SIA Report, applicable legislation and regulations, conditions of approval from State/Centre Regulatory agencies and also considering best practices and good engineering practices, as applicable.

16.1.2 Labour Influx and Worker's Camp Management Plan

The labour influx and worker's camp management plan, including the process for mitigating construction-related impacts on the local community are given below.

16.1.2.1 Labour Camp Management

- i) The contractor preferably will use unskilled/semi-skilled labour from the local area to give the maximum benefit to the local community whenever this is possible.
- ii) The contractor will follow all relevant provisions of the Building and the other Construction Workers (Regulation of Employment and Conditions of Service) Act, 1996 for construction and maintenance of labour camp.

- iii) Pooled transportation facilities as may be required, shall be provided by the contractor. The location, layout and basic facility provision of labour camp will be submitted to Engineer for approval prior to its construction.
- iv) The contractor will provide and maintain well-ventilated living accommodation and ancillary facilities for workers, including adequate working, eating, and sleeping arrangements for field workers functionally, hygienically and safely.
- v) The contractor will construct and maintain all labour accommodation in such a fashion that uncontaminated clean water is available for drinking, cooking, bathing and washing.
- vi) Clean and cool drinking water will be made available for workers by the contractor at the construction site/labour camp/s. The Contractor will also provide product water facilities at the construction site in an accessible place, as per standards set by the Building and other Construction Workers (Regulation of Employment and Conditions of Service) Act, 1996. Provision of mobile drinking water counter/kiosk, with 300-litre capacity, with at least two taps, with a bottom tank, to collect wastewater will be placed at a suitable place near worksites.
- vii) Workers shall not be allowed to defecate in the open. Proper mobile toilets fitted with a septic tank will be provided by the contractor. Separate toilets/bathrooms, wherever required, will be provided for male and female, marked in sign as well as in vernacular in the construction camp.
- viii) Adequate freshwater supply will be ensured in kitchen/mess, bathrooms, toilets and urinals.
- ix) Fuelwood will not be allowed for cooking at labour camps. LPG cylinders as cooking fuel will be provided at labour camp by the contractor.
- x) Regular damp cleaning, sweeping, disinfecting and sanitizing will be ensured at the labour campsite.
- xi) The contractor will ensure that the sewage system for the camp will be designed, built and operated in such a manner that no health hazard occurs and no pollution to the air, groundwater or adjacent watercourses take place and biologically treated, to consistently deliver excellent effluent quality with biweekly test reports.
- xii) The contractor will provide stability to the marine outfall system even during cyclonic conditions, and appropriate anchor shall be provided.
- xiii) The contractor will ensure that the pipelines such as intake pipeline and outfall line and intake arrangement in the sea and the pipeline intake and outlet shall not cause any hindrance to the movement of the local communities including the fishermen and the movement of fishing vessels. Any hindrance impacted the livelihood of fishermen partially/entirely during the construction, in particular, construction of intake-well pipeline;

will attract substance grant for the period the livelihood was impacted.

- xiv) The contractor will ensure that there is no displacement of people, housing or fishing activity as a result of the project; as nothing of that sort was observed and envisaged prior to drafting the scope.

16.1.2.2 Provision of First Aid/Medical Facilities and Emergency Response Arrangements

- i) The Construction Safety Plan to be prepared by the Contractor will identify necessary actions in the event of an emergency. This plan will be submitted for Engineer's approval along with the Work Program at the mobilization stage itself.
- ii) The Contractor will arrange for:
 - Readily available first-aid box, including an adequate supply of sterilized dressing materials and appliances, as per rules shall be provided in work zones and at the campsite/s.
 - Registered medical practitioner (Doctor) and trained First Aid personnel will be available at the construction site.
 - Emergency numbers will be displayed at camp, plant and construction sites.
 - Availability of suitable transport at all times to take an injured or sick person(s) to the nearest hospital shall be made.
- iii) The contractor will make required arrangements so that in case of any mishap on the construction site, all necessary steps can be taken for prompt first aid treatment.
- iv) First aid facilities and free emergency care shall be provided to all workforce and third party. No cost shall be recovered from them on this account.
- v) All supervisory staff shall be provided with mobile phones for better communication across operational areas, in case of emergency or otherwise.
- vi) The Contractor shall provide information to his workers on methods of avoiding COVID-19 pandemic, sexually transmitted diseases and infection by HIV/AIDS. The information about the location of camps shall be known to the District Societies for Prevention of COVID-19 and HIV/AIDS. The awareness programs launched for the prevention of COVID-19 and HIV/AIDS should be well documented.

16.1.3 Stakeholder Engagement Strategies, Plan and Implementation

- i) SMP explains interaction with the community, including project information disclosure and emergency response planning relevant for the community. This sub-plan should cover means and methods to inform the affected population about the construction schedule and expected impacts such as access limitation to properties, if any, and also spell out the grievance redressal mechanism available to the communities to ensure any concerns brought to the CMWSSB are resolved appropriately and on time.

- ii) The Contractor shall implement all requirements of the SMP approved by CMWSSB during the entire period of the contract, i.e. during Construction Stage and Operation Stage of the Desalination Plant and associated facilities.
- iii) Operation and Maintenance of aforesaid the Desalination Plant and associated facilities are to be carried out strictly as per the approved SMP and as directed by the CMWSSB and State Norms.

16.1.4 Social Monitoring Plan (SMoP)

- i) SMoP shall be prepared to ensure that the envisaged purpose of the SMoP is achieved across all stages of the project. Performance indicators will be developed for critical social conditions. For each of the indicators, the monitoring plan will specify parameters to be monitored, the location of monitoring sites along with frequency and duration of monitoring. The monitoring plan will also specify applicable standards, implementation and supervising responsibilities and reporting requirements.
- ii) The Contractor shall regularly monitor the quality of the working sites and their surroundings in terms of social performance indicators as specified in SMP and submit the monitoring results to CMWSSB. The Contractor shall also be responsible for periodic submission of Monitoring Reports to the Regulatory Agencies in compliance with requirements of the SMP.
- iii) It may be noted that the status of social monitoring shall be communicated to JICA as part of the Quarterly progress report. JICA would disclose information on the status of social monitoring of the project in collaboration with CMWSSB on its website in order to ensure transparency, accountability and to promote the participation of various stakeholders.

16.2 Work Requirements

16.2.1 Site

The proposed Chennai Perur 400 MLD Desalination Plant (DSP) is located in Nemmeli revenue village, Nemmeli Panchayat in Thiruporur Taluk (Thiruporur Block) of Chengalpattu district (earlier Kanchipuram District), Tamil Nadu State, India. The village is bifurcated into East and West part by the State Highways- 49, i.e. East Coast Road (ECR) towards Mamallapuram. In North-to-South direction. The proposed desalination plant is located in the Eastern part of Nemmeli village and on the shore of Bay-of-Bengal. Moreover, this plant will be constructed about 0.8 kilometres distance on the North of already existing Nemmeli 100 MLD plant.

16.2.2 Socio-economic Profile

Nemmeli village comprises of ten habitations viz.; Pudukalpakkam, Nemmeli, Nemmeli Kuppam, Kannima Nagar, Perur, Perur colony, Sulerikadu, Sulerikadu colony, Sulerikaattu Kuppam and Krishnan Karanai, Out of these ten habitations, Pudukalpakkam, Nemmeli Kuppam, Sulerikaattu

kuppam habitations are on the eastern side of East Coast Road (ECR) with a distance of 1.865 Km, 815 m and 2.365 Km apart respectively. All these three habitations belong to fishermen communities and are covered under the Most Backward Class (MBC) category. Other habitations are on the Western side and are substantially distanced from seashore who would get affected from seawater flood in case of Tsunami and periodic cyclones.

Referring to Chennai Perur 400 MLD DSP; Nemmeli kuppam and Sulerikaattukuppam are two habitations adjacent to the plant in North and South direction respectively. However, from a plant construction and operation perspective, Nemmeli Kuppam habitation is expected to have a more interactive process than other habitations. Hence, a further detail socio-economic aspect of Nemmeli Kuppam is presented below.

There are 166 houses in Nemmeli kuppam, of which owners have occupied 142 houses, and rest are occupied by 24 tenants. All the 166 houses have patta land. After Tsunami devastation in the year 2004, 124 houses were being constructed in by the NGO ‘World Vision’. The total population of this habitation is 442, of which 230 are male, and 212 are female. Of the 166 houses, owners have occupied 142 houses, and 24 tenants are there.

All 142 families of this fishermen habitation practice Hindu religion (Hindu Meenavar Parvatharaja Kulam) and belong to Most Backward category defined by Government of Tamilnadu. Only a few tenants who have come from other areas belong to Most Backward and Backward communities. The habitants are literate and educated, except few people above 80 years old.

Occupationally, in general, men are engaged in fishing and allied activities. Few men are working in the companies and offices during daytimes. Women are engaged in selling of fish in neighbouring areas and dry fish preparation. Educated youngsters are working in offices and companies located in ECR and OMR. Two of them are employed in the existing 100 MLD desalination plant located nearby. Few fishermen are doing fishing in the morning, and during the daytime, they are employed in the local companies. Nearly 30 members (women) from this habitation are employed under “The Mahatma Gandhi National Rural Employment Guarantee” program by Ministry of Rural Development, Government of India. They are getting employment for 100 days in a year on a wage rate of INR 256/day. On an average family earn INR 12000 to INR 15000 per month from fishing activity and around INR 10000 to INR 15000 as their wages from the companies.

There are 4 Self Help Groups run by women of this habitation, and mainly they do microfinance through their loan amount. There is only one Public health sub-centre available for this Nemmeli village panchayat wherein a nurse is available for vaccination and immunization purpose.

16.2.3 Issues and Impact

Chennai Perur 400 MLD DSP is planned to be constructed in a land belonging to M/s Arulmigu Alavandar Nayakkar Trust (a religious and charitable group) maintained by the Hindu Religion and Charitable Endowments (HR&CE) Department of the Government of Tamil Nadu (GOTN)). This land is leased for a period of 30 years to CMWSSB. There are no settlements or households that exist on the portion of the land leased. However, in the DSP site, there are two burial grounds; but the plant layout has been arranged in such a way that no facility would be constructed in the burial grounds. There is open-well with a pump house connected to three-phase line is used for daily water supply through transmission pipeline to Nemmeli Kuppam and Perur colony habitations. In case the construction and operation of the plant will require to interrupt the water supply to the said habitations; alternate arrangement should be placed for uninterrupted water supply prior to disconnecting existing water supply.

16.3 Components for Social Development

16.3.1 Peripheral Development

16.3.1.1 Nemmeli Kuppam Habitation

- i) Landing Centre Protection: During the intake well construction for Chennai Perur 400 MLD DSP there are possibilities of seawater flow towards Nemmeli Kuppam habitation from East-to-West direction causing soil erosion. As a result, the fishermen boat parking area and the landing centre might get affected. Hence, the provisional budget for the purpose needs to be allocated for probable construction activities for the protection of the landscape.
- ii) Community Toilet: One community toilet is present in the southern side of the plant site for the use of Nemmeli Kuppam habitation, which will be inaccessible once the boundary wall of the plant site is constructed. Though currently this community toilet is not in use due to non-availability of water and is dilapidated; provisional budget for community usable toilet needs to be allocated, in case the requirement arises in due course.
- iii) Bore Well for Community Product Water: There is the presence of open-well from where water is pumped through a three-phase connected pump house to Perur and Perur colony on the Western side of ECR. In case the current water supply system to both the habitation is abandoned due to the boundary wall and upcoming plant; provisioning budget for the bore-well system with transmission pipeline to the community storage system to both habitations for the supply of product water is suggested..
- iv) Subsistence Grant for partial loss of livelihoods: Understanding possibilities of livelihood disruption during the construction period of intake well; provisional budget for subsistence grant to one member of primary Fisherman cooperative Society (PFCS) for the period their

livelihood is affected considering 8 months per year as fishing period. In case any of the family member/s employed by the contractor part-time or full-time basis should not be entitled to such a subsistent grant in a typical case. However, there can be flexibility in adhering to the condition according to the ground situation.

v) Public Consultation

While there will be construction and operation of the plant activities, regular public consultations need to be conducted to develop a better understanding among the habitats around the plant area; particularly Nemmeli Kuppam. The public consultation should be recorded audio-visually as well as in print material. Hence, budgetary provision towards this expenditure to be made accordingly.

16.3.2 Dispensary within Plant Premises

In the Nemmeli village, there is one Health Sub-centre that is managed by a Nurse. Hence, understanding the intensity of construction work is suggestive of setting up and operate a dispensary within the plant site during the construction period. Accordingly, 24 hours availability of one doctor and two health support staff within the plant site is felt highly essential. The dispensary should procure essential First aid material, medicines and health kits according to regulatory compliance. In addition, the contractor should procure an ambulance (Multipurpose with advance life support system) for 24 hours availability to cater to the emergency needs. Also, the ambulance service may be extended to the peripheral habitants in the high-end emergency case as part of humanitarian assistance and cordial rapport building.

16.3.3 Public Awareness and Capacity Building

Awareness programmes within the plant site and focussed periphery particularly related to health due to conglomeration of external and local manpower for engagement in the construction of the plant. Apart from HIV/AIDS-related issues; the recent Covid-19 pandemic is alarming for the contractor to conduct periodic health check-up camps within and periphery of the plant site. In addition, towards a goodwill building and long-term livelihood support strategy; vocational/skill development training needs to be conducted.

It is often observed that, there are gaps in understanding social issues by the personnel more involved/focused on engineering technical aspects. Hence, periodical orientation will help to handle some of the sensitive social aspects in the work environment.

16.3.4 Natural Disaster and Relief

The Bay of Bengal and the coast of Tamil Nadu is vulnerable to the impact of the cyclone and other natural disaster like Tsunami. Hence, to address the tragic, natural disaster relief fund should be available for immediate response during and aftermath of such disaster in terms of health and food security. However, this fund does not create scope for infrastructure development.

16.3.5 Engagement of Social specialist to implement and address related issues

Social Specialist having substantial experience in similar activities needs to be appointed by the Contractor after awarding of the contract and before the start of work; to carry out social safeguard intervention activities within the plant premise and the peripheral.

16.4 Technical Schedules for Social Management Plan

The Bidder shall provide his Social Management Plan (SMP) in detail to demonstrate the procedures that will be used to ensure that the social concerns and requirements as outlined in contract conditions are satisfactorily met.

After award of contract and before the start of work, the Contractor shall review the available Social Management Plan (SMP) for the project available below with CMWSSB. The contractor shall duly update the SMP to ensure compliance with all applicable legislation and regulations of State / Central Government and also with Sustainability Guidelines of JICA and IFC Performance Standards on Social Sustainability. The SMP shall incorporate the requirements stipulated in the Project's SIA Report and conditions of approval from State/Centre Regulatory agencies. The SMP shall also clearly define roles, responsibilities, reporting requirement and budgetary allocations for the implementation of mitigation measures. Any revision to SMP shall be submitted by the Contractor to CMWSSB for necessary approval before initiating any groundwork.

The SMP shall identify the potential social impacts from the various construction and operations and maintenance activities to be undertaken in the Contract and set out in detail the approach he will adopt in mitigating these impacts to ensure that the impacts are minor and confined to a short period.

The Bidder shall provide separate descriptions of its proposals for minimizing any adverse social impacts/effects during the construction phase and the subsequent operations and maintenance phase.

CONSTRUCTION, OPERATION AND DECOMMISSIONING PHASE MITIGATION MEASURES FOR DESALINATION PLANT AND ASSOCIATED INTAKE AND OUTFALL UNDERSEA PIPELINES

Required approvals and permits are also needed during operations and decommissioning phase, therefore, CMWSSB needs to ensure the required compliance

Sl. No	Systems/ Impacts	Action to be taken	Time frame	Responsible agencies	Responsible Agency for Review and Monitoring
1.1	Rapid Social Screening	<p>The contractor shall undertake the social screening survey within the proposed project area and identify potential social impacts due to proposed plants construction, operations decommissioning. Social screening should identify but not limited to the following aspects:</p> <ul style="list-style-type: none"> ▪ Permanent and temporary economic and physical displacement of the communities. ▪ Potential impacts of livelihood and income. ▪ Potential impacts on common property resources, fishing area 	Pre-construction, Operations & Decommissioning phase	Contractor	CMWSSB
1.2	Construction of labour camps	<ul style="list-style-type: none"> • Contractor shall follow all relevant provisions of the Contract Labour (Abolition and Regulation) Act, 1970 and the Building and the other Construction Workers (Regulation of Employment and Conditions of Service) Act, 1996 for construction and maintenance of labour camp and other applicable laws. • The location, layout and basic facility provision of each labour camp will be submitted to CMWSSB Engineer prior 	Pre-construction, Operations & Decommissioning phase	Contractor	CMWSSB

Sl. No	Systems/ Impacts	Action to be taken	Time frame	Responsible agencies	Responsible Agency for Review and Monitoring
		<p>to their construction.</p> <ul style="list-style-type: none"> • The construction will commence only upon the written approval of the Engineer. • The contractor shall maintain necessary living accommodation and ancillary facilities functionally and hygienically and as approved by the Engineer. • The contractor shall provide an adequate number of toilets, bathing area, kitchen and safe fuel for cooking. • The labour camps shall be designed to protect from heat, rains, flooding, insects, snakes and mosquitoes. It should have adequate provisions for an emergency response such as first aid and fire safety etc. • All temporary accommodation must be constructed and maintained 			
1.3	Risk Assessment and preparation of management plans	<p>Risk and hazards associated with different construction activities shall be identified by the contractor, and accordingly, management plans shall be prepared for implementation on site such as :</p> <ul style="list-style-type: none"> • Construction Labour Management Plan; • Emergency Response Plan; and • Construction Demobilization Plan. 	Pre-construction Operation & Decommissioning phase	Contractor	CMWSSB

Sl. No	Systems/ Impacts	Action to be taken	Time frame	Responsible agencies	Responsible Agency for Review and Monitoring
1.4	Disaster Management Plan	<ul style="list-style-type: none"> • The CMWSSB shall identify the key risks associated with each component/ activity for entire project life cycle (construction, operations, & decommissioning) and shall prepare Disaster Management Plan (DMP) for the proposed plant. • Further, the DMP for the plant should be synchronized with the district disaster management plan for off-site emergencies. • Contractor shall ensure the availability of required resources for the implementation of DMP at the site and help local communities in handling disaster and emergency response. 	Pre-construction Operation & Decommissioning phase	Contractor	CMWSSB
1.5	Information disclosure and stakeholder consultations	The contractor, in consultation with CMWSSB, shall undertake detailed mapping and analysis of key stakeholders which includes the community. Based on the outcomes of stakeholder analysis, shall prepare and implement a stakeholder engagement plan and regularly update the plan and undertake the proper reporting & documentation (minutes and photographs) of the stakeholder engagements. The CMWSSSB and contractor shall ensure that stakeholder, including impacted communities, are consulted and made aware of the project's outcome, risks/ impacts, mitigation measures and time frame.	Pre-construction Operation & Decommissioning phase	Contractor	CMWSSB

Sl. No	Systems/ Impacts	Action to be taken	Time frame	Responsible agencies	Responsible Agency for Review and Monitoring
1.6	Grievances management	The CMWSSSB and contractor shall establish the formal system for Grievance management (GRM). The GRM should cover the staff, contracted workers and community. The contractor shall ensure the wider publicity of the functioning and availability of GRM and designate the required resources for the effective functioning of GRM. The stakeholders, including communities, shall be made aware of the presence of GRM since the inception of the project.	Pre-construction Operation & Decommissioning phase	Contractor	CMWSSB
1.7	Living and Livelihood	Intake/outfall installation sea areas <ul style="list-style-type: none"> • Visual inspection on turbid water in the sea during installations of intake/outfall pipelines • Pipelines installation schedules • Installation (Construction) Management 	Daily for the installation period	Contractor	CMWSSB
1.8	Social Infrastructure and Services	<ul style="list-style-type: none"> • Implementation of meetings with communities, • Organising awareness camps 	Construction site and surrounding communities where necessary	Contractor	CMWSSB
1.9	Risks of cyclones and tsunami	<ul style="list-style-type: none"> • Contractor shall ensure that adequate measures and communication system is available in case of any natural hazard; • Evacuation plan shall be in place for the site. 	Construction, operation and decommissioning phase	Contractor	CMWSSB

Sl. No	Systems/ Impacts	Action to be taken	Time frame	Responsible agencies	Responsible Agency for Review and Monitoring
2.0	Risk of Pandemic diseases such as COVID-19	Implementation of Health and Sanitation awareness and education	Construction site and surrounding communities Once/Month	Contractor	CMWSSB
2.1	Risk of infectious diseases such as HIV/AIDS	Implementation of Health and Sanitation education on STD.	Construction site and surrounding communities Twice/Year	Contractor	CMWSSB
2.2	Working Conditions/Work Safety	Visual inspection on the utilisation of PPE by workers/labours	Construction site Daily	Contractor	CMWSSB
2.4	Removal of temporary construction Structures and demobilization of construction machinery	<ul style="list-style-type: none"> • Contractor to prepare site restoration plans, the plan is to be implemented by the contractor prior to demobilization. • On completion of the works, all temporary structures will be cleared away, all rubbish cleared, excreta or other disposal pits or trenches filled in and effectively sealed off and the site left clean and tidy, at the contractor's expenses, to the entire satisfaction of the engineer. 	After completion of the project	Contractor	CMWSSB
2.5	Labour camp & facilities	Setting up of labour camps needs to be done as per the above-mentioned guidelines and procedures. <ul style="list-style-type: none"> • Adequate product water facilities, sanitation and drainage, 	Construction operation and	Contractor	CMWSSB

Sl. No	Systems/ Impacts	Action to be taken	Time frame	Responsible agencies	Responsible Agency for Review and Monitoring
		<p>etc., in conformity with the Indian labour laws such as building and other construction workers act and IFC guidelines for workers accommodation, shall be ensured.</p> <ul style="list-style-type: none"> • The contractor shall also guarantee the following: <ol style="list-style-type: none"> i. The location, layout and basic facility provision of each labour camp will be submitted to Engineer prior to their construction. ii. The construction will commence only upon the written approval of the Engineer. iii. The Contractor shall construct and maintain all labour accommodation in such a fashion that uncontaminated water is available for drinking, cooking and washing. iv. Supply of sufficient quantity of product water (as per IS) in every workplace/labour campsite at suitable and easily accessible places and regular maintenance of such facilities. v. The sewage system for the camp shall be designed, built and operated in such a fashion that no health hazards occur and no pollution to the air, groundwater or adjacent watercourses take place. Ensure adequate water supply is to be provided in all toilets and urinals. 	decommissioning phase		

Sl. No	Systems/ Impacts	Action to be taken	Time frame	Responsible agencies	Responsible Agency for Review and Monitoring
2.6	Compliance to Indian labour Laws	<ul style="list-style-type: none"> • The contractor and CMWSSB should ensure the compliance of applicable Indian Labor Laws such as Factories Act 1948, Building and Other Construction Workers act 1996, Inter-State Migrant Workmen Act 1979, Contract Labor (Regulation & Abolition) Act 1971, Workmen Compensation Act 1923 Child Labour Prohibition & Regulation Act 1986, Minimum Wages Act 1948, Employee state insurance Act 1948, Employees Provident fund Act 1991, Payment of Wages Act 1936, Payment of bonus act 1965, Equal Remuneration Act 1976, and Payment of Gratuity Act 1972 and other International Labour organization conversions ratified by India. • Maintain the required document at the site and regularly submit the compliance report to the concerned department and conduct internal and external labour audit. 	Construction/Maintenance, Operations and decommissioning phase	Contractor	CMWSSB & External Auditor
2.7	First Aid	<p>The contractor shall arrange for:</p> <ul style="list-style-type: none"> • A readily available first aid unit, including an adequate supply of sterilized dressing materials and appliances as per the Factories Rules in every work zone. • Availability of suitable transport at all times to take an injured or sick person(s) to the nearest hospital. • Tie up with nearby hospitals. 	Construction, maintenance, operation and decommissioning phase.	Contractor	CMWSSB

Annexures

The following annexures are included with this RFP Report:

Annexure 1 – Social Policy, Legal and Administrative Framework

- Annex 1.1: JICA Environmental and Social Framework
- Annex 1.2: Screening and Categorisation
- Annex 1.3: Regulations, Laws and Permitting
- Annex 1.3: Institutional Arrangements

Annexure 2 – Salient Features of Key Applicable Labour Laws

ANNEXURE 1: SOCIAL POLICY, LEGAL AND ADMINISTRATIVE FRAMEWORK

Annex 1.1. JICA Environmental and Social Framework

JICA requires the consideration of social matters in all aspects of JICA operations and the requirements for social considerations as described in JICA guidelines (April 2010). In addition, adherence to International Performance Standards has been suggested. JICA guidelines endeavours to achieve transparency, predictability, and accountability in support for and examination of social considerations.

Annex 1.2. Screening and Categorisation

The requirement of the JICA's Guidelines is dependent on "project categorization" of the Project, which is stipulated in the JICA's Guidelines, as shown in Table 1. Currently, the Chennai Seawater Desalination Project (the Project) has been classified as "Category B" by JICA. However, in the study, if the project is likely to have any significant adverse impact on the environment and society. the Project may be recategorized as "Category A".

Table 1. Project Category in the JICA Guidelines

Category	Description
A	Proposed projects are classified as "Category A" if they are likely to have significant adverse impacts on the environment and society. Projects with complicated or unprecedented impacts that are difficult to assess, or projects with a wide range of impacts or irreversible impacts, are also classified as "Category A". These impacts may affect an area broader than the sites or facilities subject to physical construction. "Category A", in principle, includes projects in sensitive sectors, projects that have characteristics that are liable to cause adverse environmental impacts, and projects located in or near sensitive areas.
B	Proposed projects are classified as "Category B" if their potential adverse impacts on the environment and society are less adverse than those of "Category A" projects. Generally, they are site-specific; Few, if any, are irreversible; and in most cases, normal mitigation measures can be designed more readily.
C	Proposed projects are classified as "Category C" if they are likely to have a minimal or little adverse impact on the environment and society.

Based on the Initial Environmental Examination carried out by JICA, the proposed Chennai Perur 400 MLD desalination project is categorised under "B". Since the project is not located in a socially sensitive area, nor has sensitive characteristics, nor falls into sensitive sectors under the JICA guidelines for environmental and social considerations (April 2010), its potential adverse impacts on the environment are not likely to be significant. Details of categorisation are available in JICA website:

https://www.jica.go.jp/english/our_work/social_environmental/id/asia/south/india/c8h0vm0000ahdaf4.html

Annex 1.3. Regulations, Laws and Permitting

There are various acts, rules, policies and regulations currently in force in India that deal with social issues that could apply to infrastructure development. Some of the specific regulatory compliance requirements of the subproject are presented below.

i) Tamil Nadu Right to Fair Compensation and Transparency in Land Acquisition, Rehabilitation and Resettlement Rules, 2017

The Act provides for transparent and acceptable fair and enhanced compensation and assistance measures. It stipulates a more consultative and participatory approach in dealing with the Project Affected Persons. It emphasizes the rehabilitation and resettlement of the PAPs before the implementation of the actual project.

ii) The Street Vendors (Protection of Livelihood and Regulation of Street Vending) Act, 2014

This act aims explicitly to protect the rights of urban street vendors and to regulate street vending activities. It provides for Survey of street vendors and protection from eviction or relocation; issuance of a certificate for vending; provides for rights and obligations of street vendors; development of street vending plans; organizing of capacity building programmes to enable the street vendors to exercise the rights contemplated under this Act; undertake research, education and training programmes to advance knowledge and understanding of the role of the informal sector in the economy, in general, and the street vendors, in particular, and to raise awareness.

iii) The Scheduled Tribes and other Traditional Forest Dwellers (Recognition of Forest Rights) Act, 2006.

An Act to recognise and vest the forest rights and occupation in forest land in forest-dwelling Scheduled Tribes and other traditional forest dwellers who have been residing in such forests for generations but whose rights could not be recorded; to provide for a framework for recording the forests rights so vested and the nature of evidence required for such recognition and vesting in respect of forest land.

iv) Right to Information (RTI) Act, 2005

The basic object of the Right to Information Act is to empower the citizens, promote transparency and accountability in the working of the Government, contain corruption, and make our democracy work for the people in the real sense. It says that an informed citizen is better equipped to keep necessary vigil on the instruments of governance and make the government more accountable to the citizens.

v) National Fisheries Policy (Draft) 2020

The policy aims at comprehensive development of the fisheries sector through appropriate interventions to address the critical gaps with an overarching goal for growths in exports, an increase in farmer's income and better choice for consumers. It aims for robust management and regulatory framework with necessary legal backing for effective fisheries resource management through an Ecosystem Approach of Fisheries (EAF) management within the overall framework of relevant national and international instruments, policies and standards. To generate gainful employment and entrepreneurship opportunities along the value chain leading to the higher

income of fishers and fish farmers, improve their living standards and usher in economic prosperity.

vi) Tamil Nadu Marine Fishing Regulation Act 1983 (Amended in 2016)

An act to provide for the regulation, restriction and prohibition of fishing by fishing vessels in the sea along the whole or part of the coastline of the State.

vii) The operational policy of the World Bank on Social Safeguard

- Indigenous People: This policy applies for both positive and negative impacts on tribal population wherever the project activities are undertaken. Accordingly, the policy creates scope to study whether the project will have an impact on any individual or cluster of tribal people during any phase of the project.
- Involuntary Resettlement: Involuntary resettlement should be avoided where feasible, or minimized, exploring all viable alternative project designs. Where it is not feasible to avoid resettlement, resettlement activities should be conceived and executed as sustainable development programs which provide sufficient investment resources to enable the persons displaced by the project to share in project benefits. Displaced persons should be meaningfully consulted and should have opportunities to participate in planning and implementing resettlement programs. Displaced persons should be assisted in their efforts to improve their livelihoods and standards of living or at least to restore them, in real terms, to pre-displacement levels or to levels prevailing prior to the beginning of project implementation, whichever is higher.
- Policy on Access to Information and Disclosure: World Bank safeguards policy requires consultation with PAPs during planning and implementation of resettlement action plan and tribal development plan and public disclosure of drafts. Once the draft is prepared, it is to be made available at a place accessible to, and in a form, manner and language understandable to the displaced or affected people and local NGOs. RTFCTLARR, 2017 also requires disclosure of draft SIA and RAP and other project reports followed by mandatory Public Hearing. Consultations with PAPs or interested people, people in the vicinity of the project area is to be done and public disclosure on the project details, positive/negative social impacts and to get their feedback is to be carried out at appropriate intervals of the project period.

viii) India enacted the Wildlife (Protection) Act 1972

ix) ADB's Safeguard Policy

Safeguard policy statement (SPS) are generally operational policies that seek to avoid, minimize, or mitigate adverse environmental and social impacts, including protecting the rights of those likely to be affected or marginalized by the development process. ADB's safeguard policy framework consists of three operational policies on the Environment, Indigenous Peoples, and

involuntary resettlement and brings them into a consolidated policy framework that enhances effectiveness and relevance. Accordingly,

- i) impacts are to be identified and assessed early in the project cycle;
- ii) plans to avoid, minimize, mitigate, or compensate for the potential adverse impacts are developed and implemented; and
- iii) affected people are informed and consulted during project preparation and implementation.

Annex 1.4. Institutional Arrangements

Under overall direction, guidance and coordination of the CMWSSB Project Implementation Unit (PIU), the perspective contractor will implement Chennai Perur 400 MLS Desalination Plant. The Project Management Consultant (PMC) appointed by Employer comprises of the subject, and sector-specific specialists will provide onsite expert guidance as well as supervise the progress and attainment of drafted specified guidelines by the contractor in compliance with the regulatory mandates. Referring to the Social Management Plan (SMP) and implementation; Social Communication Specialists will be the interacting regular basis with the social specialist appointed by the contractor for social safeguard compliance.

ANNEXURE 1: SALIENT FEATURES OF KEY APPLICABLE LABOUR LAWS

(the law/rules as current on the date of bid opening will apply)

- 1) Payment of Wages Act, 1936: It lays down as to by what date the wages are to be paid, when it will be paid and what deductions can be made from the wages of the workers.
- 2) Minimum Wages Act, 1948: The employer is supposed to pay not less than the Minimum Wages fixed by appropriate Government as per provisions of the Act if the employee is scheduled employment. Construction of buildings, roads, runways etc. are scheduled employments.
- 3) The Building and Other Construction Workers (Regulation of Employment and Conditions of Service) Act, 1996 and the Cess Act of 1996: All the establishments who carry on any building or other construction work and employs 10 or more workers are covered under this Act. All such establishments are required to pay less at the rate not exceeding 2% of the cost of construction as may be modified by the Government. The Employer to whom the Act applies has to obtain a registration certificate from the Registering Officer appointed by the Government.
- 4) Inter-State Migrant Workmen's (Regulation of Employment & Conditions of Service) Act, 1979: The Act applies to an establishment which employs 5 or more inter-state migrant workmen through an intermediary (who has recruited workmen in one state for employment in the establishment situated in another state). The Inter-State migrant workmen, in an establishment to which this Act becomes applicable, are required to be provided certain facilities such as housing, medical aid, travelling expenses from home up to the establishment and back, etc.
- 5) Employees P.F. and Miscellaneous Provision Act, 1952: The Act provides for monthly contribution by the employer plus workers @ 10% or 8.33%. The benefits payable under the Act are:
 - (i) Pension or family pension on retirement or death, as the case may be.
 - (ii) Deposit linked insurance on the death in a harness of the worker.
 - (iii) Payment of P.F. accumulation on retirement/death etc.
- 6) Employees Compensation Act, 1923: The Act provides for compensation in case of injury, disease or death arising out of and during employment by certain employers to their employees for injury caused to them by accident. It enables an employee, and in case of death of an employee, his dependents, to get, at the cost of his employer compensation for employment injury if an employee contracts an occupational disease while in employment, it is also treated under the Act as injury caused by accident.
- 7) The Personal Injuries (Compensation Insurance) Act, 1963: This Act provides for the employer's liability and responsibility to pay compensation to employees where workmen

sustain personal injuries in the course of employment. The employer has to provide workmen with insurance against the liability. The Act describes the term which is of major importance under the Act is called as partial disablement and total disablement.

- 8) Employer's Liability Act, 1938: This Act protects workmen who bring suits for damages against employers in case of injuries endured in the course of employment. Such injuries could be on account of negligence on the part of the employer or persons employed by them in the maintenance of all machinery, equipment etc. in healthy and sound condition.
- 9) Employee's State Insurance Act, 1948: The Act provides for certain benefits to insured employees and their families in case of sickness, maternity and disablement arising out of an employment injury. The Act applies to all employees in factories (as defined) or establishments which may be so notified by the appropriate Government. The Act provides for the setting up of an Employees' State Insurance Fund, which is to be administered by the Employees State Insurance Corporation. Contributions to the Fund are paid by the employer and the employee at rates as prescribed by the Central Government. The Act also provides for benefits to dependents of insured persons in case of death as a result of an employment injury.
- 10) Payment of Bonus Act, 1965: The Act applies to all establishments employing 20 or more employees. The Act provides for payments of annual bonus subject to a minimum of 8.33% of the wages drawn in the relevant year. It applies to skilled or unskilled manual, supervisory, managerial, administrative, technical or clerical work for hire or reward to employees who draw a salary of Rs. 10,000/- per month or less. To be eligible for the bonus, the employee should have worked in the establishment for not less than 30 working days in the relevant year. The Act does not apply to certain establishments. The newly set-up establishments are exempted for five years in certain circumstances. Some of the State Governments have reduced the employment size from 20 to 10 for applicability of this Act.
- 11) Payment of Gratuity Act, 1972: Gratuity is payable to an employee under the Act on the satisfaction of certain conditions - on separation if an employee has completed 5 years of service or more or on death, the rate of 15 days wages for every completed year of service. The Act applies to all establishments employing 10 or more employees.
- 12) Labour (Regulation and Abolition) Act, 1970: The Act provides for certain welfare measures to be provided by the contractor to contract labour, and in case the Contractor fails to provide, the same is required to be provided, by the Principal Employer by Law. The Principal Employer is required to take Certificate of Registration, and the Contractor is required to take a license from the designated Officer. The Act applies to the establishments or Contractor of Principal Employer if they employ 20 or more contract labour.
- 13) Equal Remuneration Act, 1979: The Act provides that no employer shall pay to any worker employed by him in an establishment or employment, remuneration whether payable in

cash or in-kind at the rates less favourable than those at which remuneration is paid by him to the workers of the opposite sex in such establishment or employment. The Act further provides that no discrimination should be made against women at the time of recruitment. The Act also provides for not making discrimination against female employees in the matters of transfers, training and promotions etc.

- 14) Maternity Benefit Act, 1951: An Act to regulate the employment of women in certain establishments for certain periods before and after child-birth and to provide for maternity benefit and certain other benefits. It provides for maternity benefits, including leave, wages, bonus, nursing breaks etc.
- 15) Sexual Harassment of Women at the Workplace (Prevention, Prohibition and Redressal) Act, 2013: This Act defines sexual harassment in the workplace, provides for an enquiry procedure in case of complaints and mandates the setting up of an Internal Complaints Committee or a Local Complaints Committee.
- 16) Child Labour (Prohibition and Regulation) Act, 1986 amended in the year 2016: The Act prohibits employment of children below 14 years of age in certain occupations and processes and provides for the regulation of employment of children and adolescent in all other occupations and processes. Employment of child and adolescent labour is prohibited in the Building and Construction Industry.
- 17) Bonded Labour System (Abolition) Act, 1976: The Act provides for the abolition of bonded labour system with a view to preventing the economic and physical exploitation of weaker sections of society. Bonded labour covers all forms of forced labour, including that arising out of a loan, debt or advance.

CHAPTER - 17

17. LIST OF APPROVED VENDORS/ SUPPLIERS

The bidders shall use the following vendors or equivalent to these vendors to procure the equipment.

S. No.	Equipment	Supplier
1.	DAF	Leopold (Xylem)
		Degremont
		Veolia Water Technologies
		United Engineers
		IDE Technologies Ltd
2.	Cartridge Filters	PARKER HANNIFIN Corporation
		Pall Corporation
3.	High Pressure Pumps	Flowserve Corporation
		KSBAG
		WILOSE
		Sulzer
		Andritz AG
		Ruhrpumpen
		Torishima Pump Mfg. Co. Ltd.
4.	Energy Recovery Device	Flowserve Corporation
		Energy Recovery Inc.
		KSBAG
5.	RO pressure vessels	Bekaert (Protec)

S. No.	Equipment	Supplier
		Pentair pic (Codeline)
6.	RO Membranes	Dow Filmtec
		Hydranautics
		LANXESS AG
		Toray Industries, Inc.
7.	Seawater Supply Pumps (Vertical Turbine)	Flowserve Corporation
		KSBAG
		Sulzer
		WILOSE
		Andritz AG
		Ruhrpumpen
		Torishima Pump Mfg. Co. Ltd.
8.	Cleaning and flushing pumps	Flowserve Corporation
		KSBAG
		WILOSE
		Sulzer
		WEIR
		Andritz AG
		Ruhrpumpen
9.	Air Blowers	Torishima Pump Mfg. Co. Ltd.
		Everest Blowers
		Ingersoll Rand
		Kaeser Compressors
		Swam Pneumatics Pvt Ltd,

S. No.	Equipment	Supplier
		Roots
10.	Product Water Transfer Pump	Torishima Pump Mfg. Co. Ltd.
		Flowserve Corporation
		KSBAG
		WILOSE
		Andritz AG
		Ruhrpumpen
		Kirloskar
11.	Centrifugal Submersible Pumps for Product Water and other pit pumps.	Grundfos
		ABS
		Aqua Machinery
		WILOSE
		Ruhrpumpen
		KSBAG
12.	Special Duplex Material for Piping	Outokumpu
		Sandvik
		ThyssenKrupp AG
13.	Plug Valve	MTS- Victaulic
		KSBAG
		XOMOX
14.	Butterfly Valve	VAG
		Talis Belgicast
		GEMU

S. No.	Equipment	Supplier
		Audco
		BDK
		KSBAG
		Singer
		Tyco (Pentair)
		Bayer
15.	Expansion Joints	Angst+Pfister Idrosapiens KSBAG
16.	HP/LP Check Valve	Goodwin Talis Belgicast KSBAG Singer VAG L&T (Audco)
17.	Dual Plate Check Valve	Talis Belgicast KSBAG Singer VAG Tyco (Pentair) BDK L&T (Audco)
17A.	Valves for Product Water Main (For Treated Water Main)	Tyco KSBAG BDK

S. No.	Equipment	Supplier
		Singer
		VAG
		DVPL
		L&T (Audco)
18	Self Cleaning Filters	Amiad
		STF
		FILTRO
		Taprogge GmbH
		Azud
18 A.	Ultrafiltration	X-Flow (Pentair)
		Inge AG
		Dow
		Hyflux
19.	Air Valves	VAG
		Tyco (Pentair)
20.	Gate Valves	Tyco (Pentair)
		KSBAG
		H. Sarkar
		Bayer
		VAG
21.	Travelling Band Screen	Bilfinger SE
		OVIVO
22.	Chemical Dosing Pumps	Milton Roy Asia LMI
		ProMinent GmbH
		Doaspro

S. No.	Equipment	Supplier
23.	Filter Press	Andritz AG
		Dinshaw
24.	CO2 Generation Plant	ASCO
		Universal Industrial Gases, Inc. USA,
		Trinity Containers LLC.
25.	Gas Chlorination	Capital Control
		Penwalt
		Metito
		Wallaces Tiernan
26.	Air Compressor	Kirloskar Pneumatics
		Ingersoll-Rand
		Atlas Copco
		ELGI Equipments
27.	CRANE & HOIST	Hercules
		Electromech
		Eddy Cranes
		Consolidated Hoist
		W H Brady
28.	Electric Actuators	Rotork
		Auma
		Keystone
29.	Reinforcement Steel	SAIL
		VIZAG STEEL
		Electrosteel Steel Ltd.

S. No.	Equipment	Supplier
		Jindal steel
		Shyam Steel
		TATA
30.	Cement	ACC
		Lafarge
		Ambuja
		Coromandel
		Zuari
		Ultratech
31.	Structural Steel	SAIL
		VIZAG STEEL
		TATA
		Jindal steel
		Shyam Steel
		Electrosteel Steel Ltd.
32.	Ductile Iron Pipes	Electrosteel Steel
		Kobota-TATA
		Jindal
		Srikanthasthi Pipes
33.	Mild Steel Pipes	SAIL
		TATA
		Wellspun
		JINDAL
34.	GRP Piping	CPP
		Protesa
		Amiantit

S. No.	Equipment	Supplier
35.	HDPE pipes & fittings	JAIN IRRIGATION SYSTEMS LTD, DURALINE Timeplast
36.	H.V.A.C	Blue Star Hitachi Volta
37.	Exhaust Ventilation	GEC Almonard Khaitan
38.	Cooling Tower	Crompton Volta Paharpur
39.	Glassed Fused Steel Tanks	Permastore Omerastore Schumann
	ELECTRICAL EQUIPMENT	
1.	Air Circuit Breakers	ABB Alstom BHEL CGL Larsen & Toubro Legrand Schneider Siemens AG
2.	Alternators	AVK/SEGC Leyroy Sommers Stamford
3.	Annuciator (Facia Type)	Digicont Larsen & Toubro

S. No.	Equipment	Supplier
		Procon
4.	Anti Vibration Spring Mounts / Pads	E&B Rubber Metal (EGAMA)
		Resistoflex
5.	Automatic Voltage Regulating Relay (AVR)	ABB
		Alstom
		Emco
6.	Balancing Valves	Advance
		Zoloto
7.	Battery (Ni-Cd / Lead Acid - sealed maintenance free)	Amara Raja
		AMCO
		Chloride / Exide
		HBL Nife
		Sab Nife
8.	Battery Charger & DCDB	Amar Raja
		Automatic Electric
		Caldyne
		Chhabi
		Chloride / Exide
		HBL Nife
		Masstech
		Sab Nife
		Universal
9..	Bimetalic Overload Relay	ABB
		Larsen & Toubro
		Siemens AG
10.	Buchholz Relay	Prayog / Equivalent
11.	Bus Ducts / Bus trunking	Ducati
		Elpro
		Globe Electricals
		Larsen & Toubro
		Legrand

S. No.	Equipment	Supplier
		Schneider
		Stardrive
		United Electric
		Audco
		Castle
		Zoloto
12.	Cable Jointing Kit	Raychem / Equivalent
13.	Cable Termination Kits (HT - Heat Shrunk)	Densons Mahindra (MECP) Raychem
14.	Cable Trays - FRP / GRP	Densons Ercon Indiana Premier Sumip
15.	Cables (1.1 kV Grade XLPE / PVC / FRLS IS 1554)	CCI Finolex Gemscab Lapp Nicco Polycab RPG RR Kable Satna Thermo Cables Universal
16.	Cables (1C Unsheathed Cu - 1.1 kV Grade PVC/FRLS)	Finolex Larsen & Toubro Polycab RR Kable

S. No.	Equipment	Supplier
		Skytone
		Thermo Cables
17.	Cables (Control & Instrumentation)	Delton Lapp Nicco Polycab RPG Satna Thermo Cables Universal
18.	Cables (Power- 11kV UE, XLPE)	CCI Havels ICL INCAB Nicco Polycab RPG Satna Universal
19.	Capacitor Bank (11 kV)	ABB Asian CGL EPCOS Khatau Larsen & Toubro Manohar Brothers / Powercap Meher Unistar Universal
20.	Capacitor Bank (415V)	ABB Asian

S. No.	Equipment	Supplier
		CGL
		Ducati
		EPCOS
		Khatau
		Larsen & Toubro
		Meher
		Powercap
		Unistar
		Universal
21.	Ceiling Fans	Bajaj
		Crompton Greaves
		Havels
		Orient
22.	Change Over Switches	Control & Switchgear
		HPL
		Kirloskar
23.	Circuit Breaker (110kV/ 132kV)	ABB
		Alstom
		BHEL
		Crompton
		Siemens AG
24.	Connector Upto 32 Amps Screw less type	LEGRAND
		Phoenix
		Wago
25.	Contactors / Auxiliary Contactors	ABB
		Larsen & Toubro
		Schneider
		Siemens AG
		Telemecanique
26.	Control & Relay Panel (110kV/ 132kV)	ABB
		Alstom / Areva
		Bharat Bijlee

S. No.	Equipment	Supplier
		CGL
		Easun
		Enpro
		Siemens AG
27.	Control Transformers	AE Kappa Pragathi Precise Salzer
28.	Cooling Tower	Advance Bell Flow Tech Mihir Paharpur
29.	CT&PT (11 /6.6/3.3kV)	ABB Alstom CGL Kappa TELK
30.	CT&PT (110kV/132kV)	ABB Alstom Automatic BHEL CGL Pragati TELK
31.	CTs & PTs	ABB AE Crompton Kappa MECO Pragati

S. No.	Equipment	Supplier
		Precise
		Siemens AG
32.	Diesel Generator	Caterpilar Kriloskar Ashok Leyland Sterling Wilson Cummins
33.	Distribution Boards (Lighting & Power)	Adlec Advance Panel & Swgr Asiatic Switchgears Hensel Pustron Unilec United Electric
34.	Distribution Boards (PCCs / MCCs)	ABB Larsen & Toubro Legrand Pustron Schneider Siemens AG
35.	Distribution Transformer	ABB Alstom / Areva Bharat Bijlee Limited CGL Wilson
36.	Earthing (Maintenance Free)	ALTEC CAPEELECTRIC KASA-ERICO
37.	Electronic Timer	Larsen & Toubro Siemens AG
38.	Emergency Exit Lights	Agni Suraksha

S. No.	Equipment	Supplier
		MK
39.	Energy Meter (Digital)	ABB AE Alstom Larsen & Toubro Siemens AG GE
40.	Energy Saving Lighting Transformer	Indian Transformers Ltd. Rakesh Transformer / Equiv. Transformers & Electrical Transformers & Rectifiers
41.	Engineering Plastics / GRP DB's & Panel Enclosures	Hensel Sumip
42.	Exhaust Fans	Bajaj Crompton Greaves GE Havels
43.	Fuses (Solid State)	Ferraz GE Power Siemens AG
44.	Feeder Pillar (Non-Magnetic Stainless Steel)	ABB Amptech Electric
45.	Fuses with Fuse Base (HRC Link type)	ABB Alstom CGL Cooper Busmann GE Larsen & Toubro

S. No.	Equipment	Supplier
		Siemens AG
46.	Fusible Switches	ABB Alstom Bussman GE Power Siemens AG Larsen & Toubro
47.	Glands (Brass - Single & Double Compression)	Comet Dowell Electromac HMI Lotus
48.	Glands (Brass - Single & Double Compression)	Leader Sant Zoloto
49.	Indicating Lamps	ABB AE Alstom Bhartia Cutler Hammer Binay Larsen & Toubro Siemens AG Teknik Vaishno
50.	Indicating Lamps (LED type)	ABB Binay Larsen & Toubro Raas Controls Siemens AG

S. No.	Equipment	Supplier
51.	Indicating Meters (Analogue / Digital / Taut Band)	Automatic Electric Enercon IMP Larsen & Toubro Meco Rishabh SIEMENS AG
52.	Insulators (110kV/132kV)	AMEI BHEL Jayshree Modern MPL SIL WS Industries
53.	Intelligent Modules / MCCs	ABB Larsen & Toubro Rockwell Schneider Siemens AG
54.	Isolator (110kV/132 kV)	ABB Elpro GR Power S&S Siemens AG SMC
55.	KW Transducer	ABB Alstom Canopus Larsen & Toubro Rishabh Siemens AG
56.	Lamps	Bajaj

S. No.	Equipment	Supplier
		GE
		Osram
		Philips
57.	Lightning Arrestors (98kV /110kV)	ABB Alstom ALTEC CAPE ELECTRIC CGL Elpro Jayshree Lam co OBLUM
58.	Liquid Resistance Starters (LRS), Grid Rotor Resistance (GRR)	BCH Enterprising Pioneer Resitech
59.	Load Break Switch	ABB Alstom H.H.E(Elecon) Larsen & Toubro Siemens AG
60.	Lugs (Copper)	Comet Dowell Forward HMI Lotus
61.	Luminaires	Bajaj Crompton GE Philips Wipro

S. No.	Equipment	Supplier
62.	Magnetic Oil Level Indicator	Sukrut/ Equivalent
63.	MCBs, ELCB's, RCCB's & MCB DBs	ABB
		Alstom
		GE
		Larsen & Toubro
		Legrand
		Schneider
		Siemens AG
64.	Meters / Multi Function Meter (Digital / Microprocessor Based)	ABB
		Automatic Electric
		Conserve
		Enercon
		IMP
		Larsen & Toubro
		MECO
		Neptune
		Rishabh
		Secure
		Siemens AG
		Socomac
65.	Motors (LT 415 V, 690V & HT 11 / 6.6 / 3.3 kV)	ABB
		BBL
		BHEL
		CGL
		KEC
		Siemens AG
66.	Moulded Case Circuit Breaker (MCCB)	ABB
		Alstom
		Larsen & Toubro
		Legrand
		Schneider

S. No.	Equipment	Supplier
		Siemens AG
67.	Neutral Grounding Resistance	Cutler Hammer
		National
		Ohmark
		Pioneer Electricals
		Resitech
		RSI
		SR Narkhede
68.	Oil / Winding Temperature Indicators	Perfect Controls
		Scientific Controls
69.	OLTC Mechanism	Crompton
		CTR
		Easun MR
70.	Plug & Socket Units (20/32A Metal Clad / Moulded)	Clipsal
		Hensel
		Legrand
		Pustron
71.	Plug & Sockets (Computer)	AMP
		AVAYA
		SIMON
		SYSTIMAX
72.	Poles (MS/FRP/GRP)	Bajaj Sumin
73.	Power Transformers (Oil & Dry Type)	ABB
		Alstom / Areva
		Bharat Bijlee (BBL)
		CGL
		EMCO
74	Protection Relays (Conventional / Electromechanical)	ABB
		Alstom / Areva
		BCH

S. No.	Equipment	Supplier
		Easun
		GEC
		L&T
		Minilec
		Omron
		Schneider
		Siemens AG
75.	Protection Relays (Numerical / Microprocessor based)	ABB Alstom BCH Easun GEC Larsen & Toubro Minilec Schneider Siemens AG
76.	Protection Relays (P.F. Correction)	ABB Alstom DUCATI Larsen & Toubro SIGMA
77.	Push Button Stations	Asiatic Controls & Switchgear Powergear Pustron United Electric
78.	Push Buttons	ABB Bhartia Cutler Hammer Larsen & Toubro Siemens AG Teknic Vaishno

S. No.	Equipment	Supplier
79.	Rotary / Toggle Switches	ABB Alstom Kaycee Larsen &Toubro Siemens AG Switron
80.	SCRs and Diodes	ABB BHEL Hind Rectifier Schneider Siemens AG Usha Rectifier
81.	Selector Switches (Rotary Type)	Kaycee Larsen & Toubro Salzer Siemens AG
82.	Selector Switches (Voltmeter / Ammeter)	ABB Kaycee Larsen&Toubro Salzer Siemens AG
83.	Series Reactor (11 kV)	ABB Mehar PS Electricals Sagaon Power Shrihans Universal
84.	SFU, Load Break Switches, Fuses	ABB GEPC L & T Schneider Siemens AG

S. No.	Equipment	Supplier
85.	Shunt Release	ABB
		Alstom
		Larsen & Toubro
		Siemens AG
86.	Single Phasing Preventer	ABB
		Larsen&Toubro
		Siemens AG
87.	Sockets (230 Volt, 20 Amps & 24 Volt, 10 Amps)	Hensel
		Legrand
		MDS
		Pustron
88.	Soft Starters	ABB
		CGL
		Schneider
		Siemens AG
89.	Switchboards (110kV / 33 kV / 11kV - VCB Panels)	ABB
		Alstom / Areva
		Siemens AG
90.	Switches, Fan Regulators & Sockets	Clipsal
		Legrand
		MK
		Siemens AG
91.	Tacho Generators	Allen Bradley
		EFKTOR-IFM
		STROTER
		Telemecanique
92.	Telephone Tag Blocks	KRONE
		POYUTS
93.	Terminal Block (Screw less type)	Phoenix
		Wago
94.	Terminal Blocks	Connectwell
		Elm ex

S. No.	Equipment	Supplier
		Essen
		Phoenix
		S & S
		Wago
95.	Timer (Pneumatic / Electronic)	ABB Bhartia Cutler Hammer Larsen & Toubro Siemens AG
96.	Trivector Meter (Digital)	ABB Alstom Enercon GE Larsen & Toubro Siemens AG
97.	Vaccum Circuit Breaker (Indoor & Outdoor)	ABB Alstom / Areva Siemens AG
98.	Vacuum Contactors	ABB Alstom / Areva BHEL CGL Siemens AG
99.	Variable Frequency (Speed) Drives	ABB Larsen & Toubro Siemens AG
100.	Welding Socket, 63 Amps With Interlocking Switch	ABB Hensel Pustron Siemens AG
	CONTROL & INSTRUMENTATION	
1	Air Filter Regulator	Placka

S. No.	Equipment	Supplier
		Schrader-Schovill
		Shavo-Norgren
2	Annunciation System	IIC
		Instrumentation Ltd
		Lectrotek
		Minilec
3	Auxiliary Relays	OEN
		Siemens AG
4	Barrier	MTL
		Obo Bettermann (Cape Elect. Corpn.)
		P&F
5	Battery (Ni-Cd / Lead Acid - sealed maintenance free)	Amara Raja
		AMCO
		Chloride / Exide
		HBL Nife
		Sab Nife
6	Battery Charger & DCDB	Amar Raja
		Automatic Electric
		Caldyne
		Chhabi
		Exide
		HBL Nife
		Masstech
		Sab Nife
7	Cable Glands	Universal
		Comet
		Dowell's Elektro Werke
		Gland Mech Industries
8	Cable Power	Sunil And Company
		Finolex
		Havell's India Ltd.

S. No.	Equipment	Supplier
		KEI Industries
		Nicco
		Polycab
		Uniflex Cables
		Universal cable Ltd
9	Cable Trays - FRP / GRP	Densons Ercon General composites Indiana Premier Sumip
10	Cables (Control & Instrumentation)	CMI Delton Finolex Havells KEI Industries Lapp Nicco Polycab RPG Special Cables Pvt Ltd TCL Thermo Cables Universal
11	Cables (Data - CAT-VI)	AMP AVAYA SIMON SYSTIMAX
12	Cables (Telephone)	Delton Finolex Skytone

S. No.	Equipment	Supplier
13	CCTV	Honeywell Panasonic Pelco Sony
14	CCTV System Controller	Honeywell Panasonic Pelco Sony
15	CCTV Monitor / Large Screens	LG Panasonic Samsung Sony
16	Chlorine Measurement	ABB Chemtrac ProMinent GmbH E&H YIL
17	Computer	Compaq Dell HP IBM
18	Control Desk, I/O Panels& PLC Panels / Consoles	Chemin Instrumentation Limited Lotus Pyrotech Control India Rittal Siemens AG
19	DC Power Supply Unit	Aplab Elnova Phoenix Schneider

S. No.	Equipment	Supplier
		Siemens AG
20	DCS Display Unit	LG
		Philips
		Samsung
21	Digital Indicator	Chino
		Laxsons
		Lectrotek
		Master Electronics Pyrotech Instruments
		Micro systems
22	DP type Flow / Level Transmitters	ABB
		Chemtrols (Fuji)
		Emerson (Rosemount),
		Honeywell
		Siemens AG
		Yokogawa
23	Earthing (Maintenance Free)	ALTEC
		CAPEELECTRIC
		KASA-ERIC
24	Electrical Actuator	Auma
		Beacon Rotork
		IL (Vaas Bernard)
		Keystone
		Limitorque
		Marsh
25	Electro- Pneumatic Positioner	Dresser Industries (Masoneilan)
		Samson Controls.
		Siemens AG
26	Electro-Hydraulic Actuator	Askania
		Reineke
27	Electromagnetic Flow Meter	ABB
		Emerson (Rosemount)

S. No.	Equipment	Supplier
		Endress & Hauser.
		Krohne - Marshall
		Siemens AG
		Yokogawa
28	Ethernet Switch & Terminal Server	Cisco Extreme IBM Nortel Networks
29	Fiber Optic Cables	Amp Krone Molex
30	Fire Detection & Alarm System	GE/ EST Honeywell Monely/AS Notifier
31	Flow Switch	D.K. Instruments Krohne-Marshall Siemens AG Levcon Switzer
32	Fuses with Fuse Base (HRC Link type)	ABB Alstom CGL Cooper Busmann GE Larsen & Toubro Siemens AG
33	Glands (Brass - Single & Double Compression)	Comet Dowell Electromac HMI Lotus

S. No.	Equipment	Supplier
34	Hand Held Calibrator	Emerson
		Honeywell
		YIL
		REX
35	Input Converters	ABB
		Fisher-Xomax
		Forbes Marshall (Moore products)
		MIL controls
		Shreyas-Barton
36	Impulse Pipe & Fittings	Parker Hannifin Corporation
		Swagelok,
37	Instrument Panels	Instrumentation Ltd
		Pyrotech
		Rittal
38	Instrument Transformer	Automatic Electric Ltd.
		Indcoil Manufacturing Company
		National Engineering Corporation
39	Instrument Tubing	Apex Tubes Pvt Ltd.
		Choksy Tube Co Ltd.
		Maharashtra Seamless Ltd.
		Ratnamani Metal & Tubes Ltd.
		Saw Pipes Ltd , Zenith Ltd.
		Swage lock
40	Junction Boxes, Transmitter Protection Boxes	Baliga
		Flame Proof Equipment Pvt. Ltd.
		Flamepack
		Sudhir Switch Gears Pvt. Ltd.,
41	Large Video Screen Display	Barco
		Sharp

S. No.	Equipment	Supplier
		Viewsonic
42	Level (Ultrasonic Type) Transmitter	ABB Chemtrols (Fuji) Chemtrols (Vega) Emerson (Rosemount) Endress & Hauser Honeywell Krohne Marshall Siemens AG Yokogawa
43	Level Gauge (Magnetic & Reflex Type)	Levcon Instruments Chemtrols (Vega) Endress & Hauser Level-Tech Nivo Controls Pratolina Instruments SBEM Sigma Switzer Instruments Techtrol Waaree Instruments
44	Level Switch (Capacitance / RF Type)	Chemtrols (Vega) Endress & Hauser Level-Tech Nivo Controls SBEM Switzer Instruments
45	Level Switch (Conductivity Type)	Chemtrols (Vega) Endress & Hauser Level-Tech Nivo Controls

S. No.	Equipment	Supplier
		SBEM
		Switzer Instruments
46	Level Switch (Float type)	D K Instruments Emerson (Mobrey) Forbes Marshall Levcon Instruments SBEM Techtrol Trac
47	Limit switches	Bhartia Cutler Hammer Electromag Electronic & Power Control Company Honeywell Automation (1) Ltd Jayashree Electronics Kaycee Siemens AG Speed 0 Controls Pvt Ltd Telemechanique L & T
48	Lugs (Copper)	Comet Dowell Forward HMI Jainson Lotus
49	Master Station	Limitorque Rotork
50	MCBs, ELCB's, RCCB's & MCB DBs	ABB Alstom GE Larsen & Toubro

S. No.	Equipment	Supplier
		Legrand
		Schneider
		Siemens AG
51	Microprocessor based Controller (One Loop / Two Loop)	Chemtrols (Fuji).
		Eurotherm
		Honeywell
		Siemens AG
		Yokogawa
52	Network Rack	APW
		NETRACK
		PRESIDENT
53	Orifice Plate & Flanges Assembly / Venturi, Flow Nozzle	Chemtrols-Samil
		Engineering Specialities
		Hydro-pneumatics
		Instrumentation ltd.
		Micro-precision
54	ORP / pH / Conductivity Measurement	ABB
		Ametek
		Emerson (Analytical),
		Forbes Marshall (Polymetron)
		Foxbro
		Hertman & Brown
		Honeywell
		Ion Exchange
		ProMinent GmbH
		Siemens AG
		Servomax
		Yokogawa
55	Panels/ Auxiliary Panels/ Control Desk,	BCH

S. No.	Equipment	Supplier
		Hoffmann
		Pyrotech
		Rittal
		Siemens AG
56	Passive Components including FO Cable	AMP
		Krone
		Molex
		Sysyimax
57	Plant Control System / Process Controller Distributed Control System (DCS)	ABB
		Emerson (Rosemount)
		Honeywell
		L&T
		Rockwell Automation
		Schneider
		Siemens AG
		Forbes Marshall
		Yokogawa
58	Plug & Sockets (Computer)	AMP
		AVAYA
		Pustron
		SIMON
		SYSTIMAX
		Anchor
59	Pneumatic Actuator	ABB
		Dresser Industries (Masoneilan)
		Fisher-Xomox
		Forbes Marshal (Area)
		Instrumentation Ltd. (Palghat)
		MIL Controls
		Samson Controls
60	Pneumatic Positioner	ABB

S. No.	Equipment	Supplier
		Dresser Industries (Masoneilan)
		Fisher-Xomox
		Forbes Marshall (Area)
		Instrumentation Ltd. (Palghat)
		Auma
		Samson Controls
61	Pressure / Differential Pressure Gauge	AN Instruments
		General Instruments
		Manometer India
		KSBAG
		Siemens AG
		Waaree instruments
		Walchandnagar (Tiwac).
		WIKA
62	Pressure / Differential Pressure Switches	Indfoss
		Switzer
		Vasutech
63	Pressure / Differential Pressure Transmitter	ABB
		Chemtrols (Fuji)
		Emerson (Rosemount)
		Honeywell
		KSBAG
		Siemens AG
		Yokogawa
64	Pressure Relief Valve	Tyco Sanmar
		KSBAG
		Instrumentation Ltd.
		Keystone valves Ltd.
		Sebim valves
65	Printer	Canon

S. No.	Equipment	Supplier
		Epson
		HP
		TVSE
		Wipro
66	Public Address System & Associated Equipments	Philips/ BOSCH
		Neumann
67	Relays & Contactors	JVS Electricals
		ABB
		Omron
		Siemens AG
68	Rotameters	Eureka instruments. Chemtrols
		Instrumentation Engineers
		Krohne-Marshall
		Trac
69	Rotary / Toggle Switches	ABB
		Alstom
		Kaycee
		Larsen &Toubro
		Siemens AG
		Switron
70	SCRs and Diodes	ABB
		BHEL
		Hind Rectifier
		Schneider
		Siemens AG
		Usha Rectifier
71	Selector Switches (Rotary Type)	Kaycee
		Larsen & Toubro
		Salzer
		Siemens AG
72	Self Regulating Pressure Control Valve	Forbes Marshall

S. No.	Equipment	Supplier
		Instrumentation Ltd.
		Nirmal Industries
		Samson Controls
73	Signal Isolators	MTL, Stahl Chino Forbes Marshall (Protech) Pepperl & Fuchs Yokogawa
74	Sockets (230 Volt, 20 Amps & 24 Volt, 10 Amps)	Hensel Legrand MDS Pustron
75	Soft Starters	ABB CGL Schneider Siemens AG
76	Solenoid Valve	Asco Avcon Herion, Rotex Juromatic Schrader-Schovill
77	Speakers, Audio System	BOSCH BOSE PHILIPS
78	Surge Protection Device	MTL Obo Bettermann (Cape Elect. Corpn)
79	Telephone Tag Blocks	Krone Poyuts
80	Temperature Gauges	AN Instruments General instruments Manometer India

S. No.	Equipment	Supplier
		ODIN
		Waaree instruments
		WIKA
81	Temperature Switch	AN Instruments General Instruments Indfoss Manometer India Switzer Vasutech WIKA
82	Temperature Transmitter	ABB Chemtrols (Fuji) Emerson (Rosemount) Honeywell Siemens AG Yokogawa
83	Terminal Block (Screw less Type)	Phoenix Wago
84	Terminal Blocks	Connectwell Elm ex Essen
		Phoenix S & S Wago
85	Terminals	Elm ex Phoenix Wago
86	Thermocouple & RTD / Thermowell	General Instruments Industrial Nagman Instruments Pyroelectric Instruments Tempsens

S. No.	Equipment	Supplier
		Toshniwal Industries
87	Thermocouple Compensating Cable	General Instruments
		Paramount
		Therm cables
		Toshniwal Cables
		Udey Pyrocables
88	Turbidity Measurement	ABB
		E&H
		GE Instrumentation
		YIL
89	UPS	Amar Raja
		APC
		Chloride (Emerson)
		DB Power Electronics
		Emersion Process Management
		GE
		Hirel Electronics Ltd
		PCI
		Siemens AG
90	Vibration Monitoring System	Bentley Nevada
		Schenk Avery Corporation
		SPM Instruments
91	Wireless Data Communication System	Motorola
		SPM Instruments
		Radwin
91	Wireless Data Communication System	Motorola
		Radwin