******CHENNAI METROPOLITAN WATER SUPPLY & SEWERAGE BOARD**

**TENDER NO: CMWSSB/CNT/WSS/ICB/JICA/DESAL/CP01/\_018\_/2020-21**

**LOAN AGREEMENT NO. ID-P267**

**JICA FUNDED PROJECT**

**BIDDING DOCUMENT**

**FOR**

**PROJECT FOR CONSTRUCTION OF CHENNAI**

**SEAWATER DESALINATION PLANT (I)**

**PART-II**

**(EMPLOYER’S REQUIREMENTS)**

**(VOLUME 1 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 |

**Date of Issue of Bidding Document:** xx/xx/xx

PART-II- EMPLOYER’S REQUIREMENTS

**Section VI. Employer’s Requirements**

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**CHAPTER-1**

# PROJECT REQUIREMENTS

## Background to the Project

The Chennai Metropolitan Area (CMA) is facing chronic water shortage due to the lack of rainfall and the increasing population and growing economy. The surface water from the rivers and reservoirs, as well as the groundwater, has been the major water resources for the CMA. However, the yields from such conventional water resources are not stable because of the frequent droughts.

The supply of potable water in the CMA is not sufficient to meet the water demand in the area. It is revealed that in wide areas of Chennai, the service continuity is only three to four hours a day. As per the estimate of the Chennai Metropolitan Water Supply and Sewerage Board (CMWSSB), the estimated water production in 2015 was about 686 million liters per day (MLD) against the demand of 933 MLD. To secure sufficient water supply for the people and industries, the State Government of Tamil Nadu (GoTN) decided to construct seawater desalination plants (DSPs) as one of the reliable water resources, which would not be subjected to the recurring droughts.

At present, two DSPs, one in Minjur (100 MLD) and another in Nemmeli (100 MLD), are already operational in the CMA, but the water demand is not yet satisfied. In order to further augment the water supply, GoTN has awarded a contract for construction of DSP of 150 MLD at Nemmeli and also has initiated construction plan for a DSP of 400 MLD capacity at Perur (Chennai Seawater Reverse Osmosis Desalination Plant). Following the state government's direction, the CMWSSB prepared the detailed project reports (DPRs) for the 400 MLD project, and the Government of India (GoI) approved the DPR and proposed the construction of Perur 400 MLD DSP for Japanese Official Development Assistance (ODA) loan. Subsequently, the Japan International Cooperation Agency (JICA) carried out the Preparatory Survey on Chennai Seawater Desalination Plant Project. After prolonged deliberation, an agreement was signed between GoI, GoTN and the loan provider JICA on March 29, 2018 to construct the 400 MLD desalination plant at Perur, Chennai.

Through this tender, Chennai Metropolitan Water Supply and Sewerage Board intends to construct a Seawater Reverse Osmosis (SWRO) based 400 MLD desalination plant at Perur, Chennai, Tamil Nadu, India to augment further the drinking water supply to the city of Chennai. The said installation shall have a total product water capacity of 400 MLD.

This project involves the construction of intake and outfall structure along with the required pipelines, construction of pre-treatment processes, SWRO desalination plant, remineralisation plant, GIS-based electrical substations and other allied processes and units to build a complete operating plant within the proposed site premises for the production of 400 MLD product water of the required drinking water quality. After successful completion of testing and commissioning of works, the Plant shall be operated and maintained for 20 years under Design Build Operate (DBO) basis. The Contractor shall be responsible for all the works related to the construction and 20 years O&M of the Plant as per the provisions of the contract.

## Description of the Works

### The Works

For the purpose of this Tender, the **Work(s)** is the construction of Seawater Reverse Osmosis (SWRO) Desalination plant at Perur, Chennai with seawater intake and brine outfall, pre-treatment, RO system, post treatment, sludge treatment facility and all other works at the site followed by 20 years of operation and maintenance (O&M) as per the Conditions of Contract to produce net 400 MLD product water of the required quality. All technical requirements have been given in the Employer’s Requirements and so the Employer’s requirements may be construed as the technical requirements.

### Description of the Works

The main purpose of this project is to construct a 400 MLD Seawater Reverse Osmosis (SWRO) Desalination plant at Perur, Chennai and operate the Plant automatically without any trouble. The contractors are encouraged to visit the plant site and understand the site location and requirements to construct the Plant. If additional works are needed which have not been mentioned in the tender documents or in the Schedule of Costs, then Contractors must identify those additional works separately and include in the offered cost in the corresponding schedules. The Plant will be built in two completely separate streams of 200 MLD each. All the process units, storage tanks, chemical buildings shall be kept separate for the two streams with only a common intake and outfall system, CWR and sludge treatment system. The major areas of works included but not limited to the following are given below:

1. Seawater intake system with Intake head, pipeline, intake well (forebay), band screens and pumping station
2. Pre-chlorination – Shock chlorination, air bursting system, hypochlorite storage and dosing system
3. Inlet structures, flash mixing and distribution chambers
4. Chemical building, acid, coagulant/flocculant storage and dosing systems
5. Flocculation and clarification system with tube settlers
6. Dissolved air flotation system
7. Gravity dual media filtration system
8. Micron cartridge filters
9. Reverse osmosis desalination system with all chemical storage and dosing systems
10. Remineralisation system (limestone filters) with CO2 storage and dosing system
11. Post-chlorination - Hypochlorite storage and dosing system
12. pH adjustment with caustic soda
13. Sludge treatment with thickeners and belt press filters
14. Brine outfall system with waste tanks, pipeline and offshore diffusers
15. Service water system and all yard pipes at the site
16. All electrical and instrumentation equipment
17. MCC rooms, all substations (230/110 kV, 110/11 kV, 11/0.433 kV) and cable system
18. DG sets for emergency lights and safe shut down of plant in case of power failure
19. Distributed Control System
20. All buildings and all concrete and metal tanks at the site
21. Mechanical and electrical workshop and warehouse
22. All other allied systems, as indicated in the technical specifications and required for the DSP.

The detailed technical specifications of the above works have been provided in the following documents of Section VI, Part-2.

**Section VI: Employer’s Requirements**

1. Technical Specifications
2. Project requirements
3. Site details
4. Particular Process Requirements
5. General requirements
6. Particular civil requirements

5A. General civil requirements

5B. Specifications for Architectural, Landscaping and MEP works

1. Pipelines, pipework and fittings
2. General mechanical requirements
3. General electrical requirements
4. General instrumentation, control and automation requirements
5. Inspection and testing requirements
6. General painting and protection requirements
7. Training and advisory requirements
8. Operation and maintenance
9. Hand over
10. Environmental management plan
11. Social management plan
12. Investigation Report
13. EIA Report including CRZ Clearance
14. Bathymetry Survey Report
15. Seawater Sample Analysis Report
16. Brine Diffusion Report
17. Geotchnical Report
18. Drawings
19. Site Drawings
20. Process Drawings
21. General Arangement Drawings
22. Electrical Drawings
23. Instrumentation, Control and Automation Drawings

### Scope of the Works

The Scope of Works under Contract shall include the design, supply, construction and installation, commissioning, testing, process proving, documentation and process proving of the 400 MLD seawater desalination plant at Perur, Chennai followed by the operation and maintenance for 20 years on Design Build Operate (DBO) basis. The Works shall be executed as per the Technical Specifications. The design criteria and indicative design parameters have been proposed in the technical specifications and the bid evaluation shall be based on the same. The contractor may propose his own design parameters with sufficient justifications during detailed design phase of the plant. This part of the specifications should be read in conjunction with other parts of the specifications, drawings and appendices which provide further scopes and details.

The Works include all process, mechanical, electrical, civil, instrumentation and control, and all other allied works required for the construction of the 400 MLD seawater desalination plant with a sludge treatment and waste disposal facilities. The Plant shall be built in two similar process streams - each of 200 MLD capacity and fully separated to each other. The intake pumping system shall be common for both the process streams. The Plant shall be fully automated and complete in all respect to the world-class standard even though the specifications in this bid documents do not cover the complete requirements. Provision to turn down the production capacity below 50% mainly during Monsoon period and/or as advised by the Engineer shall be included in the design. Hereinafter, the “Engineer” means the “Employer’s Representative” or the person named as such in the Particular Conditions of Contract, Part-III. Both the words “Employer’s Representative” and “Engineer” are used interchangeably in the bidding document and have the same meaning.

The Contractor shall be fully responsible to ensure that the whole of the Works, including each plant component, is designed and constructed in a manner so that the System as a whole operates as a fully integrated system which is capable of achieving the required output efficiently and economically, including all the Plant, equipment and accessories required for the safe and satisfactory operation of the facilities. To achieve this, the Contractor shall ensure that each individual component performs in a manner which is complementary to that of all other components. Accessories which are not specifically mentioned in the specifications but are usual or necessary for the completion of the Works and successful performance of the System and facilities shall be provided by the successful Bidder within the tendered cost. The Contractor shall, to the maximum extent practical and feasible, endeavour to standardise on the manufacture and supply of Plant and equipment to minimise the operation and maintenance requirements. The Contractor shall ensure that his designs are "maintenance-friendly" and that all items of Plant and equipment are designed and installed in a manner which will facilitate routine and periodic maintenance operations.

Apart from the above, the works to be executed by the bidder shall include but not be limited to the following. The details of the works have been covered in the civil, electrical/Instrumentation, mechanical and other specifications of Part-2.

1. Elevating the site land up to CD +6.5m to protect the Plant from strong and high waves during Tsunami.
2. Construction of internal roads, including connecting roads to site from existing East Coast Road (ECR) to have separate and independent entries to plant/site.
3. Stormwater drainage within battery limits and extension up to the nearest drain/point of disposal. Stormwater has to be collected on the plant site and to be used for rainwater harvesting as much as possible and rest to be directed to the sea through outfall tank.
4. Drinking water & sanitation water system for operation & maintenance personnel, yard lighting and fencing around equipment/ units, etc.
5. Construction of permanent boundary walls and internal fencing, entry gates and lighting including any temporary fencing required during construction as per the contract.
6. Solar Street lighting to illuminate the street as per specification in the contract.
7. Ventilation system for all buildings and units, air conditioning system as needed, cranes and hoists, fire fighting system, workshop, tools & tackles for handling of the equipment during maintenance.
8. Commissioning spares parts
9. The laboratory complete with instrumentations and equipment for testing and efficient operation of the Plant. A list of laboratory items and equipment to be provided by the contractor is as given in the contract.
10. Site services as required for the construction, commissioning and O&M of the RO Plant till handover.
11. Lay-down areas, warehouses, workshops for site construction and prefabrication purposes, vehicles, mobile equipment etc.
12. The Plant shall be built with minimal leakage. Water leakage if any shall be transferred to the plant intake well. Leakages have to be monitored, counted in m³/d and be part of the reporting. Maximum % of leakages must be stated by the bidders in the process description/ water balance and to be part of the O&M contract.
13. A minimum of 6 Metro Water Engineers/ personnel will be trained every year on-site for at least two months or as advised by the Employer in every plant function during regular O&M period." Necessary staff of the Chennai Metropolitan Water Supply & Sewerage Board (CMWSSB) shall be deployed to the site of the Plant for supervision/participation during construction and operation.
14. The Plant shall be connected to the national Tsunami warning system directly. In case of a Tsunami warning, an alert shall be issued. A programme shall be introduced so that the Instrumentation and Control System of the Plant shall set the Plant into a safe mode (including backflushing/ cleaning of membranes with desalinated water, closing all interconnected valves to the membranes and shutting down all electrical devices) with minimum interaction of an operator to minimise the damage to the Plant. The evacuation of the staff shall be planned and executed according to an occupational health and safety system. A yearly mock drill shall be conducted in the presence of CMWSSB officials to secure the operation of the Tsunami Response System. The result of this mock drill shall be reported to CMWSSB. The distributed control system (DCS) shall allow remote control of the Plant from CMWSSB’s office room.
15. The Contractor shall comply with requirements specified under Environment (Protection) Act, 1986, and Water (Prevention and Control of Pollution) Act, 1974, Air (Prevention and Control of Pollution) Act, 1981 and Noise Pollution (Regulation and Control) Rules, 2000 and Hazardous Material (Management, Handling and Transboundary Movement) Rules, 2008 as applicable to the project and also with all other applicable current legislation, regulations and specifications, with respect to all measures, operations and administrative steps required for the full protection and safeguarding of the environment.
16. The CMWSSB is responsible for obtaining necessary permits/clearances from the State/Centre Regulatory agencies, namely Coastal Regulation Zone (CRZ) Clearance under CRZ Notification 2011, Consent to Establish from Tamil Nadu State Pollution Control Board (TNPCB) and Approval / NOC from the Forest Department for the Wildlife Conservation and Management Plan. Other than the permits/ clearance as specifically mentioned above, the Contractor shall be responsible for obtaining necessary statutory permits/clearances from the State/Centre Regulatory agencies under the applicable laws namely Consent to Operate from TNPCB and others as applicable to the project and comply with all such requirements during the entire period of the contract, i.e. during Construction Stage and Operation Stage.
17. After award of the contract and before the start of work, the Contractor shall review the Environmental and Social Management Plan (ESMP) for the project available 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 on Social and Environmental Sustainability. 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 the implementation of mitigation measures. The revised ESMP shall be submitted by the Contractor to CMWSSB for necessary approval before initiating any groundwork.
18. The ESMP updated by the Contractor shall include all required Sub-plans. The Sub-Plans to the ESMP to be prepared by the Contractor shall include but not be limited to:
    * *Stakeholder Engagement Plan* which 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 affected population about 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 in a timely manner.
    * *Waste Management Plan* covering brine discharge / solid disposal and compliance with regulatory standards. The plan shall contain quantities and type of waste as well as the type of disposal. It shall cover all waste generated such as brine, pre-treatment sludge, CIP wastewater, solids, R.O. membrane etc. The design of the outfall shall comply with EIA study and waste disposal regulations as per the Ministry of Environment, Forest and Climate Change, Government of India (MOEFCC) and State Pollution Control Board (SPCB). The quality of return water to be discharged into the sea shall meet TNPCB requirement (tolerance limit for the discharge of trade effluents into Marine Coastal Areas as per Water (Prevention and control of pollution) Act, 1974). The used RO membranes shall be disposed of in compliance with Indian laws and regulations. The way of disposal will be reported regularly to CMWSSB. Confirmation of official disposal sites shall be provided as and when identified by the Contractor after getting approval from CMWSSB in concurrence with TNPCB.
    * *Turtle Nesting Conservation Plan* for the beach in front of the project premises to address threats to the turtle populations from fishing activities, artificial lightening’s from anchoring vessels, oil spills etc. The project activity such as pipeline laying is not likely to affect the Turtle nesting as they will be buried more than 1.0 m from the sea bed surface hence, not expected to interfere with the turtle nesting. Also, the water pipe laying is suggested to be undertaken in the non-breeding season to further reduce the impacts. The conservation plan should enlist certain activities and should allot budget to them. Some of the indicative activities for conservation are: minimising impacts from lightings towards the seaside for Turtle hatchlings and cooperation with local Turtle conservation groups in order to conserve a maximum of Turtle eggs laid near the facility. In this regard CMWSSB will extend support to Forest Department/ WWF – India Personnel / Students Sea Turtle Conservation Network (SSTCN) for the conservation of Olive Ridley Turtles as required.
    * *Separate E&S Management Plans for Construction and Operations Stages* shall be prepared to address the impacts associated with construction and operation activities on the environment, the workforce engaged and surrounding communities. These plans shall incorporate the requirements stipulated in the Project’s EIA Report, applicable legislation and regulations, conditions of approval from State/Centre Regulatory agencies and also considering best practices and good engineering practices, as applicable.
    * *Environmental and Social Monitoring Plan* shall be prepared to ensure that the envisaged purpose of the ESMP is achieved across all stages of the project. Performance indicators will be developed for critical environmental and 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.
19. The Contractor shall implement all requirements of the ESMP approved by CMWSSB during the entire period of the contract, i.e. during the Construction Stage and Operation Stage of the SWRO based Desalination Plant and associated facilities.
20. Operation and Maintenance of the aforesaid SWRO based Desalination Plant and associated facilities is to be carried out strictly as per the approved ESMP and as directed by the CMWSSB and State/Central Pollution Control Board Norms.
21. The Contractor shall seasonally monitor the environmental quality of the working sites and their surroundings in terms of environmental and social performance indicators as specified in ESMP 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 ESMP.
22. All pressure containing equipment and components shall be designed, fabricated, tested, and inspected in accordance with project specification and ASME Section VIII, Div 1. Material certification to BS-EN-10204:2004 shall be supplied for all items.
23. Inspection and Quality Control of all equipment and civil works, erection, commissioning, trial run, along with all consumables and manpower, project management and monitoring for timely submission of design documents and drawings and timely execution of the project with a demonstration of performance guarantee parameters including the supply of all measuring instruments and manpower.
24. The Bidder’s proposal shall include details and references of the recorded operational reliability of the key equipment and systems to be provided. The proposal shall include a description of the RO Plant’s ability for flexible operations.
25. Industrial workshop with suitable size EOT cranes for maintenance – area up to 2000 sqm.
26. Sewage Treatment Plant of capacity 20 KLD. The sewage shall be treated to the quality approved by the regulatory authority for reuse/surface discharge.
27. Garden & Landscaping work shall be done around the Administrative building and all open areas at the site as per the contract and to the satisfaction of the Engineer.
28. Security Cabin – two security cabins each of minimum size 20.0 sq.m floor area with toilets for two plant gates shall be designed & constructed in RCC frame structure with 230mm thick brick/concrete block panelling, including sand face plaster & cement-based paint from outside and plain cement plaster from inside. Height of the Security Cabins shall not be less than 3.0 m. Window opening shall be to the extent of 20% of wall surface area with 100% Glazing.

#### Summary of the Scope of Works

The Works shall include the:

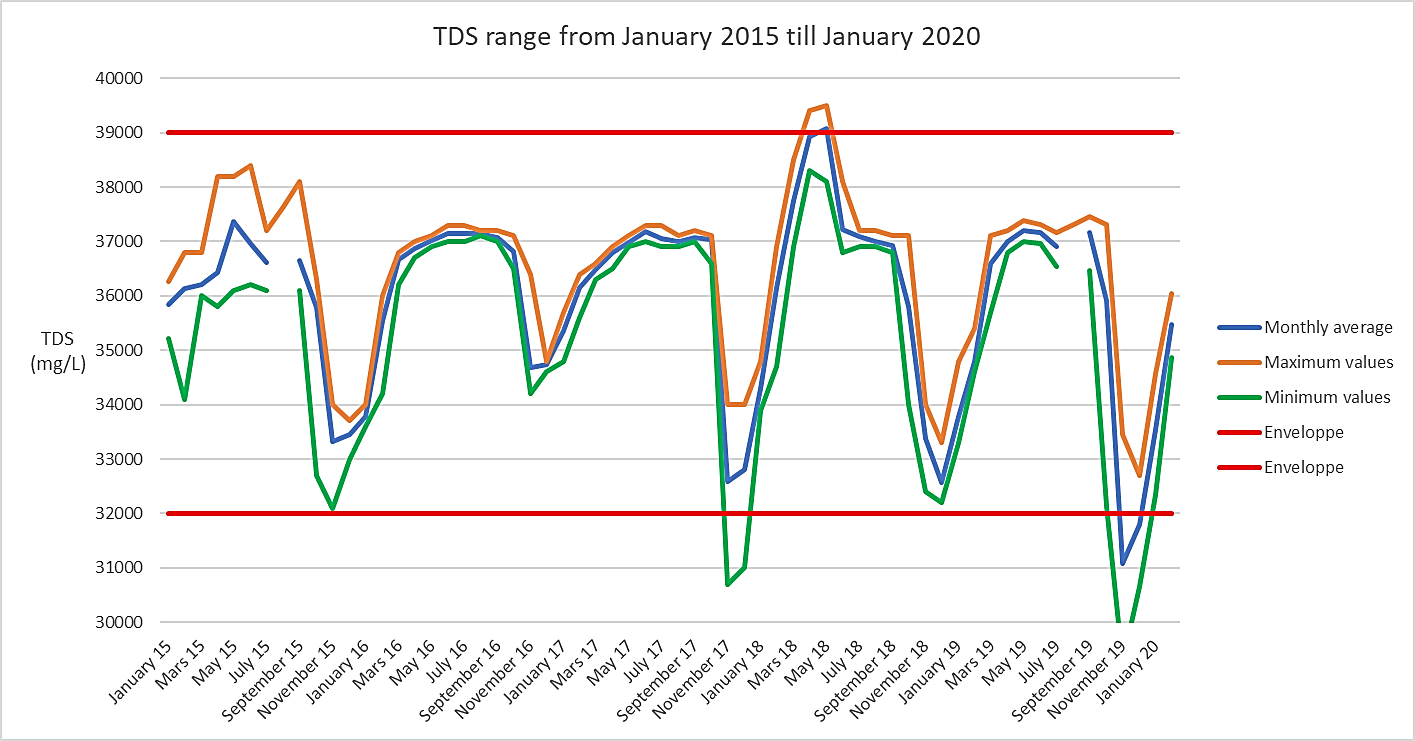
* Designing, construction, procurement, installation, commissioning and 20 years operation and maintenance of a 400 MLD SWRO desalination plant on Design, Build and Operate (DBO) basis;
* Plant process and hydraulic design and construction for two fully separate process parallel streams of capacity 200 MLD each;
* Raising and preparation of the site ground level at CD +6.5m for civil structure construction and boundary of the plant site as per the contract.
* Procurement and installation of all mechanical, electrical and instrumentation & control works;
* Design and construction of all civil structures including tanks and building works;
* All piping works including yard piping at the site (including intake & outfall pipes off seashore) and all mechanical/electrical/civil general arrangement and section drawings;
* Full automation of plant processes with distributed control system;
* Design and manufacture, supply, testing at manufacturers' works, storage when required, delivery to site, unloading and site transportation, erection, site testing, painting and finishing of the Plant;
* testing, commissioning, process proving and 20 years of operation and maintenance of the SWRO desalination plant;
* provision of spare parts, special tools, operation and maintenance manuals and As-Built drawings;
* Wastewater treatment and safe disposal of solid and liquid waste as per the local & central government norms;
* All other works as required for 2x200 MLD SWRO desalination plant with all allied works for production of 400 MLD product water of the required quality.

## Raw Water

### Raw Water Source

The proposed site for 400 MLD Perur SWRO Plant is within 1 km of the site of 100 MLD Nemmeli desalination plant. The records of seawater quality at 100 MLD Nemmeli desalination plant cover data for a period of 5 years which is the only extended continuous data available for the plant design. It is to be noted that the maximum TDS values up to 39,500 mg/l were recorded on a short period during April 2018 to May 2018, over 5 years of data recording. Apart from this short period, all TDS records at 100 MLD Nemmeli plant are below 38,500 mg/l(plant laboratory operated by Wabag).

The variation of TDS over more than 5 years period is presented below in Figure 1.

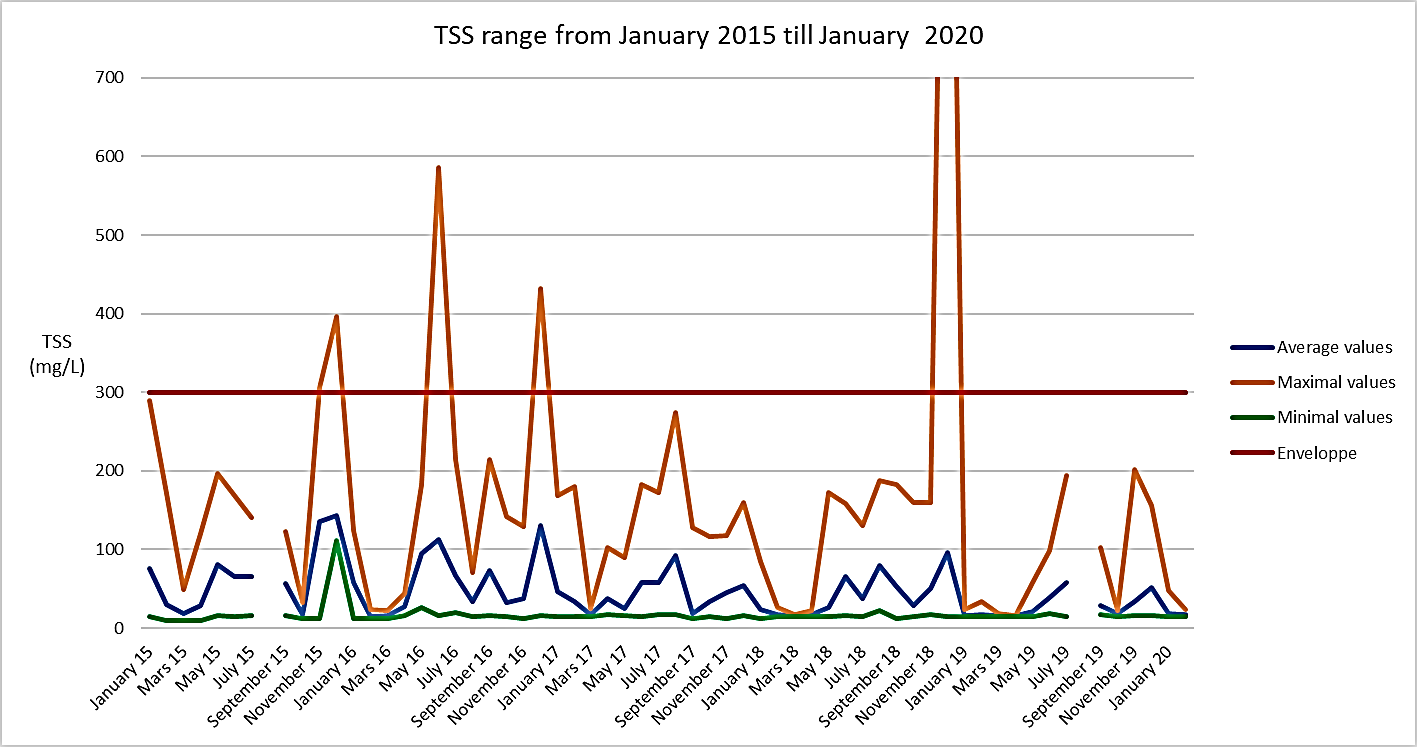


**Figure ‎1‑1: TDS profile over a period of 5 years (Nemmeli Data)**

The TDS range is quite extensive due to freshwater impact during the Monsoon period. The decrease of TDS (to 32000 mg/l) in November every year is repetitive, and its intensity depends on the rainfalls. Except for two restricted periods in 2015 and 2018, repeatability of TDS values below 37,500 mg/l are observed during spring and summer before the rainy season.

Considering the above, the range of TDS adopted for the Perur RO design is 32000 mg/L to 39000 mg/l, which is quite reasonable.

The variation of TSS in seawater over 5 years period is presented below in Figure 2.



**Figure ‎1‑2: TSS profile over a period of 5 years**

A peak of TSS reached 1478 mg/l in December 2018. Usually, such abnormal value (one day) is considered an outlier and discarded. The maximum value of TSS in seawater has been considered at 300 mg/L for the pre-treatment design purpose.

TOC (total organic carbon) is an important parameter to monitor since it is responsible for biofouling on the membrane surface. It is also revealed that the seawater in the site vicinity contains small white particles which are organics in nature and result in membrane fouling and frequent cleaning. Bidders are advised to investigate seawater for the TOC content and design the pre-treatment accordingly to avoid membrane fouling.

The desalination plants at Minjur and Nemmeli have recorded specific event of jellyfish attacks, but regarding HABs (Harmful Algae Blooms or “red tides”), they have no specific records. However, such events have been reported in the local press and research papers.

Table 1-1 provides the maximum, minimum and mean values of the seawater characteristics at Perur.

**Table ‎1‑1: Raw seawater design parameters**

| **Jan’2015-Jan’2020** | **Minimum value1** | **Mean value3** | **Maximum value2** |
| --- | --- | --- | --- |
| **SWRO parameter envelop** | | | |
| **TDS** | 32000 | 36000 | 39000 |
| **pH** | 8.00 | 8.13 | 8.20 |
| **Temperature** | 26.0 | 28.3 | 31.5 |
| **Boron** | 3.2 | 3.53 | 3.80 |
| **Pre-treatment parameter envelop** | | | |
| **Turbidity** | 1.0 | 12 | 150 |
| **TSS** | 10 | 75 | 300 |
| **Total Organic Carbon 4 (TOC)** | 3.0 | 5 | 8 |
| **Algae count (cells per ml) 4** | 100 | 500 | 30000 |
| **Jellyfish attacks** | - | - | Yearly Occurrences |

**1** Minimum is the monthly minimum data over Jan 2015 to Feb 2020

**2** Maximum is the monthly maximum data over Jan 2015 to Feb 2020

**3** Mean is the monthly average data over Jan 2015 to Feb 2020

**4** Assumed values, to be confirmed by the bidders.

### Product Water Quality

The Product water quality requirements at the inlet of clear water reservoir are specified in the Table below. The product water TDS shall be less than 450 mg/l, Boron < 1 mg/l, turbidity < 0.5 NTU and hardness ≥ 60 mg/l as CaCO3. All other parameters shall meet the drinking water standard in line with BIS:10500-2012.

**Table ‎1‑2: Product Water Quality Requirement**

|  |  |
| --- | --- |
| **Parameter** | **Required Quality** |
| Turbidity (NTU) | < 0.5 |
| True Colour | < 3 |
| Chlorides (mg/L) | < 250 |
| TDS (mg/L) | < 450 all the time |
| Boron (mg/L) | < 1.0 mg/l all the time |
| LSI | > positive |
| Hardness | ≥ 60 mg/L as CaCO3 |
| All other parameters | As per BIS 10500 - 2012 |

## Design Flow and Capacity

The SWRO desalination plant at Perur shall be able to treat minimum 1040 MLD seawater to produce net 400 MLD product water at the Clear Water Reservoir (CWR). CWR is in scope of works but the pumping station to transfer water to Porur is not in the scope of this contract. An indicative mass balance of the plant process is provided below.

## Mass Balance for the Proposed Plant

An indicative calculation for mass balance for 400 MLD desalination plant for 42% and 46% recovery are presented in Table 1-3 and Table 1-4. As there are two parallel process streams of 200 MLD each. The flow to each stream will be half of the flow given below. The Plant will be running most of the time at 46% RO recovery, and the recovery will be reduced to minimum 42% in case of an adverse situation of feed water quality and/or during the possibility of vigorous membrane fouling. The plant design shall be based on the production of additional permeate in order to compensate the loss of production during non-availability of the plant. The required plant availability is 97% but the net 400 MLD production shall be maintained every month during the O&M period.

**Table ‎1‑3: Indicative Mass Balance for 400 MLD Desalination Plant at 42% RO Recovery**

| **Process Stage** | **m3/day** | **Wastewater** | **Factor to Feed Flow** |
| --- | --- | --- | --- |
| Intake Pumps | 1,052,180 |  | 100.00% |
| Service Water | 2,000 |  | 0.19% |
| Utility and Leakage |  | 2,104 | 0.20% |
| Lamella + DAF waste |  | 31,437 | 2.99% |
| GMF Backwash |  | 30,706 | 2.92% |
| Pre-filtered water | 988,145 |  | 93.91% |
| Feedwater RO+ERD | 988,145 |  | 93.91% |
| Feed to RO | 988,095 |  | 93.91% |
| HP pumps | 415,000 |  | 39.44% |
| Recir. Pump | 573,095 |  | 54.47% |
| Feed to ERD | 573,145 |  | 54.47% |
| RO permeate | 415,000 |  | 39.44% |
| RO Reject |  | 573,145 | 54.47% |
| CIP & Flushing |  | 2,000 | 0.19% |
| Total plant waste discharge |  | 639,393 | 60.77% |
| Net Plant Product Water | 413,000 |  |  |
| Overall Plant Recovery | 39.2% |  |  |

**Table ‎1‑4: Indicative Mass Balance for 400 MLD Desalination Plant at 46% RO Recovery**

| **Process Stage** | **m3/day** | **Wastewater** | **Factor to Feed Flow** |
| --- | --- | --- | --- |
| Intake Pumps | 960,705 |  | 100.00% |
| Service Water | 2,000 |  | 0.21% |
| Utility and Leakage |  | 1,921 | 0.20% |
| Lamella + DAF waste |  | 28,711 | 2.99% |
| GMF Backwash |  | 28,043 | 2.92% |
| Pre-filtered water | 902,224 |  | 93.91% |
| Feedwater RO+ERD | 902,224 |  | 93.91% |
| Feed to RO | 902,174 |  | 93.91% |
| HP pumps | 415,000 |  | 43.20% |
| Recir. Pump | 487,174 |  | 50.71% |
| Feed to ERD | 487,224 |  | 50.72% |
| RO permeate | 415,000 |  | 43.20% |
| RO Reject |  | 487,224 | 50.72% |
| CIP & Flushing |  | 2,000 | 0.21% |
| Total plant waste discharge |  | 547,900 | 57.03% |
| Net Plant Product Water | 413,142 |  |  |
| Overall Plant Recovery | 43.0% |  |  |

## Design Criteria for the Proposed Plant

The overall design criteria for the base processes of the Plant are given below in Table 1-5 below. Bidders shall include these design criteria in their proposal for the construction of the 2x200 MLD SWRO desalination plant and the associated works. In case of any suggestion for a change in the design criteria, bidders may raise this in the pre-bid meeting and get it resolved. Further details of the design may be discussed later with the Contractor during the detailed design of the Plant.

**Table ‎1‑5: Indicative Design Criteria for 400 MLD Desalination Plant at Perur**

| **Process Stage** | **Design Criteria (2 x 200 MLD)** |
| --- | --- |
| **Product water** | * + *Net 400 MLD product water – with provision of min. 50% turndown capacity as advised by the Engineer.*   + *TDS ≤ 450 ppm,*   + *Chlorides ≤250 ppm*   + *Turbidity ≤ 0.5*   + *Boron < 1.0 ppm*   + *Hardness ≥ 60 mg/l as CaCO3*   + *LSI - Positive*   + *pH – 6.5 to 8.5*   + *Other parameters as per BIS 10500-2012* |
| **RO recovery** | * *Nominal RO recovery: 46% (provision for 42% in case required)* |
| **Production Turndown** | * *Provision for production turndown below 50% to reduce production flow < half as needed.* |
| **The offshore seawater intake header** | * *Submerged open-intake @ > 10 m seabed depth* * *Velocity cap type* * *Horizontal velocity at 0.12m/s* * *Screen bar with 10cm spacing with a fishing net* * *Shock chlorination + compressed air system* |
| **Offshore seawater intake pipes** | * *2 pipes (buried) of HDPE (2500 mm OD,PE100, SDR <26)* * *Length - 1150m from seashore Same profile/ alignment trench* |
| **Brine outfall system** | * *1 pipe in HDPE OD 2500 mm. SDR <26* * *Length – 750m from seashore:* * *Brine diffuser: >30 units; dia-350mm; spaced 6 m.* |
| **Ancillary equipment for the intake system** | * *Intake well (4 Chambers)/ 4 sets Band screens (4x 50%)* * *Air bursting and Shock chlorine dosing system* * *The intake pipes are designed to be cleaned by pigging system with a launcher/receiver installed at the pumping station/ intake.* |
| **Seawater intake pumping station – provides water to two streams of 200 MLD each** | * *6 + 3SB units of vertical turbine pump for total flow 43333 m3/h (1040 MLD); Minimum flow: 39500 m3/h (948 MLD) @ 46% RO recovery (half of the flow to each stream)* * *Discharge pressure: >18 m* * *VFD required* |
| **Pre-treatment** | * *Composed by chemical and physical processes.* * *Main stages:*    + *Coagulation/flocculation – Flash mixing*   + *Clarification by Lamella Settler*   + *Dissolved air flotation*   + *Dual media gravity filtrations (optional third media as needed)* * *Cartridge filters* * *Alternate bid with change in pre-treatment scheme is allowed as per the condition of the Contract - justification for technical advantage with capital and O&M cost saving must be provided.* |
| **Coagulation stage – Flash mixing** | * *Retention time: min. 20 seconds* |
| **Flocculation stage** | * *Retention time: min. 20 minutes* |
| **LS Clarification stage** | * *Lamella surface loading rate: ≤ 1.0 m3/m².h.* |
| **Dissolved air flotation** | * *Surface loading rate with recycling: 25 m3/m².h* * *15% recycling* |
| **Gravity dual media filters** | * *Surface loading rate: < 7.5 m3/m².h with all filters operating* * *The top layer (Anthracite): 1.2 m* * *The bottom layer (Silica sand): 1.5 m* |
| **Cartridge filters** | * *Filtration size: 5 μm.* * *Construction material GRP* * *Cartridges: melt-blown polypropylene* |
| **Chemical pre-treatment** | * *Sulfuric acid – as required for pH adjustment* * *Ferric chloride 5 – 30 ppm as pure chemical (jar test needed for ppm level)* * *Polymer (0.1- 0.5 ppm Lamella, DAF)* * *Pre Chlorination -Sodium hypochlorite (1-3 ppm)*   + *Post Chlorination -Sodium hypochlorite (1-2 ppm disinfectant)*   + *Sodium bisulphite (10 ppm)*   + *Sodium hydroxide (pH control, 10 ppm – as needed for Boron treatment)* * *Antiscalant dosage for SWRO (~1 ppm)* * *Biocide for biofouling control* |
| **Filtered water tank** | * *Two RCC tanks – one for each stream with interconnection proposed with 2 compartments/tank for isolation and cleaning:* * *Tank Capacity - 10000 m3 each (30 min)* |
| **SWRO desalination streams** | * *Two main streams (2x 200 MLD)* |
| **SWRO membranes** | * *8 elements per vessel* * *Mixed HR and LE membrane/PV allowed.* * *Operating flux: 13.4 l/h/m²* * *Diameter: 8”, Length: 40”, Area: 440 sq.ft* |
| **High-pressure feed pumps (Booster RO)** | * *Design pressure: ~ 4 bar as per design requirement* * *With or without VFD as needed* |
| **High-pressure pumps** | * *Suitable for seawater maximum TDS with minimum Temperature; and min TDS with max temperature.* * *With VFD* * *Provision of production turndown.* |
| **Energy recovery system** | * *Isobaric pressure exchanger with high reliability. (ERI preferred)* |
| **Booster pumps for energy recovery system (if required)** | * *Centrifugal mono-stage horizontal type or as needed.* * *Design pressure: ~ 2.5 bars or as per design requirement* * *As per design requirement* |
| **Recirculation pumps for energy recovery systems** | * *Centrifugal mono-stage horizontal type or as needed.* * *Design pressure: ~ 2.5 bars or as per design requirement* * *With VFD* |
| **SWRO skids** | * *Each RO train size – 25 MLD* * *Each stream will have 8+1 RO skids (trains)* |
| **SWRO front permeate tank** | * *2 metallic tanks – one per stream interconnected* * *Each tank volume: 5,000m3 per stream* |
| **Post-treatment** | * *Composed by remineralisation with CO2 and limestone beds (at least 48% permeate to be treated)* * *pH adjustments with NaOH* * *Disinfection with sodium hypochlorite* |
| **Limestone bed for remineralisation** | * *Upflow / Continuous Feeding Limestone Remineralization system.* * *Number of cells: 28 units (14 per stream).* * *Surface loading rate:* 10 m3/m².h * *Contact time: 25 minutes (min)* * *Integrated storage system for limestone with capacity for minimum 30 days* * *Air + water backwash system* |
| **Product water tanks** | * *2 metallic or RCC tanks for each stream* * *Total capacity 30,000 m3 (2 hours) – Each stream tanks capacity - 15000 m3 with partition for isolation & cleaning* |
| **Clear water tank** | * *1 RCC CWR with partition – with partition and provision to clean one part* * *Total capacity 9,000 m3* * *Two 1600mm DI flanged puddle for feed to CWR and six (6) 900mm DI flanged puddle for discharge from CWR* |
| **Interface with other packages** | * *Provide puddle and flange to connect with pipeline of CP2 package for product water transmission.* * *Provide GIS substation for the 230kV cable under CP5 package* |
| **Cleaning (CIP) and flushing system** | * *Preparation Tank : as per system requirement* * *CIP pumps flow:1152 m3/h or as required.* * *Flushing pumps flow: 1024 m3/h or as required* |
| **Wastewater treatment** | * *physiochemical treatment. At least 1 sludge balance tank, 2 thickeners, 1 sludge holding tank and BFP building with up to 5 BFPs considering average raw water TSS of 75mg/l.* |
| **Specific requirements** | * *Pre-treatment pilot plant* * *RO cleaning pilot plant* * *Membrane testing plant* |

## Works Life Expectancy

The Contractor shall design the Works for a minimum life expectancy as follows:

* Civil works, buildings and buried pipelines: 50 years
* Concrete tanks, process chambers 50 years
* Heavy mechanical and electrical equipment 25 years
* Other mechanical and electrical equipment 15 years
* Buried earth electrode systems 30 years
* Automation and sensors equipment 15 years
* Control panels 15 years
* Instrumentation systems 15 years
* Metallic reservoir and tanks (not for seawater or brine) 25 years
* Polyethylene tank (or other chemical containers) 10 years
* Pressure vessels 30 years

SWRO membranes >5 years

## Turnkey Contract

The implementation of the construction works for the 400 MLD SWRO desalination plant at Perur shall be a ‘turnkey contract’. Accordingly, the Contractor shall be required to execute the construction works followed by 20 years of Plant O&M under DBO basis as per the performance requirements of the proposed Plant including civil, mechanical, electrical, and instrumentation components as specified in the Employer’s Requirements and elsewhere in the bid documents.

Apart from the scopes described above, the scope of the Contractor who shall execute the works and guarantee plant and process performance shall also include, but shall not be limited to the following:

* All preparatory works including clearing, levelling and compaction of the site, site grading/ dressing of site as per specified formation or finished ground level (FGL), provision of access roads, roads inside and around the site etc., excavation, dewatering as required and disposal of all surplus earth to a suitable location.
* Necessary topographic survey and geotechnical investigation and any other investigation(s) which are considered necessary in the opinion of the Contractor as well as those deemed fit by the Engineer.
* Prepare process and hydraulic design with the layout and hydraulic flow diagram of the complete desalination plant considering two streams, to meet the product water quality parameters.
* Undertake complete detailed engineering design of the desalination plant including process, civil, structural works, mechanical (with intake/outfall pipings), electrical and instrumentation/ DCS system equipment and allied works with construction drawings, to ensure process performance, and submit for the approval of the Engineer and the Employer.
* After approval of the designs and drawings by the Engineer and the Employer, the Contractor shall commence implementation of civil, mechanical, electrical and instrumentation and allied works at the site as per the approved QA/QC and safety plan.
* Placing of orders, manufacture, testing at the place of manufacture, inspection by the Employer’s representatives/Engineer, finishing and painting, packing, transport, supply/delivery, storage, erection/ installation, testing and commissioning of the plant mechanical, electrical and instrumentation equipment as per the tender and with the consent of the Employer.
* Providing as-built drawings for all components in soft and hard copies.
* Contractor shall provide the operation and maintenance manuals for the Plant and shall update them regularly.
* Contractor shall provide all services required to operate the Plant successfully to meet the required product water quality.

The Contractor shall be responsible for all aspects of design and construction to meet the required plant performance and other conditions/standards laid down in the specifications within the plant battery limits.

## Perur Plant Design Philosophy

The Plant shall be designed and operated in 2 plant streams of 200 MLD each. The Contractor shall provide two fully separate streams in all respect. Only the intake pumping station, clear water reservoir and Outfall tanks will be common to both the streams. All pre-treatment units, RO system, post-treatment system, tanks and chemical storage and dosing systems shall be separate to both the streams. The detailed information is given in the indicative plant flow diagram and layout drawing provides in Part-2, Section VI, Drawings.

The Perur project is expected to be the spine of the water production for Chennai and will be operated at its maximal available capacity most of the time; therefore, it shall offer the lowest cost (CAPEX and OPEX combined) compared to the other desalination facilities of lower capacities. The production turndown ratio shall be a minimum 50 % per stream and so all upstream and downstream units shall be sized to meet this requirement.

## Uninterrupted Power Supply (UPS) Systems

The Contractor shall provide an uninterrupted power supply for plant instrumentation and control system. The Contractor shall demonstrate the operation of the UPS systems by actually simulating a plant-wide or localised power failure condition (as agreed with the Employer’s representative) and proving that:

* all the process instruments have continued to measure the plant data
* the PLC has been processing these and posting the data to HMI
* the HMI performing with no interruption and continue to log and trend these data.
* all the instrumentations, including valves, are set in the fail-safe mode.

Refer to Part-2, Section VI, Chapter-8 for detailed information about the UPS.

## Plant Layout

Overall tentative layout for the entire Desalination plant shall be referred from Employer’s Requirement – Part-2 Section VI, Drawings enclosed. Final layout of the systems shall be furnished by the Contractor and finalised during detailing.

The general arrangement drawing as proposed by the bidder shall clearly indicate the dimensions of the various equipment, pipe routing, valve locations etc. The pipes shall be laid out in such a way that they are easily accessible for any maintenance or repair and also permits easy movement of the personnel. The exact layout considering the actual equipment dimensions, handling facilities, clearances as required for easy operation and maintenance, pipe support locations etc. shall have to be firmed up by the bidder for satisfactory operation of the systems covered under the scope of work. All platforms and stairways shall have a minimum clear width of 1000 mm.

The drawing shall be prepared on standard-sized drawing sheets not larger than size AO (840 mm × 1190 mm).

## Time for Works Completion

The whole of the Work, including mobilisation, reconnaissance, survey, sub-soil investigations, design, manufacturing, transportation, construction, installation, commissioning, testing and proving is to be completed within the scheduled Time for Completion as set out in the Part 3, Section VIII, Particular Condition (PC). The duration of the Preliminary Test period is 15 days, and the Proving Period is 90 days. The physical completion of the Works and Facilities in all respect followed by commissioning and process proving shall be completed within 42 months after the award of the contract. The O&M period for 20 years will start after the process proving and submission of all the required documents to the Employer, as explained in Part 3, Section VIII, Particular Condition (PC).

## Milestones

The Contractor is to ensure consistent pro-rata progress on all components of the Contract during the entire Contract period. The key milestones set out in Table 6, or such other Milestones as may be proposed by the Contractor and agreed by the Employer at the time of bidding, are proposed to be adopted for periodic review of the progress of various components. These milestones provide the stages of progress and assessment of any delay in the implementation of the works and accordingly the basis for making decisions of delay damage penalty as per the provisions of Clause 8.5 of the Particular Conditions of Contract – Part 3, Section VIII.

## Interface with Other Contract Packages

The Works under this Contract will physically interface with Works under two other contract packages i.e. Pumping station contract (CP-2) and electrical power supply (CP-5). The Contractor of this contract shall co-ordinate with the Engineer and the contractors of other contracts as required and ensure that all interfaces are designed, constructed, installed, tested, commissioned, operated, and maintained properly to provide a fully functional system meeting all plant performance requirements. The Contractor of this contract shall be fully responsible for independently field-verifying all information he may consider relevant in order to provide a fully functional system.

**Table ‎1‑6: Milestones of Works Description for 400 MLD DSP**

| **Sl. No.** | **Work Description** | **Time (Months) from Date of Notice to Proceed** | | | | | | | | | | | | | |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Milestone I** | | **Milestone II** | | **Milestone III** | | **Milestone IV** | | **Milestone V** | | **Milestone VI** | |  | |
| **3** | **6** | **9** | **12** | **15** | **18** | **21** | **24** | **27** | **30** | **33** | **36** | **39** | **42** |
| **1** | **Mobilisation** |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| 1.1 | Establish site offices | 100% |  |  |  |  |  |  |  |  |  |  |  |  |  |
| 1.2 | Set up site laboratory | 100% |  |  |  |  |  |  |  |  |  |  |  |  |  |
| 1.3 | Finalisation of the work plan | 100% |  |  |  |  |  |  |  |  |  |  |  |  |  |
| **2** | **Surveys & Investigations, Design, Drawings and Documentation** | | | | | | | | | | | | | | |
| 2.1 | ***Survey, Process Design and Drawing\**** | Start | **50%** | 75% | **100%** |  |  |  |  |  |  |  |  |  |  |
| 2.2 | ***Civil Structural, Mechanical, Electrical and ICA Designs and Drawings\**** |  | Start | **50%** | 75% | **100%** |  |  |  |  |  |  |  |  |  |
| 2.3 | As Built Drawings and documents |  |  |  |  |  |  |  |  |  |  |  |  | Start | 100% |
| **3** | **Intake and Outfall Pipeline (400 MLD) for Procurement, Supply, Construction, Installation/Erection, Testing & Commissioning** | | | | | | | | | | | | | | |
| 3.1 | ***All works related to laying of HDPE Pipeline for Intake and Outfall works\**** |  |  | Start | **50%** |  |  |  |  | **100%** |  |  |  |  |  |
| 3.2 | Fixing of Offshore Velocity Cap type Heads and Offshore Diffusers with all allied works at offshore intake |  |  |  |  |  |  |  | Start | 100% |  |  |  |  |  |
| 3.3 | Any other offshore structure/ works to complete at the intake and outfall system |  |  |  |  |  |  |  |  | Start | 100% |  |  |  |  |
| **4.** | **Civil Works - Supply & Construction, Testing, Commissioning for 2 x 200 MLD Plant** | | | | | | | | | | | | | | |
| 4.1 | All Intake and Outfall Structures onshore, including pigging. |  |  | Start | 25% |  | 50% | 75% |  | 100% |  |  |  |  |  |
| 4.2 | All Chemical Buildings - for Pre, Post and RO feed treatment including Shock Chlorination System |  |  |  |  |  | Start | 25% | 50% | 75% | 100% |  |  |  |  |
| 4.3 | ***All Pre-treatment System - Coagulation and Flocculation, Lamella Settler, DAF, GDMF including RO feed Tanks and allied System\**** |  |  |  | Start | **25%** |  | **50%** |  | **75%** |  | **100%** |  |  |  |
| 4.4 | RO System - Housing, CIP, MCC, Tanks and allied Systems |  |  |  | Start | 25% | 50% | 75% | 100% |  |  |  |  |  |  |
| 4.5 | Post Treatment System – CO2 storage/dosing area, Limestone Filter Structures, etc. |  |  |  |  |  | Start | 25% | 50% | 75% | 100% |  |  |  |  |
| 4.6 | Waste Sludge Treatment System – SBT, Thickeners, Holding Tanks, BPT buildings and allied system. |  |  |  |  |  |  | Start | 25% | 50% | 75% | 100% |  |  |  |
| 4.7 | Product Water Tank and allied systems |  |  |  |  | Start | 25% | 50% | 75% | 100% |  |  |  |  |  |
| 4.8 | Clear Water Tank and allied systems |  |  |  | Start | 25% | 50% | 75% | 100% |  |  |  |  |  |  |
| 4.9 | All Electrical Buildings and other related structures |  |  |  | Start | 25% | 50% | 75% | 100% |  |  |  |  |  |  |
| 4.10 | Admin, Control and other Buildings at the plant including Workshop and Warehouse |  |  |  |  |  | Start | 25% | 50% | 75% | 100% |  |  |  |  |
| 4.11 | Sewage Treatment Plant and allied systems |  |  |  |  |  |  |  | Start | 25% | 50% | 75% | 100% |  |  |
| 4.12 | ***Site backfilling to CD+6.5m\**** | Start | **100%** |  |  |  |  |  |  |  |  |  |  |  |  |
| 4.13 | All other works at site including boundary walls, roads, fire-fighting building, Security building, land scaping, plantation etc. |  |  |  |  |  |  |  |  |  | Start | 25% | 50% | 75% | 100% |
| 5 | **Mechanical Works - Procurement, Supply, Installation/Erection, Testing, Commissioning for 2 x 200 MLD Plant** | | | | | | | | | | | | | | |
| 5.1 | Intake & Outfall System onshore - All mechanical items pumps, valves, gates, screens and any other items |  |  |  |  | Start | 15% | 25% | 50% | 75% | 85% | 100% |  |  |  |
| 5.2 | All Pre-treatment chemical dosing systems with allied works. |  |  |  |  |  | Start | 15% | 25% | 50% | 75% | 100% |  |  |  |
| 5.3 | ***All Pre-treatment Units - Coagulation and Flocculation, Lamella Settler, DAF, GDMF including RO feed Tanks and all allied works\**** |  |  |  |  | Start | 15% | **25%** | 35% | **50%** | 75% | **100%** |  |  |  |
| 5.3 | ***RO System – RO Skids, Chemical dosing and CIP system including Permeate and Neutralization tanks and all allied works\**** |  |  |  |  | Start | 15% | **25%** | 35% | **50%** | 75% | **100%** |  |  |  |
| 5.4 | Post Treatment System – CO2 System, Limestone Filters, Chemical System and all allied works |  |  |  |  | Start | 15% | 25% | 35% | 50% | 75% | 100% |  |  |  |
| 5.5 | All mechanical works at tanks PWT, CWR, Outfall tank, and all other structures and allied works |  |  |  |  | Start | 15% | 25% | 35% | 50% | 75% | 100% |  |  |  |
| 5.6 | Waste Sludge Conveyance and Treatment System – all mechanical works including allied works |  |  |  |  |  | Start | 15% | 25% | 35% | 50% | 75% | 100% |  |  |
| 5.7 | All misc. mechanical works at all buildings, including sewage treatment system, Cranes, motorboat and all other allied works. |  |  |  |  |  | Start | 15% | 25% | 35% | 50% | 75% | 100% |  |  |
| **6** | **Electrical & ICA Works - Procurement, Supply, Installation/Erection, Testing and Commissioning for 2x200 MLD Plant** | | | | | | | | | | | | | | |
| 6.1 | All Intake and Outfall works – onshore and offshore |  |  |  |  |  |  | Start | 25% | 50% | 75% | 85% | 100% |  |  |
| 6.2 | All Pre-treatment Chemical Systems and allied works |  |  |  |  |  |  | Start | 25% | 50% | 75% | 85% | 100% |  |  |
| 6.3 | All Pre-treatment Process Units including RO feed tanks and allied works |  |  |  |  |  |  | Start | 25% | 50% | 75% | 85% | 100% |  |  |
|  | ***RO System – RO Skids, Chemical dosing and CIP system including permeate and neutralization tanks and all allied works\**** |  |  |  |  |  |  | Start | **25%** | 35% | **50%** | 75% | **100%** |  |  |
| 6.4 | Post Treatment System – CO2 System, Limestone Filters, Chemical System and all allied works |  |  |  |  |  |  | Start | 25% | 35% | 50% | 75% | 100% |  |  |
| 6.5 | All Electrical works at tanks PWT, CWR, Outfall tank, and all other allied works |  |  |  |  |  |  | Start | 25% | 35% | 50% | 75% | 100% |  |  |
| 6.6 | Waste Sludge Conveyance and Treatment System – all electrical works including allied works |  |  |  |  |  |  | Start | 25% | 35% | 50% | 75% | 100% |  |  |
| 6.7 | ***Substations – all works for transformers, switchyards, Cabling, Grounding & Lightning Protection, and all allied works\**** |  | Start | 15% | **25%** | 35% | **50%** | 75% | **100%** |  |  |  |  |  |  |
| 6.8 | All misc. Electrical works at all buildings including sewage treatment system, UPS, DG sets and all other allied works. |  |  |  |  |  | Start | 15% | 25% | 35% | 50% | 75% | 100% |  |  |
| **7** | **Miscellaneous Works - Procurement, Supply, and Installation Testing and Commissioning for all works at 2x200 MLD Plant** | | | | | | | | | | | | | | |
| 7.1 | Chemical Laboratory Items as per schedule and required. |  |  |  |  |  |  |  |  |  | Start | 75% | 100% |  |  |
| 7.2 | Workshop items as per schedule and required. |  |  |  |  |  |  |  |  | Start | 50% | 75% | 100% |  |  |
| 7.3 | All Heating, Ventilation and Air conditioning systems including Cooling tower etc. as required in all buildings/ structures |  |  |  |  |  |  |  | Start | 25% | 50% | 75% | 100% |  |  |
| 7.4 | Complete Firefighting system - fire detection and protection system in all buildings and covered spaces - |  |  |  |  |  |  |  |  |  |  | Start | 100% |  |  |
| 7.5 | Security and Surveillance system at the plant as per the contract |  |  |  |  |  |  |  |  |  | Start | 50**%** | 100% |  |  |
| 7.6 | Any other works required to operate the 400 MLD DSP smoothly as per Contract. |  |  |  |  |  |  |  |  |  |  | Start | 100% |  |  |
| **8** | **Commissioning and Testing** | | | | | | | | | | | | | | |
| 8.1 | Commissioning and initial performance test run |  |  |  |  |  |  |  |  |  |  |  |  | 100% |  |
| 8.2 | Process Proving |  |  |  |  |  |  |  |  |  |  |  |  |  | 100% |

**\*** The delay damages shall be applicable if the % completion is not met at every 6 months as per milestones above and the progress shall be monitored quarterly.

**CHAPTER-2**

# THE SITE DETAILS

## Location of the Site

The proposed construction site for the Desalination plant is located at Perur village, about 40 km from the Chennai city centre. The total area of the plot is approximately 34 ha. It is situated along the coastal side of the East Coast Road (ECR). Its ground elevation is chart datum (CD) +2.0 to +7.5m with varying topography. ECR is approximately CD + 11m.

There are two numbers of graveyards identified within the proposed Site – one located on the Southern side of the seacoast and another on the Northern side towards the East Coast Road. It is understood that the graveyards must be left undisturbed and shall be protected by a compound wall all across, and proper drainage shall be made draining towards the sea. Nevertheless, the unused area available at the proposed Site is enough for the construction of the proposed Plant in all respect. Overall tentative layouts for the entire Desalination plant may be referred from Generalised Site Layout enclosed in Part-2, Section VI-Drawings. The final layout of the systems shall be furnished by the Bidder and will be finalised during detailing.

The climatic conditions are characterised by warm dry winters (27oC average daily max) and hot summers (39oC average daily max) with an annual average rainfall of 1200mm. Cyclones are common in the area, and the Site is expected to be affected by cyclones.

The site land profile is sloping from East Coast Roadside towards the seashore. The site land is to be raised by earth filling with suitable soil to maintain the finished ground level (FGL) at CD +6.5. The mean seawater level is at CD+0.65m. The construction of the Plant will be at FGL CD +6.5. The land topography drawing may be referred as provided in the document.

## Land Ownership Data

The proposed land for the desalination plant identified under survey number – 208/ 2B3 belonging to the M/s. Arulmigu Alavandar Nayakar Trust maintained by The Hindu Religious and Charitable Trust (HR & CT) Department, Government of Tamil Nadu (GoTN). The land is procured by CMWSSB on a long-term lease basis.

## Site Location

The details of the local site conditions are given in table below.

**‎**Table **2‑1: Details of Site Location for the Proposed DSP Site**

| **Particulars** | **Details** |
| --- | --- |
| Site Location | District: Chengalpattu / Taluk: Thiruporur / Village: Perur |
| Site coordinates | 12°42'44"N, 80°14'26"E |
| Nearest highway | State Highway SH 49, East Coast Road |
| Nearest railway station | [Othivakkam railway station](https://ind01.safelinks.protection.outlook.com/?url=https%3A%2F%2Fen.wikipedia.org%2Fwiki%2FKathgodam_railway_station&data=02%7C01%7Ckrithikas%40tce.co.in%7C1d6c36a4380a4a89cc4308d71bc22e42%7C5af76741f8864d20ad04775dee0ce762%7C0%7C0%7C637008393117746756&sdata=zaqkY6TkSovu7%2BlX4yC9zw%2F%2BJzGRtDFLfphGsQ0ZCho%3D&reserved=0) |
| Nearest Airport | [Chennai Airport](https://ind01.safelinks.protection.outlook.com/?url=https%3A%2F%2Fen.wikipedia.org%2Fwiki%2FPantnagar_Airport&data=02%7C01%7Ckrithikas%40tce.co.in%7C1d6c36a4380a4a89cc4308d71bc22e42%7C5af76741f8864d20ad04775dee0ce762%7C0%7C0%7C637008393117746756&sdata=29nhgukgEIiUVoHED7B%2BBWXyjWxQa%2F1ooXbVTctVMW0%3D&reserved=0) |
| Nearest town/ City | Chengalpattu, Pudupattinam,  Tirukalukundram, Nandivaram-Guduvancheri |
| Archaeologically Important places | Mahabalipuram |

## Topography

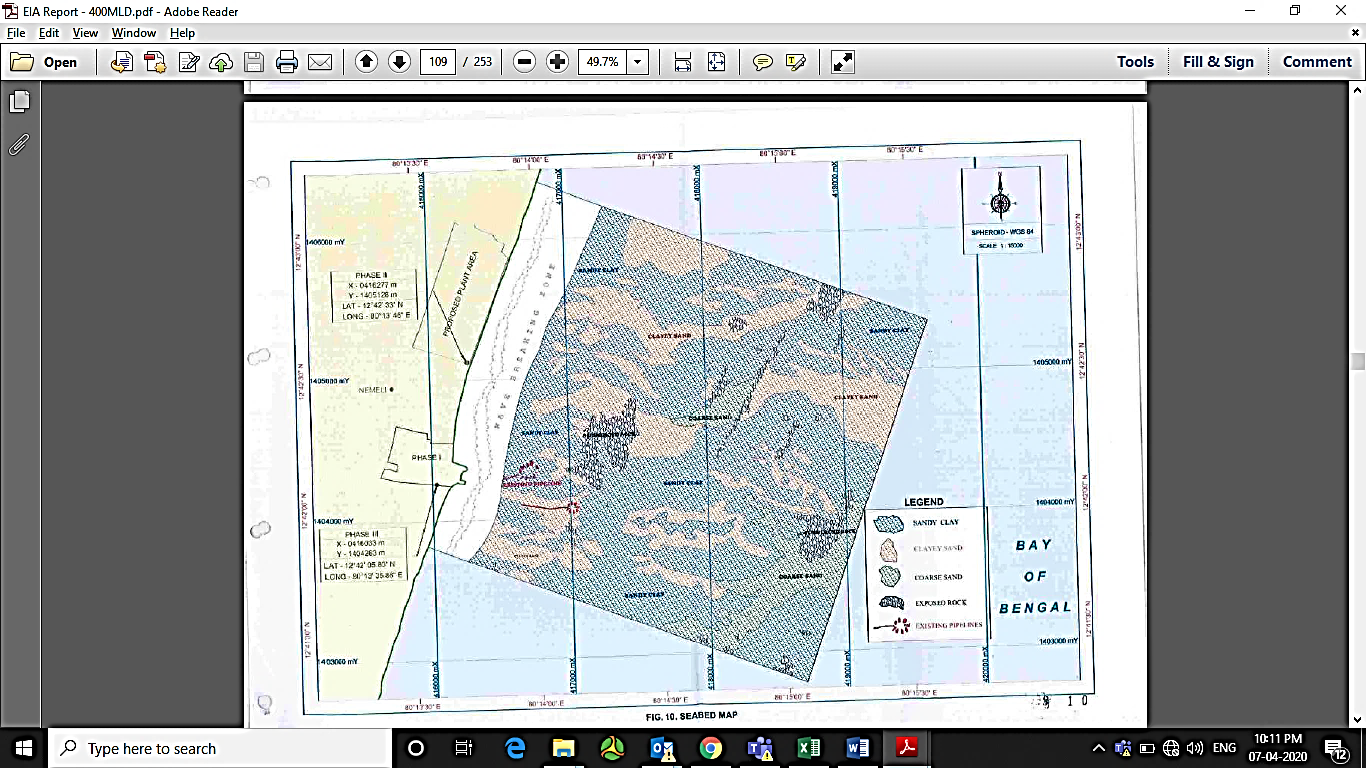
Based on the preliminary onshore topographic survey and offshore Bathymetry survey, the details are given below. However, the contractor has to repeat the study for confirmation.

##### Onshore topography

The Existing Ground Level (EGL) at the test conditions varied from +2.0m Chart Datum (CD) to + 3 m CD indicating the almost uniform condition. The site is having tree plantation of Casuarina. The site falls under Seismic Zone III as per BIS code IS: 1893 (Part I).

##### Offshore Bathymetry

Based on the bathymetric survey, buried rocks have been found near the shore that is spread in different direction and depth. Figure 4 presents a seabed map indicating the location of buried rocks.



**Figure ‎2‑1: Seabed Map**

The bathymetry survey shows that the depth contours are generally running parallel to the coast. The depth of the seabed with respect to the distance from the shore as obtained from the DPR report is furnished below.

**Table ‎2‑2: Variation of Sea Depth with Distance from Shore**

| **Depth w.r.to CD (m)** | **Distance from Shore (m)** |
| --- | --- |
| 2 | 150 |
| 3 | 200 |
| 4 | 225 |
| 5 | 340 |
| 6 | 440 |
| 7 | 520 |
| 8 | 660 |
| 9 | 835 |
| 10 | 1040 |
| 11 | 1360 |
| 12 | 1890 |
| 13 | 2160 |
| 14 | 2480 |
| 15 | 2720 |
| 16 | 2950 |

Sedimentary layers of silty sand were identified between – 0.0 and -8.0 m below the seabed.

## Climate

Chennai features a [tropical wet and dry climate](https://en.wikipedia.org/wiki/Tropical_savanna_climate). Chennai lies on the [thermal equator](https://en.wikipedia.org/wiki/Thermal_equator) and is also coastal, which prevents extreme variation in seasonal temperature. For most of the year, the weather is hot and [humid](https://en.wikipedia.org/wiki/Humidity). Typical meteorological data for Perur DSP is furnished below. Cyclones are more common in the Bay of Bengal, and the proposed Perur site is expected to be affected by cyclones by approximately 3 times per year.

The hottest part of the year is late May to early June, known regionally as Agni Nakshatram, with mean maximum temperature in Pre-monsoon season (May) was observed at 42.2 °C and mean minimum temperature observed at 24.2 °C. The mean maximum temperature in the monsoon season (June) was observed to be 40.6 °C whereas the mean minimum temperature was observed at 23.8 °C. By the end of September with the onset of Northeast monsoon (October), day temperatures decrease slightly with the mean maximum temperature at 35.5 °C with the mean minimum temperature at 22.2 °C. The city gets most of its seasonal rainfall from the north east monsoon which is from middle October to middle December.

The details of Typical Meteorological data for Perur DSP site are furnished below.

**Table ‎2‑3: Typical Meteorological Data for Perur DSP**

|  |  |  |
| --- | --- | --- |
| **Meteorological Parameters** | **Unit** | **Values** |
| Mean annual ambient temperature (min./ max.) | ° C | 24.5 / 33.5 |
| Barometric pressure | K Pa | 100.1/ 101.35 |
| Relative humidity (min./ average/ max.) | % | 57 / 70 / 83 |
| Main wind direction |  | South westerly |
| Average annual rainfall | mm | 1399.3 |
| Average rainfall during Northeast monsoon (June to Sept) | mm | 454.3 |
| Average rainfall during Southwest monsoon (Oct to Dec) | mm | 837.1 |
| Maximum rainfall within 24 hours | mm | 346.6 |

## Ocean Conditions

The oceanography of the region is influenced by 3 climatic conditions viz., Southwest monsoon (June – September), Northeast monsoon (Mid – October to Mid – March) and a fair-weather period (Mid -March to May). The coast is more influenced by the Northeast monsoon than the other two seasons. Wave action is high during the Northeast monsoon and cyclonic period. The coastal current within a 5 km radius distance is greatly influenced by winds and tides. The nearshore remains more dynamic and turbulent due to persistent action of seasonal wind, high waves and sea currents. The distribution of temperature and salinity indicates that the nearshore water is well mixed without stratification. The influence of littoral drift is significant, and the annual net drift takes place in a northerly direction. The tide elevation at Perur with reference to Chart Datum (CD) is furnished in table below:

**Table ‎2‑4: Tidal Elevation at Perur**

|  |  |  |
| --- | --- | --- |
| **Tidal elevation** | **Chart Datum (CD) in m** | **RL (m)** |
| Mean High water spring | 1.15 | RL 0.5 |
| Mean High water neaps | 0.84 | RL 0.2 |
| Mean Sea Level | 0.65 | RL 0.0 |
| Mean low water neaps | 0.43 | RL -0.22 |
| Mean low water spring | 0.14 | RL -0.51 |

Note: Onshore survey levels are recorded as m above sea level. Hence, the mean high water springs conversion of CD to MSL is 1.15 -0.65 m = RL 0.5.

## Geotechnical data

A geotechnical survey was carried out on behalf of CMWSSB during the year 2014. The subsoil is made up of three distinct layers, as indicated below. However, the Contractor is required to undergo the geotechnical study to conform the values.

* Greyish silty fine sand : From - 0.0 to – 10.0 m (SPT N value = 10 to 64)
* Brownish silty stiff clay : From - 10.0 to – 13.0 / - 15 m (SPT N value = 7 to 9)
* Soft Disintegrated Rock : From - 13.0 to -15 m to – 19.0 m (SPT N value ≥ 100)
* Hard granite rock : From -17m to -23 m

Note: SPT – Standard penetration test

The groundwater table readings were recorded between 28th October 2014 to 5th November 2014. The groundwater table was encountered within depths of 1.54 m to 1.72 m below the EGL. In general, the groundwater table was almost consistent with the ground surface undulations, which implies that the groundwater is not perched water.

A preliminary geotechnical report is attached in Annexure-2D-1

## Land Development Plan

The height of the project site varies from CD +7 m on the East Coast Road to CD +2-3 m on the seashore side (Figure-5). Hence is it proposed to raise the site by additional earth fill to realize the Finished Ground Level (FGL) at CD +6.5 m. Raising of Finished ground level (FGL) up to +6.5 m CD is warranted to maintain safety factor to protect from strong winds and global warming, Tsunami and other emergency conditions. The boundary of the Perur DSP will be constructed on the raised land with high retaining wall of reinforced concrete. The retaining wall is proposed with pile foundation to keep it stable. A boundary wall of the same height shall be constructed on the ground level around the rest of CMWSSB land area including the burial grounds as indicated in the Plant Layout drawing (7061563/PMC400MLD/CP1/LAY/002) and Retaining wall/ Compound wall drawing (7061563/PMC400MLD/CP1/RET/005)

## Access to the Site

The proposed 400 MLD desalination plant is located on the coast of the Bay of Bengal. Regular access to the Perur site from Chennai is via the East Coast Road. The Site is located about 34 km South of the City Centre, along the East Coast Road.

The Employer will provide access to and limited possession of the Site to the Contractor for carrying out the Works. The Tenderer shall be deemed to have inspected the Site, including access before submitting his Tender.

The Nemmeli desalination plant is in the vicinity within 1 km of the proposed Site. The Contractor shall ensure that the operation of the Nemmeli plant and production of the potable water for supply to the city shall not be hindered any way due to construction works or mobilisation of the equipment, civil or any contract related works at Perur plant site. The strategy of the work implementation shall be discussed with and approved by the Engineer before any work execution to avoid any unforeseen difficult situation.

## Employer’s Requirements

The Contractor shall use the proposed process design given in the Employer’s Requirements (Part-2) as a guide to understanding the requirements. However, the final process, mechanical, electrical and civil designs for the required performance of the complete design-build and O&M Works at the Plant with sludge treatment and waste disposal out of the site premises are the responsibilities of the Contractor. The bidders are encouraged to visit the proposed Perur plant site and understand the nature of works and level of site rehabilitation required for the plant construction and smooth operation as per Employer’s Requirements. The successful completion of the full design-build Works and O&M Works as per the Contract is the responsibility of the Contractor. If additional works are essential which have not been mentioned in the bid document and Schedule of Price, then the bidders must identify those additional works in the technical schedule and price schedule in the related system and include in their offered project cost accordingly.

## Maintenance of the Site

The Bidders shall include cost for maintaining the accommodation, equipment and all related services during construction, installation and operation of the works until the expiry of the Contract period or until such time as the facilities mentioned above, with the permission of the Engineer, are removed.

## Areas outside the Site

In the event of the Contractor making use of any special or temporary wayleave or accommodation acquired by him or any tip for the disposal of surplus materials, or any borrow pit or quarry, he shall obtain the written consent of the owner, occupier or authority having charge of the land in which such wayleave, accommodation or tip is situated and shall make a record agreed by the owner, occupier or authority as aforesaid of the condition of the surface of that land before entering thereon.

Under these circumstances, the Contractor shall form a working area extending five (5) m from the edge of the Permanent Works or accommodation on all sides. The Contractor shall restrict his activities to within this working area. On completion of the works in this area, the Contractor shall reinstate the area to its original condition and to the satisfaction of the Engineer.

For the purposes of this Clause, ‘accommodation' shall be deemed to include housing, offices, workshops, warehouses, and storage areas.

## Road Works

The Contractor shall obtain all permits required for carrying out works such as excavation on public roads and shall liaise with the appropriate authorities with regard to the timing and execution of the road works. The Contractor shall be responsible for establishing and maintaining temporary road diversions for the duration of the road works. The road shall be kept open at all times during the road works period, and the work shall be carried out in such a manner as to minimise the disruption to traffic. All costs related to any type of permissions needed during work execution shall be included by the Bidder in his Price Schedule.

## Maintenance of Existing Access Roads

The Contractor shall use existing access roads to the Site, which are necessary for the execution of the Works. The additional access road may be created with the consent of the Employer and after getting full permission from the concerned government authorities. The Contractor shall be solely responsible for the maintenance of the Site access roads. This responsibility shall continue until the completion of the Defects Liability Period, or until such earlier date as the Engineer may advise the Contractor in writing. Such maintenance work shall include general up-keep and any necessary repairs to the damaged road surfaces, pavement, drainage, associated slopes, etc. to original condition. While carrying out such maintenance work, the Contractor shall make arrangements to maintain the passage for the Employer's and his staff's vehicles and also those of subcontractors over these access roads, which may comprise temporary diversions all to the approval and satisfaction of the Engineer.

The Contractor shall take every precaution while operating tracked or unsprang vehicles on surfaced roads and shall use planking or some other protective material to protect the road surface.

## Clearance of the Site

The Contractor shall clear the Site to the extent required by the Engineer for checking the setting-out. Clearance of the Site shall also include the landfilling, excavation, demolition and removal of all trees, articles, objects and obstructions which are expressly required to be cleared to the satisfaction of the Engineer. The Employer will assist the Contractor in obtaining the necessary approvals and permits for removal of trees. However, obtaining such approvals and permits shall be the sole responsibility of the Contractor.

The Contractor shall remove the material arising from such clearance and dispose of it in a manner and at a location, on or off the Site, to the approval of the Engineer.

The Contractor shall not clear the Site of any structure without the prior written permission of the Engineer.

## Clearance and Reinstatement of the Site on Completion

On completion of the Construction Works, the Contractor shall clear any temporary works areas and temporary access roads and reinstate the areas to their original condition/ required landscaping and to the satisfaction of the Engineer.

## Site Records

The Contractor shall make records of the position and extent in the excavations of every type of services, stratum and obstruction encountered during the construction of the Works.

## Access for the Employer and Engineer

The Contractor shall permit the Employer/Employer’s representative, and the Engineer and any person authorised by the Employer or the Engineer including workers of the Employer, other contractors or utility undertakings access for the purposes of the Contract to all areas of the Site and any additional accommodation or temporary wayleave for the duration of the contract period.

## Facilities for Employer during the Contract Period

The Contractor shall purchase 3 new SUVs (top model) in the name of CMWSSB and provide them to the Employer for their use during DB Contract period. Additional, two new similar SUVs shall be provided by the Contractor to the Employer for their use through O&M period after 5 years of the Commencement Date of the Contract. All expenses related to driver, insurances, fuel and maintenance of the vehicles shall be the responsibility of the Contractor.

The contractor shall provide and maintain at his cost, fully furnished airconditioned temporary site office of 300 m2 for the Employer and PMC with wifi, toilets, pantry, conference room along with the following facilities through the construction period of the contract or till the Administrative Building is constructed and fully furnished or till Design-Build Period whichever is later. The drawings for the site offices shall be approved by the Employer’s Representative.

|  |  |  |  |
| --- | --- | --- | --- |
| **Sl. No.** | **Facility** | **For Employer** | **For PMC** |
| 1 | Common Hall, cabins, work stations and Laptops with latest user software | Hall with 4 work stations, 4 cabins  (8 Laptops) | Hall for 14 engineers with all facilities mentioned above and 4 cabins |
| 2 | Conference Room with white board and video conferencing facility etc. with marker pens etc. | To seat 25 persons | To seat 25 persons |
| 3 | Document storage room with printer, photocopy facilities along with required stationary. | Required | Required |

## Water Supply and Disposal on Site

The Contractor shall manage the supply of product water for the purposes of construction of the Works. The Contractor shall ensure the quality of the water remains suitable for the purpose for which it is intended and maintain the water meter in proper condition.

Wastewater shall be disposed off, clear of the Site meeting the prevailing statutory requirements to the satisfaction of the Engineer and the government authority so as to avoid no damage or complaint. In any circumstances, the wastewater can’t be discharged to the sea.

## Toilets and Washing Facilities

Throughout the period of plant construction, the Contractor shall provide, maintain and cleanse suitable and sufficient latrines and washing facilities for use by his workers. He shall ensure that his workers do not foul the Site and make proper use of the restrooms.

Where practicable the latrines shall be connected to the nearest sewer, or if this is not practicable, the Contractor shall provide an adequately sized septic tank and soak pit. The Contractor shall also provide separate latrines to the above requirements for the entire Employer’s/Engineer’s staff. After completion of the works, the latrines and washing facilities shall be removed, all ground disinfected and the surface reinstated to the satisfaction of the Engineer.

## Electricity for Contractor's Use on Site

The Contractor shall be responsible for the provision of an energy meter and distribution of an electrical supply at the Site for the purpose of construction Works.

The construction and installation works shall comply with all the relevant regulations, Indian Standards and Codes of Practice, and Health and Safety requirements, etc. The Contractor shall take every possible precaution to ensure that his execution works are safe and injury to personnel or damage to Plant and buildings is avoided. The Contractor shall be fully responsible for all safety and maintenance aspects including the asset, personnel and material safety insurance etc.

The Contractor shall test the temporary Site electric distribution system, including energy meter regularly for compliance with the relevant standards.

## Camp and Office Facilities

The Contractor shall construct and maintain to the Engineer’s satisfaction a camp to provide living accommodation for all Contractor’s staff and operatives who have no other local accommodation. The Contractor's camp shall be located close to but not on the Site itself and at a location approved by the Engineer.

Responsibility for providing all services to the living quarters and compliance with all sanitary laws and other laws and regulations shall be borne by the Contractor. Security and the fencing of these areas shall be the responsibility of the Contractor.

## Compressed Air Use on Site

The Contractor shall provide the necessary compressed air plant and equipment required for construction of the Works. In case Diesel engine driven compressors are used, it shall not be sited within buildings or at a location that may cause a health hazard to personnel owing to exhaust fumes or noise.

## Refuse Disposal on Site

Refuse, and rubbish of any kind shall be removed from the Site and disposed of by the Contractor at his own expense, frequently and regularly so as to keep the Site in an approved wholesome and tidy condition to the satisfaction of the Engineer.

## Health, Hygiene and Contamination of Water Supplies

The Site shall be an area of ‘restricted operation'. Exemptions may be granted at the discretion of the Engineer for short-term operations involving no risk of contamination.

* All personnel shall be medically accepted
* Strict discipline shall be maintained concerning personal hygiene
* Vehicles, Plant, tools and protective clothing shall be kept clean and disinfected regularly.

To obtain medical acceptance, the Contractor shall require his employees and those of his sub-contractors to undergo medical screening, to ensure that they are not harbouring waterborne pathogenic organisms, before commencing ‘restricted operations'.

All potential employees and supervisors who may have contact with the ‘restricted operations’ shall take a copy of the completed questionnaire together with two colour passport size photographs to the Medical Officer for Environmental Health of the District Health Authority where the person resides.

The Medical Officer will consult the person and return the questionnaire to the Contractor. The Contractor shall then forward the questionnaires and photographs of those he wishes to employ to the Engineer for approval. Approval in the form of a blue identity card shall be issued for the approved cases. The card is valid for the duration of the Contract or one year, whichever is less. Contracts of duration greater than one year of ‘restricted operations' carried out in the maintenance period will require a reassessment of employees.

If an employee contracts any illness, looseness of bowels or gastric disorder, he must immediately cease work on ‘restricted operations', return his identity card, avoid contact with other employees, undergo medical screening and gain fresh approval before continuing work on the `restricted operations' Site.

Works involving both ‘restricted operations' and ‘non-restricted operations’ shall either require (1) all employees to be medically accepted or (2) separate messing facilities, storage for protective clothing, tools, vehicles and Plant for the two types of employees.

## Safety and Security on Site

The Contractor shall at all times maintain a safe system of working and shall comply with all enactments, regulations and working rules relating to safety, security, health and welfare of all persons who may be affected by his work. In particular, the Contractor shall ensure that only persons who are appropriately trained for their duties are employed and that the correct tools and procedures are used.

Nothing which has been written into or omitted from this Employer’s Requirements shall be taken to relieve the Contractor from his obligations under this Clause. No clause in this Employer’s Requirements shall prevent the Contractor from drawing the attention of the Engineer to any feature of the Works which is not consistent with normal safety practices nor prevent him putting forward proposals at any time which would increase the safety of the installations.

Not later than 28 days before work commences on the Site, the Contractor shall submit to the Engineer his comprehensive proposals relating to the safety, health and welfare of all his personnel on the Site.

The Contractor shall appoint a suitably qualified representative as Safety Officer who shall be responsible for the implementation of Site procedures as per relevant standards which shall include but not be limited to:

* safety
* working in hazardous areas
* permit to work
* fire and smoking regulations
* first aid
* warning signs
* trenching scaffolding and other construction structures
* safety barriers
* protective clothing and equipment
* safety training
* safety meetings and inspections
* health and welfare

The proposals shall be appropriate for all grades of labour and personnel who will work on or visit the Site on behalf of the Employer, Engineer or Contractor. The Engineer will have the power to stop any activity or work in any area where there is a breach of the published Site safety rules such that health or life is put at risk.

The Contractor shall, also, comply with the Safety Policy of the Employer, copies of which are available from the Engineer upon request.

The Contractor shall ensure that all employees and subcontractor employees working on the Site are not working in an unsafe manner to endanger themselves, the Contractor’s personnel, other personnel or the Plant. The Contractor shall bring any violation of Site safety rules by others to the attention of the Engineer in writing.

### PPE and Protection from COVID-19

The Contractor shall ensure that all the personal protective equipment (PPE) are available with each and every worker at the site. It should include:

* Respiratory protection - for example, disposable masks, cartridge, half or full face. It is important to protect workers from transmitting any infection such as COVID-19.
* Eye protection – for example, spectacles/goggles, shields, visors.
* Hearing protection – for example, ear muffs and plugs.
* Hand protection – for example, gloves and barrier creams.

## First Aid and Life-saving Apparatus on Site

The Contractor shall provide on the Site such life-saving apparatus as appropriate and an adequate and an easily accessible first aid outfit or such outfits as required in any government ordinances, factories acts, etc., published and subsequently amended from time to time. Also, an adequate number of persons permanently on the Site shall be instructed in their use, and the persons so designated shall be made known to all employees by the posting of their names and designations in a prominent position on Site.

## Electrical Safety on Site

The Contractor shall be responsible for the electrical safety of all Plant supplied and installed. Whilst any equipment is being installed or tested; the Contractor shall ensure that all necessary precautions are taken to safeguard personnel working on Site. If necessary, this shall include fencing off areas which are considered to pose a risk and erecting warning notices.

The Contractor shall be responsible for ensuring that the electrical installation is carried out by suitably trained competent personnel and that the work is carried out in a safe manner.

The Contractor shall be responsible for the operation on the Site of a permit to work system during the period of electrical equipment installation and testing. This system shall regulate the installation, the energisation and the use of electrical Plant installed and the method of work adopted.

## Noise

The Contractor shall ensure that noise from the operations entailed in the construction of the Works does not cause annoyance to others working on the Site or to persons living adjacent to the Site.

## Warning and Safety Signs

During construction of the Works, statutory safety signs shall be adequately provided throughout the Works, both indoors and outdoors. These safety signs shall be in Tamil and English and shall cover mandatory, prohibition, warning, emergency, fire-fighting and general notices. All signs shall be positioned around the Works at highly visible points. Provision of signs and the positions of signs shall be subject to the Engineers approval. Special attention shall be given to areas designated hazardous.

## Site Working Hours

During the Construction Phase, no work shall be carried out on the Site on locally recognised days of rest, or outside regular working hours, unless:

1. otherwise stated in the Contract
2. the Employer gives consent
3. the work is unavoidable or necessary for the protection of life or property or for the safety of the Works, in which case the Contractor shall immediately advise the Engineer.

The Contractor shall not increase the working hours during the Construction Phase without the prior approval of the Engineer. During the Operation and Maintenance Period, the Work shall be carried out all 24 hours of a day.

## Delivery to Site

The Contractor shall be responsible for the transporting and handling of all the Plant as required. The storage of all equipment and construction items at the Site shall be the Contractor's responsibility.

The Contractor shall check all items against packing lists immediately on delivery to the Site and shall also inspect for damage and shortages. Damages and shortages shall be remedied with the minimum of delay.

The Contractor may, with the prior approval of the Engineer and at no extra cost to the Employer, make arrangements for any other contractor or agent to take delivery of, unload and store the Plant on the Site on behalf of the Contractor.

All deliveries shall take place during the Contractor's regular working hours.

## Storage and Protection from Weather

Indoor storage for electrical, instrumentation and any other equipment/material likely to be damaged due to moisture and outdoor storage for other plant equipment to be provided at Site for use by the Contractor for storage of Plant prior to erection will be subject to the approval of the Engineer.

The Contractor shall provide all other facilities for the safe and proper storage of Plant particularly cartridge filters, RO membranes, as recommended by the manufacturers, with particular consideration being given to temperature, rain, sunlight, wind and ground conditions the storage area shall be suitably raised to prevent waterlogging.

The Contractor shall remain responsible to the Employer for the care and insurance of the Plant, and the provisions of this Clause shall not relieve the Contractor of any of his liabilities under the Contract.

Stored Plant items shall be laid out by the Contractor to facilitate their retrieval for use in the programmed order. Stacked Plant items shall be protected from damage by spacers on load distributing supports and shall be safely arranged. No metalwork shall be stored directly on the ground. Small Plant items shall be held in suitable bins, boxes or racks and be clearly labelled. Items of Plant shall be handled and stored so that they are not subjected to excessive stresses, and so that protective coatings are not damaged.

The Contractor shall comply with the manufacturer's package and plant markings concerning the use and location of lifting slings, chains and hooks.

## Contract Signboards

The Contractor shall supply and erect signboards at locations to be specified by the Engineer. The layout and dimensions of the signboards and their preparation shall be to the approval of the Engineer and the lettering in both Tamil and English shall be black on a white background.

## Advertising

The Contractor shall not use any part of the Site for any form of advertising without the prior written approval of the Engineer.

**CHAPTER-3**

# PARTICULAR PROCESS REQUIREMENTS

## Introduction

Through this tender, Chennai Metropolitan Water Supply and Sewerage Board (CMWSSB) intends to build a Seawater Reverse Osmosis (SWRO) based Desalination Plant of capacity 400 MLD at Perur, Chennai, Tamil Nadu, India to augment its drinking water supply capacity in the city of Chennai. At present two SWRO desalination plants at Minjur and Nemmeli are already in operation.

This project involves the construction of intake and outfall structure along with the required pipelines, construction of pre-treatment processes, SWRO desalination plant, remineralization plant, GIS-based electrical substation and other processes and units to build a complete operating plant within the plant premises for the production of 400 MLD product water of the required drinking water quality.

The Contractor has to do all the works for construction of a 400 MLD SWRO desalination plant including the data collection and studies, design, engineering, manufacture, supply, transportation to site, unloading, storage, construction, installation/erection, testing, commissioning and putting into the successful operation of the Plant on Design Build Operate (DBO) basis including all Civil, Structural and Architectural, Mechanical, Electrical, Control & Instrumentation and all Infrastructural work covering lighting, drain, all preparatory & temporary works for the purpose of meeting the entire scope of works.

The Process design shall meet the Employer’s Requirements and be suitable to achieve the required performance while producing 400 MLD drinking water under all raw seawater conditions.

## Objectives and Scope

The scope of Works includes complete designing, construction, procurement, installation, commissioning and 20 years operation and maintenance of a 400 MLD SWRO desalination plant on Design, Build and Operate (DBO) basis. The Works include all process, mechanical, electrical, civil, instrumentation and control, and all other works required for construction of the plant with sludge treatment facility. The Plant shall be fully automated and complete in all respect to produce 400 MLD product water of the required quality.

The Bidder shall be responsible for the design, engineering, construction/ manufacturing, shop fabrication, assembly, testing and inspection at supplier’s works, packing, dispatch, shipping, delivery at Indian port/unloading at Indian port/delivery from Indian port to the site in case of imported equipment, and delivery/unloading at the site for indigenous equipment, unloading and safe storing at the site, insurance of all works, handling at the site, complete erection, start-up, commissioning, successful performance testing, process proving, warranty, defect liability and, operation and maintenance period.

Upon completion of the initial performance test and process proving, the Contractor shall be responsible for Twenty (20) years of the operation and maintenance of the 400 MLD plant. The plant design, procurement, construction, performance test and process proving shall be monitored and certified by the Employer’s Representative supported by PMC .

The Bidder shall include in its scope all the equipment, works and services necessary for completely safe and reliable operation and maintenance of the Plant in accordance with the terms of the DBO Contract, even if certain works are not explicitly stated in any part of this Bid Documents.

The detailed scope of works is presented in Part-2 Section VI- Chapter-1 Project Requirements. The bid document presents the site details, onshore topography, offshore bathymetry, indicative process designs and environmental conditions for the proposed Perur desalination plant. The Contractor is required to verify these data figures and design the plant suitable for production of 400 MLD potable water of the quality and quantity required as per the contract.

## General Arrangement of the Works

### Site Details

The proposed construction site for the Desalination plant is located at Perur village, about 40 km from the Chennai city centre. The total area of the plot is approximately 34 ha. It is situated along the coastal side of the East Coast Road (ECR). Its ground elevation is Chart Datum (CD) +2.0 to +7.5m. ECR is approximately at CD +11.

There are two numbers of graveyards identified within the proposed site. The one on the Southern side of the seacoast and another one on the Northern side towards the East Coast Road. It is understood that the graveyards must be left undisturbed and shall be protected by a compound wall all across and proper drainage shall be made draining towards the sea. Nevertheless, the unused area available at the proposed site is enough for the construction of the proposed plant in all respect. Overall tentative layouts for the entire Desalination plant may be referred from Generalised Site Layout enclosed in Part-2, Section VI, Drawings. Final layout of the systems shall be furnished by the Bidder and finalised during detailing. The climatic conditions are characterised by warm, dry winters (27oC average daily max) and hot summers (39oC average daily max) with an annual average rainfall of 1200mm. Cyclones are common in the area, and the site is expected to be affected by cyclones.

The proposed land has been identified under survey number – 208/ 2B3 belonging to the M/s. Arulmigu Alavandar Nayakar Trust maintained by The Hindu Religious and Charitable Endowment Board (HR & CE) Department, Government of Tamil Nadu (GoTN). CMWSSB procured the land on a long-term lease basis.

The details of the site details are presented in the Part-2, Section VI, Site Data.

#### Site Location

The details of the local site conditions are given below.

**Table ‎3‑1: Details of Site Location for the Proposed DSP Site**

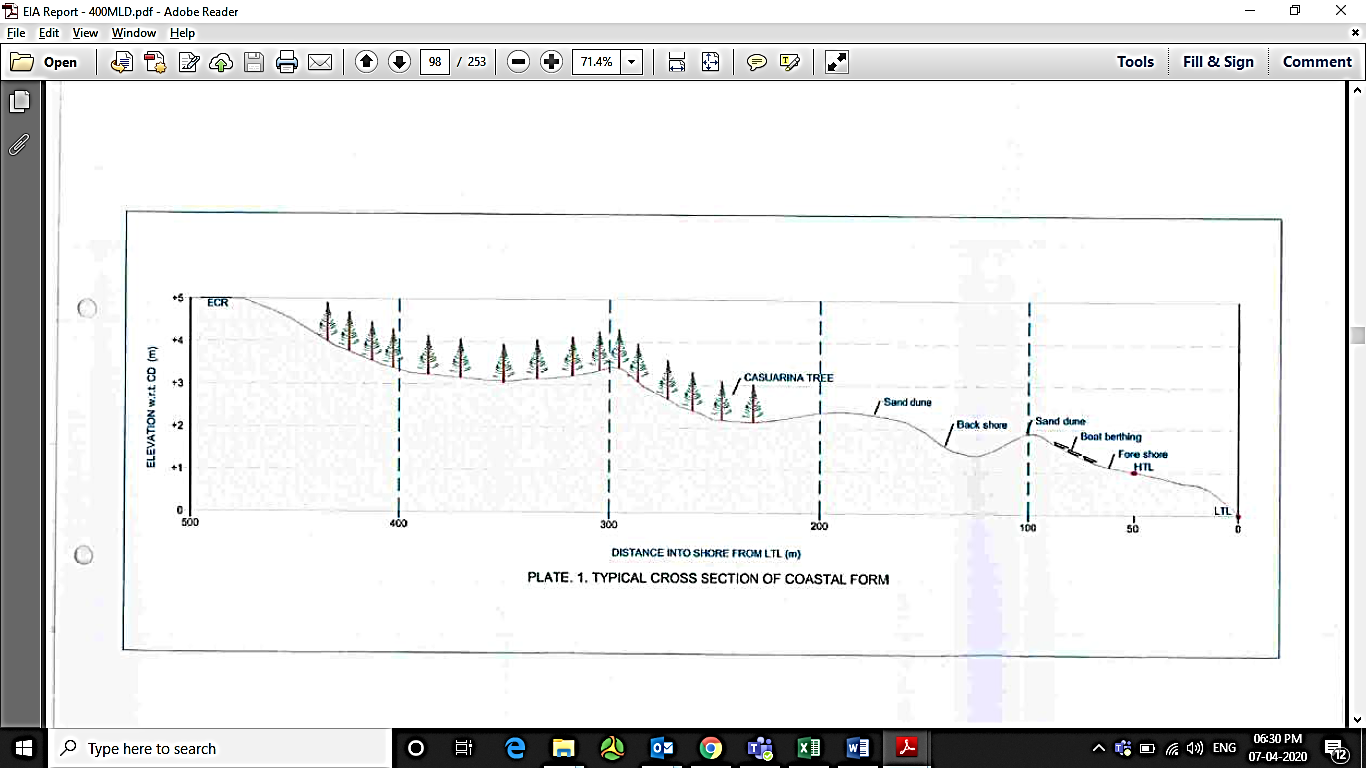
| **Particulars** | **Details** |
| --- | --- |
| Site Location | District: Kanchepuram / Taluk: Thiruporur / Village: Perur |
| Site coordinates | 12°42'44"N, 80°14'26"E |
| Nearest highway | State Highway SH 49, East Coast Road |
| Nearest railway station | [Othivakkam railway station](https://ind01.safelinks.protection.outlook.com/?url=https%3A%2F%2Fen.wikipedia.org%2Fwiki%2FKathgodam_railway_station&data=02%7C01%7Ckrithikas%40tce.co.in%7C1d6c36a4380a4a89cc4308d71bc22e42%7C5af76741f8864d20ad04775dee0ce762%7C0%7C0%7C637008393117746756&sdata=zaqkY6TkSovu7%2BlX4yC9zw%2F%2BJzGRtDFLfphGsQ0ZCho%3D&reserved=0) |
| Nearest Airport | [Chennai Airport](https://ind01.safelinks.protection.outlook.com/?url=https%3A%2F%2Fen.wikipedia.org%2Fwiki%2FPantnagar_Airport&data=02%7C01%7Ckrithikas%40tce.co.in%7C1d6c36a4380a4a89cc4308d71bc22e42%7C5af76741f8864d20ad04775dee0ce762%7C0%7C0%7C637008393117746756&sdata=29nhgukgEIiUVoHED7B%2BBWXyjWxQa%2F1ooXbVTctVMW0%3D&reserved=0) |
| Nearest town/ City | Chengalpattu, Pudupattinam,  Tirukalukundram, Nandivaram-Guduvancheri |
| Archaeologically Important places | Mahabalipuram |

#### Topography

Based on the preliminary onshore topographic survey and offshore bathymetry survey, the details are given below. However, the contractor has to repeat the study for confirmation.

##### Onshore topography

The Existing Ground Level (EGL) at the test conditions varied from +2.0m Chart Datum (CD) to + 3m CD indicating the almost uniform condition. The site is having tree plantation of Casuarina. The site falls under Seismic Zone III as per BIS code IS: 1893 (Part I). The topography of the proposed Perur DSP site is furnished below.



**Figure ‎3‑1: Typical Topography of Planned Perur DSP site**

##### Offshore Bathymetry

Based on the bathymetric survey, buried rocks have been found near the shore that is spread in different direction and depth. Figure 2-1 in Chapter-1 presents a seabed map indicating the location of buried rocks.

The bathymetry survey shows that the depth contours are generally running parallel to the coast. The depth of the seabed with respect to the distance from the shore as obtained from the DPR report is furnished in Table 2.2 above. The Contractor is to verify these figures before start of the intake works.

Sedimentary layers of silty sand were identified between – 0.0 and -8.0 m below the seabed.

#### Climate

Chennai features a [tropical wet and dry climate](https://en.wikipedia.org/wiki/Tropical_savanna_climate). Chennai lies on the [thermal equator](https://en.wikipedia.org/wiki/Thermal_equator) and is also coastal, which prevents extreme variation in seasonal temperature. For most of the year, the weather is hot and [humid](https://en.wikipedia.org/wiki/Humidity). Typical meteorological data for Perur DSP is furnished below. Cyclones are more common in the Bay of Bengal, and the proposed Perur site is expected to be affected by cyclones by approximately 3 times per year. The details of Typical Meteorological data for Perur DSP site are furnished below.

**Table ‎3‑2: Typical Meteorological Data for Perur DSP**

| **Meteorological Parameters** | **Unit** | **Values** |
| --- | --- | --- |
| Mean Ambient temperature (min./ max.) | ° C | 24.5 / 33.5 |
| Barometric pressure | K Pa | 100.1/ 101.35 |
| Relative humidity (min./ average/ max.) | % | 57 / 70 / 83 |
| Main wind direction |  | South westerly |
| Average Annual rainfall | mm | 1200 |
| Average rainfall during Northeast monsoon (June to Sept) | mm | 440 |
| Average rainfall during Southwest monsoon (Oct to Dec) | mm | 760 |
| Maximum rainfall within 24 hours | mm | 346.6 |

Source: Indian Meteorological Department Chennai, Meenambakkam, 1981- 2010

#### Ocean Conditions

The oceanography of the region is influenced by 3 climatic conditions viz., Southwest monsoon (June – September), Northeast monsoon (Mid – October to Mid – March) and a fair-weather period (Mid -March to May). The coast is more influenced by the Northeast monsoon than the other two seasons. Wave action is high during the Northeast monsoon and cyclonic period. The coastal current within a 5 km radius distance is greatly influenced by winds and tides. The nearshore remains more dynamic and turbulent due to persistent action of seasonal wind, high waves and sea currents. The distribution of temperature and salinity indicates that the nearshore water is well mixed without stratification. The influence of littoral drift is significant, and the annual net drift takes place in a northerly direction. The tide elevation at Perur with reference to Chart Datum (CD) is furnished in table below:

**Table ‎3‑3: Tidal Elevation at Perur**

|  |  |  |
| --- | --- | --- |
| **Tidal elevation** | **Chart Datum (CD) in m** | **RL (m)** |
| Mean High water spring | 1.15 | RL 0.5 |
| Mean High water neaps | 0.84 | RL 0.2 |
| Mean Sea Level | 0.65 | RL 0.0 |
| Mean low water neaps | 0.43 | RL -0.22 |
| Mean low water spring | 0.14 | RL -0.51 |

Note: Onshore survey levels are recorded as m above sea level. Hence, the mean high water springs conversion of CD to MSL is 1.15 -0.65 m = RL 0.5.

#### Geotechnical data

A geotechnical survey was carried out by CMWSSB during the year 2014. The subsoil is made up of three distinct layers, as indicated below. However, the Contractor is required to undergo the geotechnical study to conform the values.

* Greyish silty fine sand : From - 0.0 to – 10.0 m (SPT N value = 10 to 64)
* Brownish silty stiff clay : From - 10.0 to – 13.0 / - 15 m (SPT N value = 7 to 9)
* Soft Disintegrated Rock : From - 13.0 to -15 m to – 19.0 m (SPT N value ≥ 100)
* Hard granite rock : From -17m to -23 m

Note: SPT – Standard penetration test

The groundwater table readings were recorded between 28th October 2014 to 5th November 2014. The groundwater table was encountered within depths of 1.54 m to 1.72 m below the EGL. In general, the groundwater table was almost consistent with the ground surface undulations, which implies that the groundwater is not perched water.

#### Land Development Plan

The height of the project site varies from CD +7 m on the East Coast Road to +2-3 m on the seashore side. Hence is it proposed to raise the site by earth fill to realize the FinishedGround Level (FGL) at CD +6.5 m supported by RCC retaining wall. Raising of Finished ground level (FGL) up to +6.5 m CD is warranted to maintain safety factor to protect from strong winds, Tsunami and other emergency conditions. The boundary of the Perur DSP will be constructed on the raised land with retaining wall. The retaining wall is proposed with pile foundation to keep it stable. A 2.5 m high boundary wall shall be constructed on the ground level around the site area including the burial grounds as indicated in the proposed land development plan for the proposed Perur DSP provided in the Part-2 Section VI, Drawings.

### General Arrangement of Plant

It is expected that the Contractor will use his best efforts to optimize the use of Plant land area. A preliminary Plant layout of the desalination plant is shown on drawing ‘General Layout Site’ Part-2 Section VI, Drawings. The proposed Plant layout is a preliminary layout and is subject to optimization by the Bidders during the preparation of the bid as well as during detail design. The following general rules shall be followed in arranging the Plant units.

All drawings in this bid document shall be considered indicative only. In the event of any conflict between information in the drawings and this document”, Chapter 3 – “Particular Process Requirements” shall prevail.

The following general rules shall be followed for any construction work of the Plant units (to be erected):

* Sufficient space (of not less than 2.0 m wide) shall be allowed between items of Plant and adjacent Plant or fixed structures to permit safe and convenient access for operation and maintenance, and provision of appropriate structure foundations. The space between buildings shall be at least 5m to allow movement of the vehicles.
* In the case of areas that require movement of heavy equipment for installation and replacement, sufficient access shall be provided by the Contractor to move heavy vehicles. Adequate space shall be provided adjacent to all mechanical equipment as maintenance lay down area.
* Fixed ways, lifting eyes or other means shall be provided to permit the removal of Plant equipment that may logically be required to be removed during the course of its normal operational life for maintenance or any other purpose.
* Areas where the leakage is likely to occur, whether in normal use or during maintenance, shall be provided with an underground drain line or covered RCC drainage channels which shall direct the spillage to a sump from where it can be pumped to the neutralization pit or outfall tank of the plant as per the quality of the leaking fluid.
* Where necessary, Plant shall be provided with removable acoustic coverings to limit the noise produced during normal operation to the specified limits.
* The Plant shall be arranged, and the buildings shall be designed to permit the removal/relocation of Plant items.
* The drain valves from process units with a diameter up to and including 250 mm shall be operated manually and those greater than 250 mm valve shall be operated by an electric motor. For the valves located below ground level, an extended spindle shall be provided for ease of operation.
* The yard pipelines should be laid underground and all flowmeters and dismantling, isolation valves should be kept underground in chambers with the display above ground to avoid any hindrance in the passage of vehicles.
* Chemical pipework shall be secured to racks or trays to be fixed to duct walls or walls of tanks and buildings as necessary. The method of securing the pipes to the racks shall be by clips or something similar, facilitating ease of removal in such a way that individual runs can be changed without dismantling adjacent pipes.
* All chemical pipes shall be colour banded and suitably labelled to enable individual lines to be identified throughout their run. Particular attention shall be paid to the layout of the chemical pipework, which shall be functional and neat in appearance. Generally, where pipework is installed in ducts, it shall be supported not less than 150 mm clear of the floor.
* When selecting materials for pipework, the Contractor shall consider the deteriorating effect of some of the synthetic materials due to the action of ultraviolet light. Where such materials are employed, they shall be shielded from direct sunlight.
* Chemical storage should be grouped for compatible and non-compatible chemicals with separate bunding.

The Contractor shall ensure that all designs and equipment for which he is responsible are safe, feasible and durable. Nothing in this Works’ requirements 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 to prevent him making proposals for incorporating equipment or designs which would increase the safety of the Plant. The installation layout and plant design shall not allow any item of plant to be so positioned that danger to operating personnel could arise during normal operation and maintenance. Particular attention shall be paid to the position of pipes, air vents, electrical cables and rotating machinery. All rotating shafts, couplings, gears, flywheels, belt drives or other moving parts shall be fully guarded. Guards shall be designed to provide ready access to bearings, grease points, thermometer sockets/instrument probes and other checkpoints and to allow safe routine observation and servicing to be executed without the need to dismantle any part of their structure.

## Plant Process Specifications

### Seawater Quality

The Contractor shall consider the raw water quality provided in Chapter-1, Table-1.1 for the design of the desalination plant. However, the Bidders are advised to analyse and confirm the seawater quality to design a suitable pre-treatment system. The range of the parameters presented below provides an overview of the seawater quality range for the plant design.

|  |  |  |  |
| --- | --- | --- | --- |
| Parameters | Minimum value | Mean value | Maximum value |
| TDS, mg/l | 32000 | 36000 | 39000 |
| pH | 8.00 | 8.13 | 8.20 |
| Temperature, oC | 26.0 | 28.3 | 31.5 |
| Boron, mg/l | 3.2 | 3.53 | 3.80 |
| Turbidity, NTU# | 1.0 | 12 | 150 |
| TSS, mg/l# | 10 | 75 | 300 |
| Total Organic Carbon (TOC)\* mg/l | 3 | 5 | 8 |

\*to be confirmed by the bidder.

# TSS/turbidity value may be higher than the maximum value during the monsoon period.

### Product Water Quality

The water quality requirements in the product water tank shall meet the following parameters and the rest of parameters as per the Indian Standards IS:10500-2012.

* Turbidity (NTU) < 0.5
* Chlorides (mg/l) < 250
* TDS (mg/l) < 450 at plant product water tank exit
* Boron (mg/l) < 1 mg/l all the time
* pH 6.5<pH<8.5
* LSI > Positive
* Hardness ≥ 60 mg/l as CaCO3

### Intake and Outfall System

Two number of HDPE intake pipes (PE100) and one outfall pipe each of 2500mm OD at pressure rating of minimum 6.5 bar (SDR ≤ 26) shall be provided. In normal plant operation condition, each intake pipe shall cater to half the intake flow to produce net 400,000 m3/day of product water every month plus 10% extra flow to accommodate for biofouling/incrustation in the intake pipe. The intake system design shall also take into account for the additional pressure drop and resulting decrease in water level in the intake well (forebay) during pig cleaning of one of the pipelines and while maintaining the full intake feed flow. The intake shall comprise of two intake heads linked to the intake pumping station by two intake pipes laid below the seabed with the required cover (>1 m from the pipe crown level) using suitable pipe laying method. The pipe shall pass manufacturing and installation quality controls subject to the Employer’s inspection and approval. The intake head shall be made of concrete and comprise a number of vertical openings located between the seabed and seawater surface. The hydraulic analysis for the pipes shall allow for the marine growth of minimum 100 mm on all internal surfaces of the pipes. The intake and outfall pipes shall be laid on the same alignment as much as possible to avoid repeated trenching on different alignments.

The intake shall be provided with the state of art facilities to enable the pipelines to be pigged at the increase in pressure drop along the pipelines or the event of any sort of pipe blockage, preferably without the intervention of the divers entering the Intake system for manual cleaning. The pigging system shall be achieved by the provision of a pull line (launching station) linked to the pig entry point and delivering endpoint. The intake head could be provided with a removable cover on top of the intake head and mounting point for a winch which could then be used to pull the pig. It should then be possible to recover the pig through the removable cover. As the pigging system and divers as needed will be provided by the Contractor, these needs to be priced in the price bid by the bidder. The pipeline shall also have manholes at the suitable intervals for manual pipe inspection and cleaning as needed.

During Marine works and Design-Build works, the Contractor shall make necessary arrangements with prior approval from Employer/concerned authorities to prevent the shore erosion and disruption to the nearby Nemmeli Kuppam Boat Landing / Launching locations.

#### Intake Head (Tower)

A 100 mm screen with frame in Duplex Steel 2507 and bars in Cu Ni or equivalent shall be provided at the intake to exclude larger marine life. One intake chamber and screen shall be provided on each conduit. There shall be two intake heads with screen offshore separated by a minimum distance of 5000 mm. The screens will be of >8.5 m diameter, ≤1.5 m high, starting at >3m above the seabed, in ≥ 10-metre depth of seawater at low tide. The approach velocity shall be ≤0.12 m/s to minimise the entrapment of marine species.

A fishnet will be provided to minimise the ingress of jellyfish to the intake. Provision shall be provided to inspect and replace the net 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. 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 pigging. Marker buoys and floating screens shall be provided.

#### Intake Pipeline

Two intake conduits, each of 2500mm OD at pressure rating of minimum 6.5 bar, shall extend into the sea where the seawater depth is at least 10 m below the Lowest Tide Level. Water will enter the intake head opening at >3 m above the seabed and minimum 4 m below the top seawater surface during the low tide. The required CRZ clearance is obtained to lay the intake pipe at about 1150m and outfall pipe at 750m from the shore. A brine diffusion analysis shall be carried out by the Contractor to assess the quality of the seawater feed for RO system design. The velocity in the conduit at peak flow shall not exceed 1.5 m/s. Friction losses at this velocity should be less than 1.5 metre head in the pipeline. Incrustation thickness in the pipeline shall be taken 100 mm for calculating friction losses due to the marine growth on the internal periphery of the pipeline. The velocity of water through the intake head openings should be ≤0.12 m/s. The height of the vertical openings shall not exceed 1.5 m. A fish net shall be provided outside the bared head opening to prevent the ingress of fishes.

Pigging system to restore the hydraulic capacity of intakes shall be provided as discussed above to safely clean the intake pipes with better efficiency (a few days per year compared to a few weeks) that serves, of course, the Availability Factor. At least two pigs shall be provided to accelerate the cleaning process.

The bidder needs to provide the detailed Head loss calculation of intake pipes from Seawater intake head to the onshore screen intake chamber and to determine the available water levels in the Screen upstream and downstream and the pumping station. The bidder needs to submit the detailed calculation with a head curve along with the intake and outfall system.

#### Outfall Pipeline

One outfall pipe will be provided with 2500 mm OD of the same material as the Intake pipe. For a peak outfall flow of up to 640 MLD, the velocity in the pipeline should be within 1.5m/sec.

The Contractor shall design the outfall system based on the dispersion model to be conducted by him to promote better brine concentration management as per the prevailing environmental guidelines. The final outfall diffuser arrangement shall be determined after the brine dispersion analysis conducted by the Contractor and acceptable to the Engineer / Employer’s representative. There may be some increase in concentration of the seawater above its maximum value (as presented in Clause 3.4.1) at the intake head due to discharge of RO brine at the outfall. The Contractor is responsible to design the RO system based on the brine dispersion analysis results and considering the effect of any increase in salinity of the intake feed seawater on the desalination processes.

#### Intake Screening Station

Seawater intake well (forebay) will receive the seawater from the offshore intake head under gravity and transfer the seawater to the pre-treatment section. Seawater intake well will have two chambers separated by partition walls. The water production capacity of each of the chamber will be a minimum of 200 MLD. Whenever required, either one of the two chambers can be maintained, cleaned, or repaired while the other chamber in operation. So sufficient sluice gates shall be provided to isolate the chambers.

The intake well houses Travelling Band Screens which pass water to the pump chamber. A minimum of 4 (4x50%) screens, shall be provided for the proposed 400 MLD product water plant; such that the full screening capacity is available even two screens are out of service. Each screen shall be provided with a dedicated screening chamber which can be isolated from the rest of the screening station. Isolation shall be by sluice gates only. Stop logs are not acceptable. Sluice gates shall be provided both on upstream and downstream of each screen chamber made of carrion resistant material.

The screens shall be automatically cleaned and washed. Facilities shall be provided to enable an individual screen chamber to be drained entirely for maintenance.

Either the differential head loss across the screens shall be continuously monitored, or both the upstream level and downstream level shall be continuously monitored, and the differential head continuously derived.

The velocity across the screens shall not exceed 1m/s with the maximum design intake flow rate and the minimum seawater level. The screen mesh size shall not exceed 3 mm. The design should be such that it shall be possible to completely drain a single screen chamber from maximum tide level within 4 hours. The screens shall be made of materials suitable for the seawater use during plant lifetime and shall be structurally designed to withstand the maximum head-loss across the screens.

The differential head across the screens shall be recorded and used to initiate screen cleaning & washing automatically. In the event of the high differential head across the screens, an alarm shall be raised in the control system and the intake pumps shall be tripped by hardwired means. The trip differential head shall be less than the maximum structural design head-loss across the screens.

#### Intake Pumping Station

The screened water from the inlet screens shall flow into the intake pumping chamber. A minimum of (6W + 3S) pumps shall be provided for the total plant capacity (4 pumps for each process stream with one pump in store). Pair of 4 pumps shall form one manifold to supply water to one stream of 200 MLD plant. The bidder shall provide the no flow level in the pump well and hydraulic grade line entering into the pump station at both low and high tide conditions at the total inflow of seawater to produce net 400 MLD RO permeate at 42% to 46% RO recovery. The calculation for the static lift at Mean Low Water Springs and Mean High Water Springs shall also be provided.

Vertical Turbine pumps with large clear passages shall be provided in an RCC building where the motors shall be stationed on the first floor and pump discharge header at the ground floor to facilitate easy maintenance. The pump motors shall be with variable speed drive. The material of the pumps will be super duplex stainless steel (PREN No ≥ 41).

It shall be possible to isolate individual pumps for maintenance, whilst the remaining pumps are in service. The height of the pumping and screening chamber shall consider the maximum surge level which can be caused when all the pumps suddenly stop, with the seawater at maximum tidal level, and shall ensure that there is no flooding or damage to equipment under these circumstances. The standby pump shall automatically start in the event of failure of any of the duty pumps.

The bidder is required to carry out a transient analysis of the intake structure to determine the surge levels induced by pumps trip, and a pump starts and provides all calculations in connection of the same before start of intake pump station construction. The system shall be designed considering parallel operation of pumps.

The total flow-rate of water delivered by the pumping station shall be continuously monitored by two Electromagnetic Flow Meter – one in each process stream. All electromagnetic flowmeters in the plant shall be provided with a bypass line with sufficient isolation valves and dismantling joints to facilitate easy maintenance of the flowmeters.

Local indication of pump discharge pressure shall be provided. Low-level probes shall be provided in the pump well. The temperature, pressure, conductivity, oil, turbidity and chlorine residual in the pump discharge header shall be continuously monitored. The residual chlorine shall be measured at the intake well and outlet of pumping main and provision of suitable alarm shall be made in case of higher concentration.

#### Shock Chlorination System

A shock chlorination system shall be provided to inject sodium hypochlorite at the intake heads to minimise marine growth at the intake screens and in the intake conduits. The hypochlorite solution shall be injected across the intake head openings using a dosing sparger. All required system and piping shall be provided by the Contractor, including the provision of air pipe at the intake head offshore for the removal of entangled Jelly Fish on an intermittent basis. Suitable air system with compressors and air storage vessels shall be provided on shore for this purpose. The system shall be designed for chlorine residual in the conduit suitable to prevent deposition and growth of the marine organisms on the pipeline inner wall. The material of construction for the system shall be titanium or comparable.

Chlorination system shall also be provided to dose in the intake well to reduce the tendency of bio-growth in the pre-treatment system.

Along with chlorination system air bursting system at the intake head with suitable pressure vessel and compressor system shall be provided for dislodgement of the weeds and barnacles attached to the screen.

### Pre-treatment System

There will be two separate streams of the pre-treatment, desalination and post-treatment processes - each for 200 MLD product water capacity. The pre-treatment shall consist of a three (3) stage pre-treatment process to ensure sufficient safety in case of adverse Seawater quality conditions.

* Coagulation/flocculation followed by Lamella Settlers as the first stage,
* DAF (Dissolved Air Floatation) system as the second stage and,
* Gravity Dual Media Filtration system (GDMF) as the third stage,

The design of the above processes shall be proven for similar application of salinity, temperature and silt and organic matter burdens. This configuration is mandatory, and a pre-treatment design consisting of only one or two process stage is not acceptable.

Provision should be provided to allow by-pass of DAF during the period of good seawater quality. However, the process design should consider this treatment scheme to be operated continuously throughout the year.

The pre-treatment process shall be reliable to achieve the guaranteed characteristics of seawater suitable to feed the RO Plant. The Silt Density Index (SDI) after DMF shall be <3.0 (95th %ile) and <4.0 (100th %ile) and in any case, will not exceed the value recommended by any of the proposed membrane manufacturers. SDI tests shall be performed in compliance with ASTM D 4189 standard with Millipore filters.

The pre-treatment shall minimize the risk of organic and biological fouling and inorganic scaling on membrane surfaces and any damage to the membranes on account of residual chlorine in the pre-treated feed water.

The Bidder has to carry out his seawater testing/analysis to determine the raw water properties in order to ensure that the pre-treatment design offered is suitable to achieve the required treated feed seawater quality for RO system. The raw seawater quality provided above in Clause 3.4.1 provides the minimum range for the plant design. The bidder shall take full responsibility for any water analysis and plant design within his proposal. The employer shall not be liable for the accuracy or otherwise of the data and takes no liability for any water analysis and plant design.

#### pH Stabilization

The raw sea water will be dosed with sulphuric acid in the intake pump discharge line to achieve the optimum pH for coagulation. All concentrated sulphuric acid piping shall be Carbon steel and valves shall be Plug valves of Alloy 20 and butt-weld fittings shall be used. The tank should be carbon steel. Carbon content should be less than 0.25%.

Sulfuric acid chemical storage should be equipped to prevent air moisture reaching the chemical storage tank by the use of desiccant on venting and overflow pipes. All tank outlet nozzles should have double isolation valves. The pH of the dosed water shall be continuously monitored. An alarm shall be raised in the event of the dosed water pH being outside of acceptable limits.

#### Inlet Chamber

Each half process stream of 200 MLD product water will start with an inlet chamber followed by flash mixers. Coagulant will be added in this chamber. The flocculant (polymer) shall also be added after coagulant addition for better flocculation. The flash mixer will be a stirred tank (~100 rpm) of sufficient capacity. At least two flash mixing tanks shall be included for proper mixing with total residence time at least 20 seconds. Its design will be such that short-circuiting is eliminated and the coagulant is thoroughly mixed with the seawater. The inlet chamber shall have an overflow line to outfall tank or intake well (forebay).

#### Coagulant

The natural particles causing turbidity are negatively charged and repel each other, thus resulting in high stability. In order to be removed, these particles must undergo a destabilization step which is achieved by the use of suitable coagulant. The coagulant injection should be done after pH adjustment and before a dedicated flash mixing chamber. Coagulant should be ferric chloride; the purity of the product should be compatible with RO membrane application especially with regard to heavy metals/pesticides as well as must comply with the discharge norms of sludge/ solids.

Coagulant equipment should be made of plastic material resistant to UV light. Coagulant piping shall be schedule 80 HDPE or any other suitable material. The coagulant preparation and dosing tanks shall consist of two RCC Tanks. Each tank will be designed for 8 hours of service at the maximum dose rate. The coagulant and flocculant tanks shall be housed in a chemical building with RCC service water tank above the building. Tank filling with chemical and service water shall be automatic.

The drive motor shall be equipped with a variable speed drive to vary the speed of the drive mechanism. The design torque for the drive mechanisms shall be a minimum of 200% of the continuous torque. All gears shall be enclosed in housings. The details of the civil and mechanical works are provided in the civil and mechanical specifications.

#### Flocculant

Flocculation is designed to generate large aggregates that can easily settle or float. It promotes an increase in the probability of inter collision of the small particles formed during the coagulation stage so as to generate larger aggregates.

The flocculation shall be done in the flocculation tanks before the Lamella Settlers. The residence time for flocculation will be at least 20 min. Provision shall be made to dose polyelectrolyte downstream of the ferric chloride and before Lamella settler and DAF.

For each stream, flocculation will be achieved in two flocculation tanks in series with each tank consisting of one or two vertical mixers so as to have the mixing energy tapered.

Piping should be made of plastic material resistant to UV light.

The Contractor shall provide at least 1200mm wide platform with GI / GRP plate and SS 316 railings along with the Inlet Chamber, Flash mixer, flocculation tanks for close inspection of flocs formation. The Contractor shall make necessary arrangements to provide safe access for the maintenance of flash mixers, gates.

The flocculation tanks shall have tapered bottom with a hopper to discharge any sludge accumulation in the tanks.

#### Lamella Settlers

Lamella settlers consist of a series of inclined parallel tubes through which the water passes. The inclined settlers significantly reduce the TSS concentration in water. But it is only partially successful in removing the larvae, algae and jellyfish particles off neutral buoyancy. These materials will be removed effectively by the DAF and media filtration downstream of the Lamella Settler.

The Contractor shall provide integrated self-standing settling tubes made of GRP/FRP/HDPE with 55o-60o inclination. The Lamella tube settler loading rate shall be <1.0 m/hr for better clarification of suspended solids. The Lamella settler and supports shall be of RCC. The bottom of the setter will be hopper type having 45o side walls with sluice and knife valves as needed. The sludge of the settler will be directed to the sludge balance tank under gravity. The diameter of the pipe will be suitable for the sludge transfer without any blockage in the pipeline.

The Settler unit shall be complete with a self-supported access bridge or access bridge supported by the concrete tank. The access bridge shall be designed to safely withstand a live load plus any applicable dead loads and torque and wind loads. A maintenance platform complete with grating and SS316 handrail shall be provided around the drive assembly. The bridge material and coating systems, if applicable, shall be selected to withstand the marine environment. Grating shall be of GRP of functional strength to withstand live load plus any appropriate dead loads and torque and wind loads.

**Table ‎3‑4: Indicative Design Parameters for the Lamella Clarifier**

|  |  |  |  |
| --- | --- | --- | --- |
| S. No. | **Parameter** | **Unit** | **Values** |
| 1 | Minimum recovery | % | 97-98 |
| 2 | TSS removal | % | 90-95 |
| 3 | DOC removal | % | 30-50 |
| 4 | Tube Settler loading rate | m3/m² h | < 1 |
| 5 | Mechanism of sludge removal | - | Hopper bottom |
| 6 | No. of tanks | - | 36 (18 tanks in each stream) |
| 7 | Tube settler material | - | HDPE/GRP |
| 8 | Shape of tube deck | - | Hexagonal-Chevron |
| 9 | Angle of inclination of tubes | degrees | 55-60 |

#### Dissolved Air Flotation

Dissolved air flotation (DAF) is a process of liquid-solid separation by upward displacement of particles insoluble in water such as oil or solids. The removal is achieved by dissolving air in the water under pressure and then releasing the air at atmospheric pressure in a flotation tank basin. The released air forms tiny bubbles which adhere to the suspended matter, causing the suspended matter to float to the surface of the water where it may then be removed by a skimming device. This process has an advantage, especially in terms of algae removal.

Raw water that has first been flocculated enters the bottom of the structure in a chamber where it is put in contact with pressurized water distributed uniformly across the width. Particular importance should be given to the distribution of the pressurized water (source of the microbubbles) and the water to be treated to ensure that floc is not broken during the process. The sludge accumulated on the surface is removed periodically by scraping or hydraulics removal while treated water is collected at the bottom of the Dissolved Air Flotation area. The clarified water is collected downstream of the work under drilled pipes. Air-water contact is achieved in a pressure vessel.

There will be at least 12 DAF tanks – 6 tanks in each plant stream of 200 MLD. The design of the DAF should take into consideration that one DAF cell is always out of service for maintenance. If some equipment are common to multiple DAF cells, then additional standby equipment shall be provided.

The size of particles in seawater is much smaller than in freshwater, particularly during algae bloom and so, the average bubble size will be selected within 10-20 µm which can be adjusted to particle size in seawater to be captured. The minimum recycling rate shall be 15% for better particle agglomeration and removal. The DAF design shall be suitable to remove up to 95% of the suspended solids. The surface loading rate will be within 25 m3/m2/h. Based on the raw seawater quality, the Bidders have to understand the importance of DAF in the presence of upstream Lamella Settler and decide on the loading rate. In case opting for higher loading rate, the Contractor must demonstrate at least TWO operating reference plant (each ≥100 MLD) handling the similar seawater quality successfully.

Most of the suspended particles will be removed in the Lamella Settler. DAF is an additional barrier to remove the suspended particles and organics in the seawater. The purpose of providing the DAF is to remove the light particles which are not captured in the Lamella settler. Provision of coagulant and flocculant addition before DAF shall be provided to enhance the removal of the light particles during difficult seawater quality situation such as during the presence of oil and fats, organics and algae particles. A bypass line shall be provided to bypass the DAF when raw seawater quality is good.

The indicative design of the DAF is given in table below.

**Table ‎3‑5: Indicative Design Parameters for the DAF**

|  |  |  |  |
| --- | --- | --- | --- |
| **S. No.** | **Parameter** | **Unit** | **Values** |
| 1 | Minimum recovery | % | 98-99 |
| 2 | Flotation loading rate | m3/m² h | 20-25 |
| 3 | White water recirculation flow | % | 15-20 |
| 4 | Air Saturator Efficiency | % | 90-95 |
| 5 | Air Saturator Pressure | kPa | 800-900 |
| 6 | Minimum tanks | No. | 12 (6 tanks in each stream) |
| 7 | TSS removal | % | 85-95 |
| 8 | DOC removal | % | 15-30 |

#### Gravity Dual Media Filters

Dual Media Filters (DMF) is a process of liquid-solid separation by media filtration. Clarified water from the DAF outlet shall feed to the inlet channel of the gravity dual media filters.

The Dual Media Filters shall be installed within a fully covered building with RCC roof.

The filter should be designed to ensure that filtration run time is not less than 24h in worst water condition and at maximum plant output capacity. Each filter bed shall be capable of being isolated and taken out of service, i.e. for maintenance while adjacent beds are still in operation.

In each plant stream, when two filters are under backwash operation and one under maintenance, the remaining filters shall be able to handle the filtered water flow required for all the RO trains in operation.

Granular media filtration system will consist of about 80 individual filters (40 filters for each plant stream) that will operate in parallel. Each filter inlet shall include an isolation valve/gate, and in filtering mode, the feed water shall be fed into the filter, above the filter media, in such a manner so as the filter media is not disturbed. The water shall flow through the filter media, through filter floor nozzles, and into a chamber underneath the filter floor. The filter design shall be as per standard media filter design.

Filtered water shall flow from the filtrate collection chamber, through a flow control into the RO feed tank. The maximum size of an individual filter shall be within 12.5 MLD based on a successfully proven design and operating plants.

When in backwash mode, water from the backwash tank shall be pumped by dedicated duty/ standby backwash pumps, through control and isolation valves into a single filter filtrate chamber. The backwash water shall flow up through the filter media support, up through the filter media, removing filtered solids from the filter bed, and into the backwash water troughs, running the length of each filter. The backwash water troughs shall be designed to ensure that dirty backwash water is removed evenly from the whole length of the filter. Backwash effluent shall pass from the backwash troughs, through the effluent isolation valve, and to the backwash effluent tank. The system shall ensure that no more than 5% of the top media is lost over a period of one year, and this shall be tested during the performance test. Pre-Treated/Filtered Sea Water shall be used for backwashing the media filters. The water shall be withdrawn from the filtered water tank/RO feed tank. However, the use of RO reject brine may be explored for filter backwash. Suitable pumping machinery with necessary standby shall be provided.

The filter underdrain system shall be of monolithic reinforced concrete slab, or SS plates supported on concrete dwarf walls and be designed to tolerate all loads imposed during installation and during operation. The means of collecting filtrate and distributing air shall be by use of nozzles set in the reinforced concrete floor. Nozzles with fine slots shall be used for collecting filtrate and distributing backwash water and air. A uniform distribution of the nozzles of not less than 60 numbers per square metre shall be employed. The nozzles shall be constructed of suitable material and have vertical reverse wedge slots to prevent filter media greater than 0.40 mm from passing through and to be self-cleaning in the filtration mode. The design of the under-drain system shall be based on the successfully proven design and operation of the filters.

All necessary equipment for automatic backwash and operation shall be provided. It shall be ensured that the entire backwash is carried out in the proper way to reach the filter washing without operator intervention. Typically, there will be 8 automated valves/gates in each filter – 1 inlet gate, 1 waste outlet gate, 2 filtrate outlet sluice valves, 2 backwash inlet sluice valves and 2 air inlet scour valves for two beds of one filter. In addition to the automated system, the plant shall be provided of a full backup backwash system that can be operated under the guided control of one operator. Backwash system should be designed for the specific media used and for varying flow requirements with the change in water temperature in summer and winter seasons for effective backwash. Air scour system shall be provided for the better efficiency of the backwash. Blowers should have their acoustical protection and should be located inside the building or under a shade. Design should ensure that safe start-up of the blowers can be achieved automatically and should prevent backflow of water into the air system under all conditions.

For each filter, a filter control desk shall be provided for local operation of the filter in manual or automatic modes. This will allow operator selection of the filters to be backwashed and operator selection of the durations of various steps in the backwashing process. The control desks shall be equipped with selector switches for automatic/manual selection, push buttons for manual opening and closing the filter valve actuators, lights for open/close valve indications and PLCs for automatic time-based step operation of filter valve actuators in backwash operation.

The performance standard may be based on the following criteria

* The filtrate should be clear with the turbidity <0.5 NTU all the time
* The filtrate should be free from colour (with unit 3 or less on the cobalt scale)
* The SDI of the filtrate should be ≤ 3.0 at 95% of the time and < 4.0 at 100% of the time.
* The filter runs should normally be not less than 24 hours with a loss of head not exceeding 2 m.
* For an efficient filter, the wash water consumption should not exceed 3 per cent of the quantity filtered in between washing.

The indicative key design criteria for the DMF is given below in Table-13.

**Table ‎3‑6: Indicative Key Design Criteria for the Gravity Filters**

|  |  |
| --- | --- |
| Filter type | Dual media, downflow |
| Backwash | Air-water |
| Average filter cell run duration | 24hr |
| Flow distribution to individual cells | Pipe (if a concrete channel is used, the channel depth should be tapered to keep velocity in the distribution channel above 2 m/s at all times) |
| Filter cell length-to-width ratio | 2:1 preferably |
| Maximum Water depth above filter top | 2.5 m (should be equal to or slightly higher than filter bed head loss) |
| With two filters out of service (N-2) per stream | ≤ 7.8 m3/m2·h |
| Backwash rate | 25-40 m3/m2·h – variable speed with temp. |
| Air Scour rate | 50-60 m3/m2·h |
| Duration of backwashing (total air plus water) | 30 min (includes filter cell draining and fill-up) |

##### Filter Media

Filter media is defined in terms of effective size and uniformity coefficient. Effective size is the sieve opening size in millimetres that permits 10% by weight to pass. The uniformity coefficient (UC) is the ratio between the opening size of the sieve that will pass 60% by weight and the effective size of the medium. The type, uniformity, size, abrasion resistance and depth of filter media are of key importance for the performance of pre-treatment filters.

Anthracite and sand shall be used in the dual media filters. Deep dual-media filters are to be designed to achieve enhanced removal of soluble organics from source water by filtration. Perur site has high seawater TOC. Bidder shall analyse the seawater quality for the design of gravity dual media filters and all other process units in order to achieve the required filtered water quality suitable for feed to SWRO system.

Sand shall be of hard and resistant quartz or quartzite and free of clay, fine particles, soft grains and dirt of every description. It shall be high grade, complying with Sections 1, 2.2 and 5 of the Standard Specifications for Filtering Material (ANSI/AWWA B100-09, AWWA Standard for Granular Filter Material). Sand should be of high quality with ignition loss not to exceed 0.7% by weight. Silica content should not be below 90%, and wearing loss should not exceed 3%. The sand shall be well-graded, and material showing abnormal grading shall be rejected.

The particle size distribution shall be determined by screening through standard series sieves. The per cent size shall be determined from a plot of the percentage of the material passing each sieve, against the rated opening of the sieve. The filter media and underdrain system shall be designed to achieve uniform distribution of both filtrate and backwash water and air.

The indicative media parameters are given in table below. Bidders are required to fulfil the requirement unless there is sufficient operational evidence to change and which is acceptable to the Engineer.

**Table ‎3‑7: Indicative Media Description for the Gravity Filters**

|  |  |  |
| --- | --- | --- |
| **Descriptions** | **Units** | **Values** |
| Top layer |  | Anthracite |
| Minimum depth | m | 1.2 |
| Effective size | mm | 0.6- 0.8 |
| Uniformity coefficient |  | 1.4 |
| Bulk density | ton/m3 | 0.85 |
| Bottom layer |  | Silica Sand |
| Minimum depth | m | 1.5 |
| Effective size | mm | 0.5-0.6 |
| Uniformity coefficient |  | 1.4 |
| Bulk density | ton/m3 | 1.8 |
| Specific gravity |  | 2.55-2.65 |
| Below sand layer |  | Garnet |
| Depth | m | 0.2 |
| Effective size | mm | 0.5 |
| Uniformity coefficient |  | 1.4 |
| Bulk density | ton/m3 | 3.5 |

Apart from above, the gravel will be used below garnet. Gravel of bigger size will be placed between garnet and the under drainage system to prevent sand from entering the underdrain and to avoid uniform distribution of wash water. The gravel and garnet should accomplish both purposes without being displaced by the rising backwash water. Sizes of the gravel may vary from 50 mm at the bottom to 5 mm at the top with 0.3 m depth. Reference may be accessed to IS 8419 Part (I)-1977 for filter gravel.

The Contractor shall provide a detailed automatic monitoring system in the O&M manuals, to be approved by the Engineer, to ensure reliable control of the performance of the filtration plant. The filter outlet control valve position and head-loss across each individual filter bed shall be continuously monitored from the control room. The flow-rate out of each filter shall also be continuously monitored. The filtered water turbidity and flow rate in filtered water channel leading to RO feed water tank shall be continuously monitored from the control room. The quality of the filtered water from each individual filter shall be routinely monitored by a grab turbidity sample and analysis.

The air scour and backwash flow rates shall be continuously monitored during filter washing. Local indication of each backwash pump discharge pressure shall be provided. Local indication of each air blower discharge pressure shall be provided. Each air blower shall be provided with a high discharge pressure switch. A sample point may be provided on each filter backwash effluent line close to the filter, to enable the duration of the filter backwash to be optimised.

The conductivity and SDI of water in the filter to waste line as a filter is returned to service after a backwash shall be routinely monitored by a grab sample and analysis. The filtrate during the maturation period after backwash is proposed to be recycled to the filter inlet to reduce the per cent waste of filter. An alarm shall be raised in the event of high turbidity in the common filtered water main. Also, an alarm shall be raised in the event of high differential pressure across a single filter.

During filtration mode, the filter outlet valve shall be controlled to maintain a constant level in each filter. The control system shall ensure that in normal filtration mode, the instantaneous outlet flow rate from an individual filter does not vary by more than + 10% from the overall average flow rate of all in service filters even in the event of two filters out of service when the filtration rate will be enhanced to meet the total required filtrate flow rate. This shall be confirmed during the performance test by analysis of the individual filter trends from the DCS/PLC. All filter valves/gates and penstocks shall be fitted with electric actuators with facilities for remote and local manual operation using the local panel to be provided for each filter.

#### RO Feed Tank

The filtered water flows to the RO feed tank under gravity. The tank shall be constructed out of RCC and equipped with vents. The RO Feed Tank shall be equipped with an overflow line to the Outfall tank or the intake pumping station.

There will be two RO feed tanks – one for each process stream. The capacity of each tank will be designed for 30 minutes of filtered water flow, i.e. about 10000 m3 each. Provision of interconnecting the feed tanks may be explored in order to have an interoperability between the streams pre-treatment system in case needed. The RO feed tank will serve as control storage between the filtration system and the RO plant. It will ensure that the flow to the RO trains will be constant while the production from the pre-treatment system fluctuates due to backwashing. To ensure gravity filter backwash water is always available and does not disturb the RO feed flow, the tank design will offer a two-compartment design. The first compartment will feed the second compartment by overflow. The first compartment will serve the backwash requirement and provide a capacity of 2,000 m3 (backwash requirement for at least 3 filters). The ERD and HP booster pumps will be connected at the outlet of this second compartment that will offer a minimum working capacity of 8,000 m3 (at least 25 min residence time). The minimum working volume shall be kept between the high-high level and low-low level. The level in the RO feed tank shall be continuously monitored. The tanks should be partitioned in such a way that one half can be isolated for cleaning while another half tank supplying water for backwash and RO feed.

In case of emergency, this first compartment will have a provision to be fed from the outlet of DAF. As the main process flow reservoir, this two-compartment tanks will be constructed in concrete.

### Seawater Reverse Osmosis System (SWRO)

The Bidders shall provide a complete SWRO system suitable to produce net 400 MLD product water with plant availability up to 97% of the time in a year. The plant shall be designed to produce net 400 MLD product water at 97% plant availability. Bidder's offer shall include RO trains, each consisting of:

* Rack/framing, and power and instrumentation cabling and equipment;
* Feed, permeate, brine, cleaning/flushing piping and equipment including the individual suck back tank for each train (skid);
* RO trains required for providing the rated output at the end of the membrane guarantee period.
* The system shall be capable of producing contacted desalinated water on a 24 hour, 7 days a week basis.
* Provision shall be provided to operate the SWRO system at least at 50% turndown capacity particularly during monsoon period when demand of water will be low.

The trains in both the streams shall be sized for a net production capacity of 400,000 m3/d of the required product water quality at even the worst-case conditions (i.e. minimum seawater temperature, maximum seawater salinity, maximum seawater turbidity, fouled membranes, aged membranes).

The bidder shall provide membrane projections covering the whole range of anticipated seawater quality (especially extremes of temperature and salinity) for new, clean membranes and old, fouled membranes and have to submit along with the bid. In case of failure of submission of the same, the bid may be rejected, considering as non-responsive.

Each RO train shall incorporate pressure drop and regulation devices in the brine reject line to maintain and control conditions within the trains. It shall be possible to measure the product flow rate and feed - brine pressure drop of each individual RO train.

The SWRO system shall be fully automated with auto-transmission and control of all the required parameters. The bidder shall not propose any experimental features for the RO Plant construction. Only proven and well tested RO configuration shall be used. Bidders shall provide the experiences of the successful implementation and working of the plants with the configuration proposed by them for the 400 MLD SWRO system design.

The Plant shall be flexible to accept & implement the modifications, which may be desirable as a consequence of a rapid technological improvement in RO and its equipment and any changes in feed quality. The Plant shall also have the provision for interchangeability between membranes supplied by various membrane suppliers and incorporate interlocking end caps reducing permeate back pressure drops while providing long term seal integrity. The pressure at membrane inlet shall be designed such that it allows interchangeability of membrane brands and types from different Manufacturers. Furthermore, the Plant shall be designed to be operated with minimum maintenance, requiring minimum operating personnel.

Each train shall have a capacity of 25 MLD and should have its own dedicated RO Booster, ERD Booster, ERD and High-Pressure Pump along with energy recovery system. Stand by train(s) shall be provided to use in case of any train is offline during CIP or for any other maintenance work. There will be 8 duty +1 standby RO trains in each process stream.

The bidder may submit an alternative technical and price bids with 3 Centre/ Pressure Center design or any other innovative design of RO system which may be considered only for the successful bidder when his bid is declared as the lowest evaluated bid based on the proposed conventional RO system design. The bidders should provide the experiences of the successful implementation and working of the alternate RO design and also the sufficient technical and economic advantages of the alternate RO design which will be evaluated after final selection of the Contractor.

The high-pressure shall be designed not to introduce flow and/or pressure pulsation in the feed or brine stream. The reverse osmosis system has to be operated with fluctuating feed salinity, and feed temperature and variation in RO permeate recovery. An appropriate regulation of the feed pressure for each reverse osmosis train separately by a corresponding design of the high-pressure pumps and automatic feed pressure control is required.

Each train of 25 MLD shall include all necessary instrumentation and online monitoring to enable proper operation, early detection of process deviation on the trains, normalization of the trains performances and protection of the unit against the improper operation. The design must include at least instrumentation to measure and display on the HMI system: membranes feed flow, permeate flow, brine flow, ERD feed flow, membranes feed pressure, membranes head losses, membrane brine pressure, feed conductivity, ERD conductivity, permeate conductivity, feedwater temperature.

High-pressure piping and equipment should be designed as per ASME standards. Proper protection against excessive pressure must be provided.

Connection of pressure vessels should be done using Victaulic flexible couplings. Pipe and fittings material including Victaulic couplings for the feed and reject (high-pressure side) shall be suitable for the Seawater and RO brine handling under operating pressures. They shall be in super duplex stainless steel or equivalent with a minimum PREN of ≥43 and CF ≥35. The material of construction and seals for Victaulic couplings shall be suitable for the Seawater and RO brine handling under operating pressures. All castings used for coupling housings, fittings, valve bodies, etc., shall be date stamped for quality assurance and traceability. Couplings shall have a nominal 3:1 Safety Factor over published working pressures. Fittings shall be constructed of super duplex stainless steel material having PREN number equivalent to the pipe system in which it is installed.

Grooved joints shall be installed in accordance with the manufacturer’s latest published installation instructions. Grooved ends shall be clean and free from indentations, projections, and roll marks in the area from pipe end to groove.

* Gaskets shall be of an elastomer grade suitable for the intended service and shall be moulded and produced by the coupling manufacturer.
* Gaskets must meet potable drinking water standards and be listed by the approving agency. NSF61 approval and listing shall apply as a minimum standard.
* The grooved coupling manufacturer’s factory-trained representative shall provide on-site training for the contractor’s field personnel in the use of grooving tools and installation of grooved joint products.

#### Cartridge Filter

Cartridge filter shall be used for the safety and protection of the RO system and shall not be operated as a pre-treatment stage.

Carbon steel rubber-lined/GRP vessels shall be provided for housing cartridge filters with quick opening hold-down bolts and having sufficient capacity to meet the maximum flow of the plant without exceeding pressure drop limits when fully fouled. The vessel shall be designed in accordance with ASME Codes design of vessels.

The Cartridge Filter assembly line should be equipped with differential pressure gauges with a pressure transmitter and alarm signal capability. Appropriate means for measurements of differential pressure across cartridge filter shall be provided. Each cartridge filter vessel shall include inlet and outlet isolation valves, as well as drain and vent valves. Each cartridge filter inlet shall include an orifice plate to distribute flow evenly between cartridge filters. The filter vessels shall be equipped to allow the safe and efficient replacement of the expendable cartridge. On-line cartridge filter replacement shall be possible without interruption of the plant operation.

Bidder needs to provide two spare cartridge filter vessels for each train so that filter replacement is done without any impact on water production, such that the maximum loading rate is not exceeded when one vessel is out of service. Micron filter sized shall be rated for 5 µm nominal. These filters shall be arranged so that RO train has a filter upstream of the high-pressure pump. Sample points shall be provided on the cartridge filter inlet and outlet headers.

Cartridge elements shall be all polypropylene construction with non-shredding characteristics. The clean cartridge filter unit shall have a maximum differential pressure of 0.035 bar at the rated flow.

For standard size cartridges, a maximum loading of 650 l/hr per 10” round shall be used. For non-standard cartridge sizes, references shall be provided to support the selected loading rate. Bidder may propose standard cartridge filter battery for SWRO Feed & ERD Low-Pressure feed or dedicated cartridge filters for SWRO Feed and ERD Low-Pressure line.

The RO feed must be totally free of residual chlorine to prevent oxidation of the membrane. Antiscalant shall be dosed either upstream or downstream of the cartridge filters. Sodium bisulphite (SBS) shall be dosed both at upstream and downstream of the ORP meter. Dosing lines shall be provided such that the operator can select where the chemical is to be dosed automatically. Static mixer shall be provided after chemical dosing. Mixing shall be provided upstream of the cartridge filters by the cartridge filter orifice plates. Mixing arrangements shall be provided downstream of the cartridge filters. A residual chlorine analyzer and ORP meter shall be located downstream of the cartridge filter to control the SBS dosing rate. A provision to dose Biocide shall also be provided to control the biofouling of the RO membrane. All chemical dosing system shall be provided for the best application in the RO system to the satisfaction of the Employer’s representative.

#### RO Membrane

The reverse osmosis (RO) membrane shall be thin-film composite 8” spiral wound type. 16” spiral wound membranes are not permitted. The membranes shall be produced by a reputable manufacturer that has successfully provided a similar type of membranes in similar Seawater conditions and plants since at least 10 years. There will be up to 8 elements per pressure vessel.

The reverse osmosis elements shall be high rejection; low fouling seawater spiral wound polyamide membrane units proven for the use under similar conditions of seawater supply at Perur site. Thermal excursions outside the operating temperatures occurring during acid cleaning shall not have any adverse effect on the membrane.

RO Recovery rates shall be selected considering the required quality and the reliability of the system; however, the recovery ratio shall in no case be less than 42% and be more than 46%. The RO section shall be designed for an average flux rate not exceeding 13.4 l/m²/h at the maximum RO recovery of 46%.

Sufficient space provisions shall be considered in the design of the RO Trains to accommodate 10% additional pressure vessels for future requirements. The capacity of each rack should be 25 MLD.

Scope also includes 5% of the installed membranes as emergency replacement stock, to be supplied and be stocked in the plant with proposer protection during the complete duration of the contract. Spare membrane should be stored as per supplier recommendation to ensure that maximum allowable temperature, environment and other conditions of storage are not exceeded at any time. A dedicated area should be provided in the workshop or at any other convenient location within the plant. The spare membrane storage area has to be equipped with proper air conditioning (A/C). The A/C shall be designed for the allowable range of the temperature for the membranes, even in case of a more prolonged standstill of the RO Plant.

Membrane performances and replacement rate should be guaranteed by membrane supplier for at least 5 years; such guaranty should be confirmed by selected suppliers in writing and should be provided in the bid.

The expected lifetime of the RO membrane shall be 7 years (+/- 0.5 year) which shall be provided by the bidders in their bid submission. The used RO membranes and cartridge filters shall be sustainable recycle/disposal compliant with Indian laws and regulations. The procedure of recycling/disposal will be reported regularly to CMWSSB.

Plant should be designed to ensure that production and quality can be maintained with at least 3 membrane suppliers without modification of the equipment. Sufficient sampling points shall be provided to test the product water quality from every RO vessel.

#### Pressure Vessel

RO membranes shall be installed in GRP pressure vessels. These modules shall be factory assembled and tested, and supplied mounted on and within robust framing, and shall be suitable for landing into a plinth and ready for pipework connections.

The RO pressure vessels shall be designed and manufactured in accordance with ASME Section X and duly coded and stamped. Each train will have enough space to install enough number of modules to be installed at the end of the guarantee period or 10% free space whichever is greater. There should be a suitable arrangement for the air venting of the pressure vessels. The design of the pressure vessel shall allow interchangeability of membrane elements. The Pressure Vessels may be supplied as either side port side entry Pressure Vessels or multi-port, side entry Pressure Vessels. The Vessel exterior shall have a smooth surface and shall be painted with white polyurethane paint. Paint should have UV resistance properties. Each vessel shall have a resin impregnated identifying number / bar-code.

Each pressure vessel has to be equipped with conveniently accessible sampling points for product water lines. Furthermore, the RO System shall provide a sampling station for each train to take permeate sample from each vessel. Each pressure vessel shall house not more than Eight (8) membranes per vessel. Train should be designed to provide sufficient air venting of the pressure vessels. The vessel interior shall be free of pits or voids that may promote bacterial growth, and the inside of the vessel shall have a smooth and mirrorlike surface to prevent the above.

Tolerance of the pressure vessels should ensure that front port or side port connections are in compliance with Victaulic connection maximum tolerance.

#### High-Pressure Pump

High pressure (HP) pumps shall be from a reputable manufacturer who has supplied pumps that have been working satisfactorily for not less than five years. The High-pressure pump shall be designed with Variable Speed Drive (VSD). The casing, Impeller and shaft of the HP pump shall be of Super Duplex with PREN ≥43.

It should be noted that the correct sizing of the RO pumping system is critical, as under-sizing will not achieve the required permeate flows and over-sizing may require excessive pressure to be burnt-off at the throttling valve. Therefore, it is suggested that bidder take due care and full diligence in designing the system. The Bidder, in its bid, needs to submit the operational philosophy for the HP pumping system in totality with RO system over the full range of seawater salinity and temperature.

#### Energy Recovery Device

Energy in the high-pressure brine from the reverse osmosis membranes shall be recovered only by an isobaric energy recovery device (IERD). The IERD’s shall be arranged such that a single unit can be removed from service and at least 95% of the total work exchanger capacity is available whilst the single unit is isolated. Isolation shall be manually performed, either by operator valves or by fitting end caps. IERD should be made of corrosion-resistant material or in a super duplex or super austenitic stainless-steel material with a minimum PREN ≥41.

The Energy recovery system installation shall in no regard cause a constraint to operate, cleaning, maintenance, preservation or mothballing procedures of the reverse osmosis system. The ERD selection shall be with the least maintenance requirement to improve plant availability. The unit shall be mounted on a skid, valve arrangement and control based as the proprietary design. Adequate support for the equipment shall be provided. The proprietary material used in the construction of such energy recovery devices shall be suitable for the seawater condition specified in the tender document.

The salinity increase at membrane due to ERD should not exceed 3%. This shall be determined from conductivity measurements.

The proposed Energy Recovery Device(s) shall have a minimum of ten (10) years operating history in seawater applications. The expected lifetime of the Energy Recovery Device(s) shall be at least twenty-five (25) years. Efficiency of a single Energy Recovery Device (per unit) must be over 95% throughout the designed operating range. The sound levels emitted from the device should be at national standards. The Energy Recovery Device(s) must be able to operate within all the parameters of this Specification through the water temperature range and through the ambient air temperature range.

#### Neutralization

Neutralization system should be provided to neutralize the CIP solutions before it is discharged to the sea along with the RO brine via the outfall tank. The neutralization system should have a dedicated tank with recirculation /mixing facility and allow for neutralisation of the CIP solution in less than 4 hours. Neutralization in the CIP tank is not permitted. There will be two neutralization system (one for each plant stream). The neutralization tank of each stream shall have capacity about 4 times the CIP tank volume to accommodate the total volume of the waste for at least two CIP and flushing. The pump will run in recirculation mode till neutral pH is observed & then it will go to dumping mode.

No manual intervention should be required from the operator to carry out the neutralization. pH should be monitored before discharge into the outfall tank through online pH analyzer with an interface to the recirculation system. The pump will run in recirculation mode till neutral pH is observed & then the pump will run into dumping mode. The system should have 100% redundant (Stand by) pumps and valves for recirculation/dumping.

All the equipment should be designed to withstand the range for high TDS/salt concentration and high-alkaline /low-acidic pH expected, including pH of cleaning used during high fouling or scaling events. If included in the RO building, the neutralization should be covered, and a vent should allow ventilation of the gas outside of the building at a reasonable distance of any access and walkways.

#### RO Permeate Tank

RO permeate tank shall be provided to store sufficient permeate water for CIP, flushing and service water. The tank can be either in concrete with corrosion-resistant tiling or glass fused stainless steel with proper internal and external protection.

There will be two RO permeate tanks – one in each plant process stream of 200 MLD (tanks connected to each other with sufficient isolation valves). To ensure membrane flushing water is always available, each tank design will offer a large capacity of 5000 m3 allowing one skid CIP, all trains flushing and one backwashing of the limestone filter. This tank will serve membrane flushing pumps and a service network providing water to limestone bed backwash, chemical building and RO building (flushing all the seawater pumps at the stoppage, rinsing leaks to avoid corrosion).

#### Clean In Place System

At least two clean in place (CIP) system shall be provided – one in each process stream of 200 MLD. The cleaning system should enable cleaning of all plant trains. It should consist of a cleaning tank with the capacity necessary for the preparation of the cleaning solution for one complete train.

The CIP Tank shall be sized for a working volume equivalent to the volume of the maximum number of pressure vessels to be cleaned at any one time, plus the volume of the maximum length of CIP pipework in the feed, concentrate and permeate header systems with 20% safety margins.

CIP tank the volume of the tank should be at least

VCIP tank = Vskid + Vpiping + Vminimum suction level for pumps + 20% safety margin

* CIP pump design to ensure sufficient flow for the membrane cleaning minimum of 9 m3/h per pressure vessel
* CIP Cartridge filter
* Heater design for the minimum seawater temperature (temperature of the CIP solution should be monitored)
* Chemical injection and pH control
* Recirculation loop for CIP preparation and chemical dilution

Permeate from the permeate tank shall be used to fill the CIP Tank. The CIP Tank fill line inlet shall be above the CIP tank overflow and shall include a non-return valve, to ensure that there is no risk of backflow of chemicals into the permeate tank.

The location of the CIP Pump discharge back into the CIP Tank and the CIP pump suction line shall be carefully designed to ensure that when in recycle mode, the contents of the CIP Tank are well mixed. The CIP pump suction line shall also be designed so that air is not entrained into the CIP Pump, even when the tank is running in recycle mode at a low level. The bidder shall calculate the increase in temperature of the water in the CIP tank due to the heating action of the CIP pumps, either in recycle mode or cleaning mode, as well as the heat of solution of the cleaning chemicals. If the temperature of the contents rise above 45oC in normal operation, with the warmest expected seawater temperature, then facilities shall be provided to cool the CIP Tank contents. It is anticipated that this shall be achieved by a heat exchanger on the CIP Pump discharge recycle line, cooled by a suitable stream of process water.

In cleaning mode, the water pumped by the CIP pumps shall pass through nominal 5 µm cartridge filters. The design of the cartridge filters shall be as provided in the RO system, except that no excess capacity is required.

Each RO train stage concentrate header shall be connected to the CIP system concentrate header, separated by a suitable isolation valve. The CIP system concentrate header shall return cleaning fluid into the Neutralisation Tank. In cleaning mode, the RO train concentrate header shall be isolated from its energy recovery device by a suitable isolation valve.

Each RO train stage permeate header shall be connected to the CIP system permeate header, separated by a suitable isolation valve.

The CIP Tank shall be fitted with a drain flush with the tank floor. The drain shall be connected, via an easy to operate isolation valve, to the Neutralisation Tank.

#### Flushing Unit

RO train should be automatically flushed after the stop, and the flushing should include HP pump, RO train, ERD and recirculation pump. Flushing water storage (Permeate Tank) should allow to flushing of all the plant trains in one plant stream of 200 MLD while the plant is not producing water. The permeate tanks of both the plant streams shall be interconnected with sluice isolation valves to allow additional permeate water as needed for train flushing.

The flushing system must be independent of the cleaning system to allow flushing and cleaning operation at the same time. Flushing pump, pipings and necessary valves on the train must allow flushing of all the plant trains during an electrical outage. A standby pump should be provided to ensure availability of the flushing system.

Two diesel set (2x100%) of suitable capacity shall be provided for each plant stream to run the RO flushing system and to flush the RO trains in case of power failure. The diesel set shall be envisaged to supply the UPS charger of the plant as well.

#### Membrane Skid Test Unit

A membrane skid test unit must be provided to enable during operation the test of the individual membrane. Skid test unit should enable to perform test as per ASTM D 4194 standard. The membrane skid test unit should be feed by pretreated water.

It should include cartridge filter, HP pump, single membrane testing unit and all necessary equipment for flows control and sampling points. Pretreated water tank may be used to prepare cleaning for cleaning test on individual membranes.

### Chemical Storage System

There will be a separate chemical building area for Pre-treatment, RO system and Post-treatment for each 200 MLD plant streams. The allocated area shall be designed to receive and store all of the bulk chemicals safely and to meet the specified performance and technical criteria. All dosing tanks, pumps and allied system of chemical dosing shall be located under chemical building. Bulk liquid chemicals may be stored in well-designed chemical storage tanks and bunded areas close to the chemical building. The solid chemicals shall be housed in the chemical building.

#### Design Criteria

The design intent is to ensure safe unloading of chemicals, no losses of containment, and safe operation of the storage. Therefore, the storage area will be:

* Engineered to high standards
* Safe for operators and the environment
* Durable and maintainable
* Compliant with statutory regulations

Chemical area layout will allow sufficient margin between refill points and empty tanks. Control systems will ensure that the tanks do not overflow while filling. Chemical fuming shall be dealt with systems in place to manage fuming. Any heating requirement shall be provided as appropriate to avoid freezing of chemicals such as sodium hydroxide.

All piping and equipment should be suitable for transported chemicals. Chemical pipes should be housed in a trench. Piping of incompatible chemicals should be separated.

Local visual indication of the contents of all storage tanks shall be provided along with level sensors and transmitters. For liquid storage tanks, magnetically coupled type instruments shall be used.

##### Tank Capacity/Delivery Size

All chemical storage facilities shall be suitable for 30 days of chemicals availability at RO Plant Site. The Long lead chemical shall be provided with 40 days of storage facilities. For Sodium Hypochlorite combined storage & dosing shouldn’t exceed 14 days, due to its low shelf life.

For bulk deliveries, complete unloading system shall be provided with all 2x100% pumps, valves and fitting for transfer of chemicals to the storage tanks. The Contractor shall ensure that the design of the reception and storage facilities meets the standard requirements of the chemical delivery.

Unloading areas will be provided sufficient for the movement of road trucks. Unloading areas will be paved and sloped to a drain capable of collecting any spillage, and with a capacity of 9,000 L or the capacity of the largest tank vehicle compartment.

##### Tank Bunds

Storage tanks should be held in a bund to ensure that, in case of chemical spillage, chemicals are retained. Bund capacity should be at least 110% of the biggest tank or 50% of the total tank capacity whichever is the biggest. Bund should be free from cables, instruments and as far as possible free of piping.

Bund areas will be based on a bund wall height of 1.0 m and the capacity of the bund with this wall height is 100% of the total volume of the tank leaving 1 ft of freeboard. No allowances were made for sumps or the fact that the effective volumes of the tanks will be less than the total.

Because most of the materials that are being stored are Class 8 corrosives, consideration will be given to linings in the concrete bunds, as any spills will attack the concrete. In general, the bunds are lined with acid/alkali-resistant epoxy coatings. In addition, bund perimeter walls must be impervious to the chemical being stored; therefore, the lining of these walls must be considered as well.

##### Minimum Separation Distances

The information on minimum separation distances is presented below.

* Between tanks: 0.6 m
* Between a tanker connection point and protected works: 5 m
* Between a tank (3,000 to 50,000 L) and protected works: 5 m
* Between a tank (> 50,000 L) and protected works: 8 m
* Between a bund wall and protected works (from inside the bund wall): 3 m

##### Segregation

Tanks containing chemicals that react dangerously must be kept in separate bunds and segregated by a suitable distance. Therefore, the bulk chemical storages shall be grouped together and segregated accordingly as the per the appropriate British or Indian Standard.

##### Construction Material

All bulk storage tanks will be manufactured from suitable material which shall be approved by Employer’s Representative.

##### Liquid Chemical Transfer

The delivery vehicle/isotainer will supply its electric transfer pump. A suitable power point shall be provided at the unloading area for the pump. The delivery tankers will have a flexible hose and coupling to connect with the storage tanks fixed transfer pipe. In case the vehicles are not equipped with an unloading pump, transfer pumps (1W + 1S) with all appurtenances shall be provided for smooth transfer of chemicals.

##### Level Indication

Each tank shall be supplied with a level transmitter and independent low- and high-level switches. There will be a level indication display visible from the vehicle unloading point during discharge. An independent high-level alarm/switch will be provided in the tank that will be interlocked with the power supply for the delivery tanker. This alarm and switch, which will be below the overflow level, will be activated when the high level is reached. It will also stop power to the GPO, into which the tanker’s transfer pump is connected. The contents of all storage tanks shall be continuously monitored on the HMI.

##### Chemical Area Safety

The design of all chemical storage and dosing systems shall take into account all international standards and safety requirements, and shall ensure the safe reception, transfer and dosing of chemicals. As a minimum, the following safety features shall be included:

a. Chemical delivery, transfer, storage and dosing shall be carried out in bunded areas. Bunds shall be sized to retain at least the contents of the largest storage tank +10%.

b. All bunds shall include provisions for the safe removal and disposal of any spilt chemical, as well as accumulated rainwater, by the use of portable sump pumps.

c. There shall not be a direct connection from bunds to surface drain.

d. Common bunding of two or more chemicals which might result in an un-safe chemical reaction, were these chemicals to mix, shall not be permitted. Dosing lines shall be sleeved in critical areas.

e. Tanker delivery connectors shall be unique to each individual chemical, in order to avoid delivery to the wrong vessel.

f. A sufficient number of safety showers and eyebaths shall be provided to allow rapid access from all chemical storage and dosing areas.

g. All confined areas which could potentially be exposed to a toxic gas shall be equipped with a source of safe air, fit for human consumption, for use in the event of a leak.

h. All chemical storage tanks shall be vented externally.

### Chemical Dosing System

Facilities shall be provided for the delivery, storage and controlled dosing of all necessary process chemicals separately for the two plant streams.

Dosing systems shall include all the necessary equipment to ensure controlled delivery of the chemical at the required flow rate, irrespective of variations in chemical feed tank level, or delivery point pressure (e.g. pressure sustaining valves at the dosing point).

Chemical dosing system should be designed to allow safe and reliable operation. All chemical system including dosing tank should be clearly identified; chemical piping should be colour-coded.

Each dosing line shall be provided with an isolation valve and a non-return valve as close to the point of injection as possible.

Chemical systems shall be designed to ensure that there is no circumstance in which a dosing pump can generate a pressure which exceeds the design pressure of any part of the system downstream of the pump. All the necessary equipment to protect dosing pumps from unwanted particulate material present in the chemical delivery shall be provided.

All materials shall be compatible with the chemical being used. Standby equipment shall be provided for all dosing pumps. All metering pumps shall be N+2 spared (1 installed and 1 warehouse spare) and comply with API 675 standards. Stand-by should start automatically without operator manual operation. All the metering pumps considered should be of a similar type as much as possible. The pumps shall be mechanically coupled Diaphragm type metering pumps. These pumps are to include inlet & outlet valves, check valves, discharge relief valves, reciprocating mechanism, gear reducer, coupling and all necessary instruments and drivers, all assembled, aligned and mounted on a standard base plate, ready for installation. Pulsation dampeners shall be provided on the individual dosing pump. All pumps shall be supplied with ﬂow switches or flow detection devices integral with the pump.

All dosing lines and pumps shall be provided with facilities to enable the flushing of pumps and dosing lines with boosted service water. The drain lines shall be provided to drain the suction and discharge pipes of each dosing pump after flushing.

Chemical dosing pump suction should be equipped with filters and isolation valves to allow online filter maintenance. A standby filter must be provided on the shelf to enable proper maintenance while dosing system is in operation.

Chemical dosing rate should be paced with plant feed flow rate and seawater parameters such as turbidity, TSS, pH and organics. A calibration chart based on each quality parameter should be available on the HMI for auto-selection of the most optimum chemical dose rate with change in seawater quality parameters. Flowmeter should be installed on each chemical dosing line. Value should be available on the HMI systems. Chemical pumps suction and discharge pressure should be monitored.

If chemical dilution is required automatic (such as a polymer), safety should be provided to ensure that dilution is in operation during dosage. Stand-by dilution system should be provided.

The flow rate of ferric chloride coagulant, flocculation aid polyelectrolyte, RO antiscalant and other essential chemicals shall be continuously monitored on the HMI systems. These flow meters may be used to generate the low flow signal and auto-switch to the standby pump. It shall be possible to remove the flow meter for maintenance whilst still keeping the system in operation.

All chemical solution preparation and dosing tanks with dosing pumps and appurtenances shall be kept inside the chemical building with proper ventilation. There should be the mechanical lifting of the chemical for solution preparation and ejector system for polymer transfer. The tanks shall be filled automatically with service water for dilution using level transmitters and solenoid valves at the service water inlet pipe. All chemical dosing / storage dyke areas shall also be equipped with eyewash and safety shower at strategic locations.

Agitators shall be provided in each tank of appropriate size and specification as needed for the solutions which require constant stirring.

#### Sodium Hypochlorite

Sodium hypochlorite shall be dosed intermittently to the intake header for shock chlorination and continuously at the intake pump discharge to eliminate micro-organism and control bio-fouling in the downstream processes. Only one set of sodium hypochlorite storage and dosing system shall be provided for shock chlorination.

The chemical shall be delivered in liquid form, in tankers. Suitable unloading arrangements shall be provided to transfer the chemical to the storage cum dosing tanks. All pumps and/or blowers for chemical transfer shall be equipped with a standby unit.

The liquid chemical shall be dosed to each dosing point, in a controlled manner, by dedicated, duty/standby sodium hypochlorite dosing pumps.

The dosing tanks shall be connected to the dosing pumps by a common header. The elevation of the dosing pump shall be below the lowest working liquid level in the dosing tanks. The connection from the header to the dosing pumps shall be taken off the bottom of the header. The connection between the header and the dosing pump shall be kept as short as practical, and shall preferably be straight down (via isolation valve) onto the pump suction. A vent pipe shall be provided on the top of the header in the immediate vicinity of the feed to each dosing pump. Each vent pipe shall vent back into a hypochlorite tank. This arrangement is required because hypochlorite solution tends to generate gas, particularly in warm conditions, which results in dosing pumps losing their prime.

The table below specifies the physical properties for sodium hypochlorite.

**Table ‎3‑8: Physical Properties of Sodium Hypochlorite**

|  |  |
| --- | --- |
| Sodium hypochlorite | NaOCI |
| Physical form | Clear, yellow-green liquid |
| Active component | Cl2 |
| Bulk density (kg/m3) | 1170 |
| Liquid viscosity (kg/ms) | ~ 0.002 (depending on temperature) |
| Active conc. of delivered product (% w/w as Cl2) | 10%-12.5% |

Each hypochlorite dosing tank shall be sized to retain a minimum volume equivalent to the greater of:

a) 48 hours of hypochlorite solution for intake at maximum flowrate and average dose

b) the maximum quantity of intake shock chlorine required in a single shock chlorination event.

#### Sulphuric Acid

* + Sulphuric acid shall be dosed upstream of the Lamella Settler for coagulation pH and scale control.
  + The chemical shall be delivered in liquid form and stored in dedicated storage tanks.
  + The liquid chemical shall be dosed to each dosing point, in a controlled manner, by dedicated, duty/standby sulphuric acid dosing pumps.
  + Undiluted chemical shall always be within a bonded & screened area, or in dual containment pipework, with leaks ﬂowing to containment areas.
  + The system shall be designed to ensure that water cannot flow back up into the concentrated acid pipework.

The table below specifies the physical properties for Sulphuric Acid.

**Table ‎3‑9: Physical Properties of Sulphuric Acid**

|  |  |
| --- | --- |
| Sulphuric Acid | H2SO4 |
| Physical Form | Clear liquid |
| Active Component | H2SO4 |
| Bulk Density (kg/m3) | 1840 |
| Active Conc. of the delivered product (% w/w as H2SO4) | 96 to 98% |

The exterior of the tank shall be coated as follows:

* One coat of a two-pack zinc-rich epoxy primer applied to a minimum dry film thickness of 50 microns;
* One coat of a high build polyamide cured epoxy applied to a minimum dry film thickness of 150 microns;
* One coat of a re-coatable polyurethane applied to a minimum dry film thickness of 50 microns.
* The tank shall have a desiccator arrangement of the ventilation pipe to prevent moisture from entering the tank. All the outlet nozzles shall have double isolation valves.

The acid storage tank shall be installed in separate dykes. Each dyke volume shall be capable of holding the gross tank storage volume including board for the free area. The dyke area shall be provided with adequate drainage arrangement. The preferred material of construction for bulk storage of sulphuric acid is Carbon Steel with proper corrosion-resistant internal and external coating. Transfer pumps shall be provided to transfer chemicals from bulk storage tanks to the dosing tanks inside the chemical buildings. All dosing tanks and dosing pumps with all appurtenances shall be accommodated in the chemical building.

#### Ferric Chloride

Ferric chloride shall be dosed upstream of the Lamella Settler for coagulation, and also provision shall be kept to dose before DAF as needed.

There shall be two solution preparation & dosing tanks for ferric chloride and two tanks for polyelectrolyte - each of capacity more than 8 hours of maximum chemical dosing. All chemical preparation and dosing tanks, dosing pumps and chemical storage area shall be housed in a concrete building with an RCC service water tank at the top of the building for chemical preparation. There shall be two standby (1 installed and 1 in-store) chemical dosing pumps both for coagulation and flocculation chemicals connected to common header. All pumps, pipes and fittings shall be provided similar to other chemical dosing systems and the satisfaction of the Employer.

The table below specifies the physical properties for Ferric Chloride.

**Table ‎3‑10: Physical Properties of Ferric Chloride**

|  |  |
| --- | --- |
| Ferric Chloride | FeCl3 |
| Physical form | Clear Dark Red/ Brown Liquid |
| Active component | Fe3+ |
| Bulk density (kg/m3) | 1420 to 1460 |
| Viscosity (kg/ms) | Approx. 0.0121 |
| Active Conc. of delivered product (% w/w as FeCl3) | 40-42.5% |

#### Polyelectrolyte

Polyelectrolyte shall be dosed upstream of the Lamella Settler and also before DAF if required. The polymer dosed shall be approved for use by the manufacturers of RO membranes. All chemical preparation and dosing tanks, dosing pumps and solid chemical storage area shall be housed in a chemical building.

The strength of solution prepared shall be fully adjustable within the range 0.05% w/w to 0.2% w/w.

The polymer solution shall be dosed from the dosing tanks to the dosing point, in a controlled manner, by dedicated polyelectrolyte dosing pumps. The polyelectrolyte shall be dosed into a carrier water stream, to provide a dilution ratio of at least 5:1 or diluted polymer concentration <0.02. There should not be any fisheye polymer floating in the flocculation tank.

All polyelectrolyte preparation and dosing equipment shall be provided with 100% installed standby.

For sizing the dosing pumps, it may be assumed that the maximum batch strength of polyelectrolyte (0.2% w/w) is used with the maximum dose and that the minimum batch strength (0.05% W/W) is used with the minimum dose. The tank sizing shall also be done based on the maximum dose rate.

The polyelectrolyte dosing tanks (3 tanks) shall be sized to provide at least 8 hours supply under maximum dosing and maximum flow conditions.

#### Sodium Metabisulphite

Sodium bisulphite (SBS) (NaHSO3) will be prepared by dissolving sodium metabisulphite (SMBS) (Na2S2O5) in water. Dosing of bisulphite is required to remove residual chlorine from the system resulting from intake dosing. Bisulphite may also be used for the RO CIP process and also for RO membrane flushing for storing more than a day.

Sodium metabisulphite shall be dosed upstream of the cartridge filters to allow proper mixing and elimination of the residual chlorine. Provision shall also be done to dose sodium metabisulphite after ORP meter.

The chemical shall be delivered and stored in powder form, in bags. The powder shall be batched up in dilution tanks to prepare a liquid solution for dosing. A minimum of two dilution tanks shall be provided. The tanks and chemical storage shall be housed in the RO chemical building. When a batch needs to be prepared, powder shall be transferred from bags to a discharge hopper. The discharge hopper shall be provided with a sealed lid, which is removed when the hopper is being filled. The powder shall be discharged from the hopper to either of the dilution tanks via a manually operated isolation valve. The dilution tanks shall be covered, and vented to atmosphere outside the chemical building (toxic sulphur dioxide is released when sodium metabisulphite is mixed with water). The dilution tank shall be provided with an overflow which overﬂows via a water bath within the bunded area of the tank.

Each dilution tank shall be connected to the dosing pump suction manifold via an automatically controlled isolation valve. The liquid solution shall be dosed to each dosing point, in a controlled manner, by dedicated, duty/standby metabisulphite dosing pumps.

The table below specifies the physical properties for Sodium Metabisulphite.

**Table ‎3‑11: Physical Properties of Sodium Metabisulphite**

|  |  |
| --- | --- |
| Sodium Metabisulphite | Na2S2O5 |
| Physical form | White to off-white, crystalline Powder |
| Active component | Na2S2O5 |
| Bulk density (kg/m3) | 1000 to 1150 |
| Viscosity (kg/ms) | - |
| Active Conc. of the delivered product (% w/w) | 100% |

#### Antiscalant

Non-polymer based antiscalant shall be dosed upstream of the cartridge filters. The chemical shall be delivered in liquid form and stored in dedicated storage tanks.

The liquid chemical shall be dosed to the upstream of cartridge filter dosing point, in a controlled manner, by dedicated, duty/standby antiscalant dosing pumps.

The table below specifies typical physical properties for an acceptable antiscalant. Details of the selected product are to be obtained from the selected chemical supplier.

**Table ‎3‑12: Physical Properties of Antiscalant**

|  |  |
| --- | --- |
| Antiscalant |  |
| Physical form | Clear Yellow Liquid |
| Active component | Product as supplied |
| Bulk density (kg/m3) | ~ 1- 1300 |
| Viscosity (kg/ms) | - |
| Active Conc. of the delivered product (% w/w) | 100% |

Dosing tank of polypropylene or GRP construction. Each tank shall have a cover with charging port, level switches, makeup water pipe connection and a drain with isolating diaphragm valves; the pipework and valves in uPVC Class 15/PN 16; the antiscalant tank shall be installed in separate dykes. Each dyke volume shall be capable of holding the gross tank storage volume including board for the free area. The dykes area shall be provided with adequate drainage arrangement. The dyke area shall also be equipped with an eyewash and a safety shower at a strategic location. The antiscalant dosing plant shall be installed on a concrete plinth in the RO building as approved by the Engineer.

#### Biocide

Non-polymer-based biocide storage and dosing system shall be provided to combat the propensity of bacterial infection of the RO membrane. The chemical shall be dose as and when required to prevent biological growth in the RO system. The chemical shall be delivered in liquid form and stored in dedicated storage tanks.

The liquid chemical shall be dosed to the upstream of cartridge filter dosing point, in a controlled manner, by dedicated, duty/standby biocide dosing pumps.

#### Sodium Hydroxide

Sodium hydroxide storage and dosing system shall be provided for use in case required to reduce Boron in permeate. The chemical shall be dose as and when required to limit the Boron concentration in the permeate within 1 mg/l. The chemical shall be delivered in liquid form and stored in dedicated storage tanks from where it shall be transferred to the dosing tanks in the chemical building.

The liquid chemical shall be dosed to the upstream of cartridge filter dosing point, in a controlled manner, by dedicated, duty/standby dosing pumps.

### Post Treatment System

The permeate from the RO plant will be treated in the remineralization/ potabilization plant followed by disinfection and pH adjustment. There will be a separate post-treatment system for each plant stream of 200 MLD capacity. The limestone-based potabilization system shall be adopted considering the plant operation and maintenance aspects.

The post-treatment process shall be complete comprising the following stages:

* CO2 storage and injection system;
* Limestone filter beds;
* pH correction system including an arrangement for pH booster, if required;
* Corrosion inhibitor dosing;
* Product water disinfection by chlorination.

All necessary pumps, compressors, equipment, controls and pipework systems shall be included for the treatment stages. The CO2 for the potabilization plant shall be procured from external sources and stored at the plant in dedicated storage tanks. A minimum of two storage tanks shall be provided and each to be sized for adequate storage capacity (minimum 15 days storage). Tanks shall be of vacuum-sealed double-walled type. The storage tanks shall be fabricated from ASTM Gr 515/516 plates or equivalent plates as per ASME Section VIII Div I or equivalent international standards.

The dosing system shall consist of the pneumatically operated flow regulating, a flow monitor, a pressure monitor, a pressure gauge and motorised inlet and outlet valves and guard valves. The dosing control system shall be provided with a manual bypass.

Carbon dioxide dosing shall be controlled proportional to the post-treatment feed flow and based on an operator set dosing rate.

Each dosing system shall be provided with a static mixer of stainless-steel construction, with motive water provided by the motive water pumps. Water supply to each static mixer shall be regulated by control valve station. The gas supply to the static mixer shall also be provided with non-return and isolating valves.

All the pipework complete with valves, fittings, supports etc. for the total carbon dioxide plant shall be provided under this Contract. This shall include all the pipework from the storage tanks to the dosing point.

All the pipework, valves and fittings shall be in carbon steel. Internals of the valves shall be in stainless steel. Pipe connections of 2 inches and below shall be socket welded. However, the Pipe connection above 2 inches shall be flanged.

#### Limestone Filter

The remineralisation plant shall be capable of converting 100% of the permeate from the RO Plant into product water to the required Drinking Water standard. The potabilization shall be done using CO2 gas injection and limestone filters. In case of partial remineralization and then mixing of two streams, about 50% of the permeate flow should pass through the limestone filter for remineralization. The bypass stream must mix with remineralized stream thoroughly before transfer to the Product Water Tanks. The composition of the product water following remineralisation shall meet the requirements stated in IS 10500.

The required alkalinity and hardness shall be maintained in the product water during remineralization. Finally, the pH correction shall be done through caustic injection to ensure the positive LSI of the product water. The process design of the remineralization plant is given in table below.

**Table ‎3‑13: Indicative Process Design Criteria for Remineralization System**

| **Item** | **Requirement** |
| --- | --- |
| Limestone Filter Plant | 2 plants – 1 for each plant stream |
| Remineralization Process | Limestone filtration /Carbon dioxide Dosing – 2 |
| Target filter surface loading | 10 m3/m2.h |
| No. of filter modules per stream | 14 |
| Media Contact time | 25-30 min |
| Hardness in the product water | ≥ 60 mg/l as CaCO3 |
| Target pH range | 7.5 to 8.5 |
| Target Langelier Index | Positive |
| Max. TDS in product water | 450 mg/l at battery limit. |

##### Limestone Filter Beds

Limestone filters should include an automatic backwash system and loading system. Backwash should include air and water step for proper cleaning of the filters.

Proper corrosion protection should be implemented depending on filter material to ensure that corrosion will not impact post-treatment availability and operability.

Limestone grain size should be 2 – 4 mm.

The limestone used should be compatible with product water application; this should be validated by a certificate from a reputable international lab.

Storage capacity should be at least one month at full capacity.

The Contractor shall be responsible for ensuring purity and local availability of the limestone for design; however, the design should not consider purity above 96%.

Care must be taken that volatile organic and inorganic constituents (THM etc.) cannot be passed to the drinking water. Adequate adsorption and cleaning facilities (absorbers etc.) shall be installed in the CO2 feed lines to the alkalinisation stage. The use of seawater for remineralisation is not permitted.

The excess CO2 from the process after the treatment shall be vented out through the degassers or alternatively neutralised by the addition of chemical (NaOH). The degasser tower and the water storage tank shall be fabricated in GRP. In order to control the remineralisation process and to guarantee the quality control of the water the following measurements and control are required;

* Calcium monitoring and control;
* Conductivity measurement;
* Turbidity measurement;
* Residual chlorine detection and control system.

Carbon dioxide flow for re-injection shall be automatically adjusted pro-rata to permeate flow with the remote manual trimming to compensate for variations arising from product water temperature and chemical composition. The calcium alkalinity adjustment system shall be automatically controlled to maintain a positive Saturation Index to DIN 38404-10 and calcium concentration.

The piping material for the entire remineralization Plant shall be in GRP. The GRP pipes shall be designed for the maximum pressure that is likely to occur in the piping system (pressure surge phenomena shall also be considered for this purpose). However, the minimum stiffness class of the piping shall be 5000 PSI.

All the valves used for this plant shall be suitable for product water application. The Valve casings shall be in Ductile Iron or Cast Steel material. Valve internals shall be lined with fusion bonded epoxy coating. Valve discs shall either be fusion bonded epoxy coated or encapsulated with EPDM. Stainless steel shafts shall be provided for the valves.

All the pumps in the system shall be in stainless steel SS316L construction, i.e. casing, impeller, shaft, shaft sleeve, wear rings and other wetted parts. The pumps shall be designed, manufactured and tested according to the latest ISO, BS or DIN or equivalent International codes. Adequate stand by equipment shall be provided in the process. All the standby pumps shall be capable of operating automatically in case of failure of the main pump.

### Product Water Disinfection

Bidders shall consider the use of sodium hypochlorite for disinfection of product water. Suitable number of N+2 dosing pumps with solution tanks shall be kept to dose in the product water feed to Product Water Tank. The specification for sodium hypochlorite shall be as per the above chlorination description.

#### Chlorine Residual Monitors

One chlorine residual monitor shall be provided in each pipeline from Product Water Tanks to Clear Water Tank for monitoring the final water downstream of the chlorine injection points. The Contractor needs to maintain 0.5 ppm residual chlorine at the outlet of the plant.

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 the central HMI. High and low chlorine residual levels shall raise alarms at the local control panel and the central HMI.

#### Ventilation System

Each area where hypo is stored or used liquid 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 a high level.

The ventilation systems shall be designed to provide for general day to day use an air change rate of four per hour and a minimum of twenty changes of air per hour for use in the event that a chlorine leak is detected. Extract fans shall be heavy-duty industrial pattern manufactured from chlorine resistant materials.

Ductwork shall be manufactured from U-PVC extruded sheets or circular sections complying with BS 3757 and BS 3506. Fan controls shall be linked to the gas leak detection system. Hardwired fan controls shall be provided and shall be manually controlled. An override shall be provided to operate the fans as required in the event of a chlorine leak alarm. Fan controls shall be grouped in an enclosure outside the ventilated area and shall include the following:

* fan off/on;
* fan running/failed indication lights;
* low and high gas leakage indication alarm light.

An override facility shall be provided to permit, under manual supervision only, the ventilation fans to be operated in order to disperse gas after isolation of a gas leak. Indicator lights shall be provided at the entrances to the chlorination room and the drum room to indicate whether the ventilation system running.

### pH Adjustment of Product Water

Sodium hydroxide shall be used for the pH adjustment of the product water before product water tank. Sodium hydroxide storage and dosing system shall be provided for the purpose. The chemical shall be dose to maintain the pH of the permeate within 7 - 8.5. The chemical shall be delivered in liquid form and stored in dedicated storage tanks from where it shall be transferred to the dosing tanks in the chemical building.

The liquid chemical shall be dosed to the upstream of chlorine dosing point, in a controlled manner, by dedicated, duty/standby dosing pumps.

### Product Water Tank (PWT)

Product water tanks shall be provided by the Contractor with 2-hour storage capacity (at least 30 ML). Total capacity of two product water tanks for each stream shall not be less than 15ML. The tank shall be subdivided into two compartments so that one compartment can be taken out of service for maintenance or cleaning without disrupting the operation, i.e. water production and distribution. All valves, gates, pipes and instrumentation shall be provided to make a complete water storage tank. The tank will have level sensors and overflow pipeline to the Outfall tank.

The water from the product water tanks of both the streams shall be fed to a Clear Water Reservoir (CWR) for pumping water to Porur for distribution.

The main outlet pipe from the product water tanks of each stream to CWR will have two metering system, online turbidity, conductivity meters and sampling points to demonstrate the product water quality/quantity and to meet the product water guarantee conditions.

There will be provisions for pumping of the product water from PWTs to meet the plant captive water requirements for administrative building, toilets, safety showers etc. and also for a fire system (pumps, diesel set, network).

These two-compartment tanks will be constructed of concrete or metal panels with provision of corrosion protection. The remineralised water from the limestone filter will gravitate to the product water tank.

### Clear Water Reservoir (CWR)

A clear water reservoir shall be provided by the Contractor with a minimum of 30 minutes of storage capacity. The reservoir capacity shall be at least 9000 m3 and made of reinforced concrete. The tank shall be subdivided into two compartments so that one compartment can be taken out of service for maintenance or cleaning without disrupting the water production and distribution. There will be an overflow line from the CWR to the outfall tank. The CWR will be the battery limit of the contract. The Contractor is to provide all sensors, instruments, gates, inlet pipes, valves, dismantling joints, puddles in the CWR up to 5m length of flanged pipes of required specification on the discharge side. The pipes, centrifugal pumps and all valves, sensors and instrumentations at the CWR discharge line are not in the scope of the Contractor to provide.

### Plant Sludge Treatment System

A sludge treatment facility shall be constructed to treat sludge from the proposed 400 MLD SWRO desalination plant.

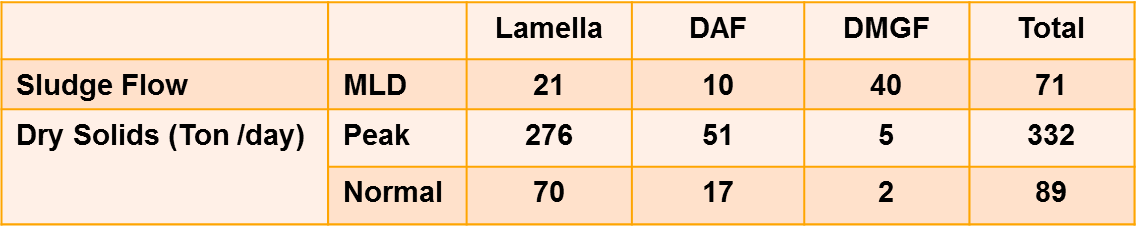
The selected sludge treatment units are sludge balance tank (SBT), thickeners and belt filter press (BFP) units. All the sludge will be collected in the sludge balance tank and mixed for a homogeneous sludge solution. From SBT, the sludge will be pumped to the thickeners where it will be thickened up to 5% solid consistency. The thickened sludge will be transferred to the sludge holding tank under gravity which will then be pumped to BFP units for dewatering. The polymer will be used before thickener and BFP to promote solid separation. The filter backwash water, supernatant from thickener and wash water/ filtrate from BFP shall be directed under gravity to the Outfall tank. Rodding points or other provisions shall be provided throughout the installation to clear sludge blockage without dismantling any pipe section.

Sludge disposal shall be as per the norms of the local and state regulations.

#### Design Basis

The pre-treatment process for 400 MLD Perur Desalination Plant includes Lamella Clarifier (LC) and Dissolved Air Flotation (DAF) followed by Gravity Dual Media Filter (GDMF). Most of the solids in raw seawater will be eliminated in the Lamella filter, and some lighter particles will be removed in DAF. The concentration of suspended solids in the seawater to GDMF is expected to be less than 5 mg/L most of the time, which will be removed in filter beds. The sludge generation in LC, DAF and GDMF at a peak feed flow rate (42% recovery) and high/average turbidity are given below.

**Table ‎3‑14: Indicative Sludge Flow and Dry Solids at Sludge Treatment System**



The generation of sludge streams from LC, DAF and DMGF will be about 21, 10 and 40 MLD. The primary solid loads will be in the Lamella clarifier and DAF waste streams. The design will be based on the normal condition with average seawater quality having TSS 75 mg/l. The solid load from the DMGF waste stream is expected within 2 tons/day, which is very low compared to LC and DAF. Therefore, only LC and DAF sludge have been considered for treatment.

#### Sludge Balance Tank

The sludge from the Lamella Settler and DAF will be collected in a sludge balancing tank before pumping to the sludge thickener. The sludge balancing tank shall be of reinforced concrete construction.

The Contractor shall provide at least three submersible mixers installed and one mixer in store (3 duty/1 standby). The mixers shall be of the wall-mounted type with coupling devices, guide rails and support brackets. The mixers shall be provided with adjustment for depth and mixing directions.

An overflow line for discharging of excess sludge to the Outfall tank shall be provided. The system shall be complete with all necessary controls and a set of level elements to provide the required controls and alarms. An indicative design criterion for the sludge balancing tank is listed below.

**Table ‎3‑15: Indicative Design Criteria for Sludge Balancing Tank**

| **Parameters** | **Unit** | **Value** |
| --- | --- | --- |
| Required tank volume | cu m | 2592 |
| Number of RCC tanks |  | 1 |
| Tank sludge depth | m | 3.5 |
| Tank area | sq m | 741 |
| Tank diameter | m | 31 |
| Flow Meter |  | Electromagnetic |
| No. of submersible mixers |  | 4 (3 duty/1standby in-store) |

#### Thickener Feed Pumps

Three thickener feed pumps (2 duty/1 standby) shall be provided. The pumps shall be of the submersible non- clog type and be mounted in a wet well within the tank. The pumps shall be automatically controlled by the water level in the sludge balancing tank.

A static mixer or equivalent device shall be mounted on the pump delivery line inside the pumping vault to ensure adequate mixing of the injected polymer within the bulk of the sludge. A manually operated chain pulley block and running beam shall be supplied for removal of the pumps. The indicative design criteria for the thickener feed pumps are listed in in the table below.

**Table ‎3‑16: Indicative Design Criteria for Thickener Feed Pumps**

| **Thickener Feed Pumps** | **Unit** | **Value** |
| --- | --- | --- |
| Design flow | cu m/hr | 650 |
| Maximum flow | cu m/hr | 800 |
| Minimum flow | cu m/hr | 400 |
| Pump type |  | Submersible non-clog |
| Discharge head | m | 15 |

#### Polymer Dosing System

Two metering pumps (1 duty/1 standby) and all associated polymer make facilities, pipework and valves etc. shall be provided to dose polymer from a polymer storage tank into the thickener feed line at a rate of up to 5 kg per ton of dry solids.

The metering pumps shall be of the diaphragm type driven by a fixed speed motor with manual stroke adjustment, with a 10 to 1 turndown and an accuracy of ±3% over the operating range. An indicative design criterion for the thickener polymer dosing system is listed in the table below.

**Table ‎3‑17: Indicative Design Criteria for Thickener Polymer Dosing System**

| Thickener Polymer | **Unit** | **Value** |
| --- | --- | --- |
| Polymer Type |  | Food grade |
| Polymer dosing concentration | % | 0.5 |
| Operating hrs | hrs | 24 |
| Polymer dosing rate | kg/SS-T | 5 |
| Polymer Dosing System |  |  |
| Type |  | Metering pump |
| Number, duty |  | 1 |
| Number, standby |  | 1 |
| Pump capacity | m3/hr | 0-15 |

#### Sludge Thickeners

The sludge in the sludge balancing tank will be pumped to sludge thickener. The sludge thickener shall have two functions:

* to clarify the supernatant to turbidity below 10 NTU prior to the return of the supernatant to mixing and distribution chamber.
* to thicken the sludge to a concentration of up to 5% solids prior to dewatering using belt filter presses (BFPs)

The sludge thickener shall have a sloping bottom and shall be fitted with a rotating sludge scraper to transfer thickened sludge to a central removal hopper. The scraping gear shall be supported from the tank base and a fixed bridge carrying the central electric 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 conditions. Suitable overload protection for the drive shall be provided to ensure that the sludge shall not overload the equipment and emergency stop pushbutton shall be provided. The scrapers shall be fitted with rotation monitors and overload protection to alarm in the event of a failure.

The supernatant shall overflow a peripheral v-notch weir into a collecting channel and then flow by gravity to the Outfall tank. The supernatant may be directed to the Intake well. In that case, the polymer should be food grade.

The thickener shall have a full diameter fixed bridge complete with a walkway for personnel access to the centre, access stairs to ground level and handrailing, a motor-driven sludge scraper complete with tie bars and tensioning members, all necessary controls, delivery pipework, a stilling well and overflow steel weir plates. Walkways, access steps etc. shall be galvanised. Handrailing shall be of Type 316 stainless steel material. Underwater fasteners shall be Type 316L stainless steel material.

The electric motor, gearbox, etc., shall be provided with a sunshade. The fixed bridge and the stilling chamber shall be steel coated with polyurethane, including the scraper mechanism. Suitable overload protection for the drive shall be provided to ensure that the sludge shall not overload the equipment and emergency stop pushbutton shall be provided. The scrapers shall be fitted with rotation monitors and over-torque protection to alarm in the event of a failure.

An electromagnetic flow meter shall be provided in the supernatant return pipe to the mixing and distribution chamber. The supernatant pipework shall be arranged to ensure that the pipework in the region of the flow meter always remains full. Flows shall be indicated, totalised and recorded at the local control panel and at the central SCADA system HMI. An online turbidity sensor shall be provided in the return pipeline to assess and record the performance of thickener. An indicative design criterion for the sludge thickener is listed in in the table below.

**Table ‎3‑18: Indicative Design Criteria for Sludge Thickener**

| **Sludge Thickener** | **Unit** | **Value** |
| --- | --- | --- |
| Type |  | Continuous Circular Thickener |
| Design flow | cu m/hr | 1500 |
| Design inlet solid | kg/hr | 13721 |
| Solid loading rate | kg/day/sq m | 86 |
| Thickener surface area required | sq m | 3830 |
| Number, duty |  | 2 |
| Diameter of thickener | m | 35 |
| Hydraulic loading rate | cu m/sq m/hr | 0.7 |
| Depth of thickener | m | 4 |
| Thickener removal efficiency | % | 90 |
| Flow meter on supernatant return pipe |  | electromagnetic |

#### Thickened Sludge Holding Tank

A tank shall be provided to store thickened sludge and to act as a sump for the BFP feed pumps. The tank overflow shall pass to the Outfall tank. The tank shall be fitted with continuous level measurement equipment.

The Contractor shall provide two agitators. The agitators shall be mounted on platforms that extend across the tank. The indicative design criteria for the thickened sludge holding tank are listed in the table below.

**Table ‎3‑19: Indicative Design Criteria for Thickened Sludge Holding Tank**

| **Thickened Sludge Holding Tank** | **Unit** | **Value** |
| --- | --- | --- |
| Total sludge flow | cu m/hr | 240 |
| HRT | hr | 4 |
| Required tank volume | cu m | 960 |
| Number, duty |  | 1 |
| Depth of tank | m | 4 |
| No. of agitators |  | 2 |

#### Sludge Dewatering Process

1. *General*

Continuous-feed belt filter presses (BFPs) that use 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. Polymer (non-food grade) shall be dosed to the sludge via a static mixer. The conditioned sludge shall be introduced on a gravity drainage section where it is allowed to thicken. Following gravity drainage, the pressure shall be 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.

1. *BFP Feed Pumps*

The BFP feed pumps shall be progressive cavity pumps.

1. *BFP Requirements*

The indicative design criteria for the BFP dewatering system are listed in the table below.

**Table ‎3‑20: Indicative Design Criteria - BFP Dewatering System**

| **System** | **Unit** | **Value** |
| --- | --- | --- |
| **BFP Feed Pumps** |  |  |
| Type |  | Progressive cavity pump with VFDs |
| Minimum capacity | cu m/hr | 24 |
| Maximum capacity | cu m/hr | 30 |
| Number, duty |  |  |
| Number, standby |  |  |
| **Belt Press Filter** |  |  |
| Design flow | cu m/hr | 240 |
| Design flow | cu m/day | 5760 |
| Operation times (minimum) | hr/day | 16 |
| Required BFP capacity | cu m/hr | 360 |
| Number, duty |  |  |
| Number, standby |  |  |

1. *Polymer Dosing System*

All associated polymer makeup facilities, calibrator, pipework, flowmeter and valves etc. shall be provided to dose polymer from a polymer tank into a static mixer on the BFP feed lines. The metering pumps shall be of the diaphragm type driven by a fixed speed motor with manual stroke adjustment, with a 10 to 1 turndown and an accuracy of ±3% over the operating range. The metering pump shall start and stop simultaneously with the associated BFP feed pump. The indicative design criteria for the BFP polymer dosing system are listed in the table below.

**Table ‎3‑21: Indicative Design Criteria for BFP Polymer Dosing System**

| **BFP Polymer Dosing System** | **Unit** | **Value** |
| --- | --- | --- |
| **BFP Polymer** | | |
| Polymer Type |  | Non-food grade |
| Polymer dosing concentration | % | 0.5 |
| Operating hrs | hr | 16 |
| Polymer dosing rate | kg/SS-T | 5 |
| **Polymer Tanks** | | |
| Type |  | Circular tank |
| Number, duty Tank |  | 2 |
| **Polymer Dosing Pumps** | | |
| Type |  | Metering pump |
| Number, duty |  |  |
| Number, standby |  |  |

### Functional Design Specification

#### General

Before commencement of software development for the PLC/DCS/SCADA system, the Contractor shall prepare the Functional Design Specifications (FDS) for the plant processes. The Contractor shall be fully responsible for collecting all relevant data and information such as process parameters, alarm setpoints, interlocks etc. required to develop the FDS. Information collection by way of posting a Request for Information is not acceptable.

#### Plant Interlocks

The FDS shall comprise a listing of all plant interlocks. The plant interlocks shall include but not be limited to

* interlocks between various process units
* interlocks within a processing unit
* interlocks between equipment
* interlocks within a piece of equipment
* interlocks between the plant and external system

It is also the responsibility of the Contractor to identify any new equipment type interlock that may not be shown on the Standard Starter Templates. All these interlocks shall be presented in the form of a table and may also be presented in the form of a spider diagram or any other means subject to approval by the Engineer.

### Hydraulic Profile

The Contractor shall provide the hydraulic profile of the complete seawater desalination plant including the intake pumping station, inlet chamber, flash mixing, flocculation and Lamella clarification, DAF, media filtration, RO system, Remineralization, disinfection, product water storage, sludge treatment and any other water treatment plant process.

## Material Selection and Corrosion Control

The material selected for each equipment item shall have a proven track record for that same equipment item in an equivalent operating environment. The selected material shall be clearly indicated in the Contractor’s Proposal Attached to the Contract. The material selection for all major equipment including pipes, pumps, valves, gates, joints, meters, tanks etc. shall be submitted to the Employer for approval during the design phase.

The quality of all materials, prefabricated parts and instruments as well as the quality of workmanship during assembly and erection shall be such that the plant shall have its operational life as defined in bid document elsewhere. The equipment shall be of a well-proven design and renowned manufacturer. The latter shall demonstrate that the proposed equipment has been installed in other plants running successfully under similar conditions. Moreover, in the selection of equipment, the Contractor shall take into account that workshops and offices of the vendors exist in the region.

The Contractor shall indicate the corrosion/erosion allowances intended to be applied based on the operational life for the whole installation.

At locations where the contact between different metals cannot be avoided, protection against corrosion due to galvanic potential difference shall be provided. Where necessary, bolted connections of dissimilar materials shall be insulated from the surrounding metals by means of insulating washers and sleeves to prevent electric current to circulate and establish a galvanic element.

All external stainless-steel components shall be protected against salt deposits

The design and the construction shall be performed so as to avoid crevice corrosion.

External bolts, nuts and washers shall be of corrosion-resistant material.

Any rubber or plastic parts, coatings etc. shall be provided with suitable protection against the ultraviolet radiation of the sun.

Fittings like valves, filters, pumps etc. shall be standardised as much as possible (made by the same manufacturer) to minimise spare parts inventory. The spare parts shall be fully documented, and clearly identified in related drawings.

Workmanship and general finish shall be of first-class commercial quality and in accordance with the best workshop practices and shall provide what is generally recognised as waterworks finish as defined elsewhere.

All similar items of plant and their component parts shall be completely interchangeable. Spare parts shall be manufactured from the same materials as the originals and shall fit all similar items of plant. Machining fits on renewable parts shall be accurate and to specified tolerances so that replacements made to manufacturer's drawings may be readily installed.

All equipment shall operate without excessive vibration and with a minimum of noise as defined in the bid document elsewhere. All revolving parts shall be dynamically balanced so that when running at all operating speeds and any load up to the maximum, there shall be no vibration due to lack of balance.

All parts which can be worn or damaged by dust shall be totally enclosed in dust-proof housings.

Dynamic balancing of rotary components shall be to the relevant standards. All bearings shall have L-10 rating life of minimum 16,000 hours.

### Requirements for Materials

Materials selected by the Contractor shall be proven to be eligible and sufficient for the RO Plant design life. All materials and equipment shall be designed for long life and shall be suitable for continuous 24 hours per day operation for prolonged periods with a minimum of maintenance. The Contractor may be called upon to demonstrate this for any component either by the service record of similar equipment elsewhere or by records of extensive type tests.

All materials incorporated in the Works shall be the most suitable for the duty concerned and shall be new and of first-class commercial quality, free from imperfections and selected for long life and minimum maintenance. The selection of the material of all the equipment and pipelines shall be done with consent of the Engineer.

All parts in direct contact with various chemicals shall be completely resistant to corrosion, or abrasion by these chemicals, and shall also maintain their properties without aging due to the passage of time, exposure to light or any other cause.

Seawater pumping pipes and all pipes and fittings in Pre-Treatment area shall be manufactured in GRP in accordance with AWWA C 950.

Pipe and fitting for low-pressure system and reject (low pressure) shall be GRP of minimum pressure rating of PN10. The piping material for permeate/ product water shall be GRP of pressure rating PN25 as a minimum.

The pipes shall have a minimum stiffness of 2500 N/m2 in accordance with AWWA C 950 and shall include an internal and external corrosion barrier. These pipes shall also be designed for the full vacuum conditions that may occur in the piping system and shall be designed to withstand the pressure scenarios that occur during the surge condition.

Components of the RO Plant which are in contact with Seawater or are subject to abrasion or potential high rates of wear shall be selected from proven grades of high corrosion/erosion-resistant materials.

All stainless-steel material in contact with seawater and concentrate (brine) in minimum shall have a Pitting Resistance Equivalent Number (PREN) and Crevice Factor (CF) as follows:

PREN = Cr(%) + 3.3 x Mo (%) + 16 x N (%) for austenitic material or

PREN = Cr (%)+3.3 x Mo (%)+30 x N (%) for Duplex material ≥43

CF = Cr (%) + 3 x Mo(%) + 15 x N (%) of not less than 35.

Material for desalination major process pumps (Seawater supply, Seawater booster and high-pressure pumps) shall be super-duplex stainless steel with a PREN ≥ 43. The materials of the other balance of plant equipment and systems shall be suitable for the services intended.

Cathodic protection system as applicable shall be provided to mitigate the corrosion that may occur due to a combination of different materials.

Particular attention shall be paid to the prevention of corrosion due to the close proximity of dissimilar metals. Where it is necessary to use dissimilar metals in contact, these shall be selected so that the bimetallic corrosion is as low as possible and the dissimilar metals shall be isolated by barriers or isolating material. The publication by H. M. Stationery Office (in the U.K.) entitled “Corrosion and its Prevention at bimetallic Contacts" shall be used as a guide.

All outdoor instruments shall be provided within FRP/GRP enclosures, or of any other equivalent suitable material which shall withstand the corrosive sea environment.

Butterﬂy valves for On-Off service and non-return valves that are in contact with seawater shall have a Ductile Iron body with hard rubber lining. Control valves for modulating service which is in contact with seawater and subject to abrasion and high rates of wear shall be of highly resistant materials such as Ni-Al Bronze.

The staircase and platform shall have SS316 handrails for safe climbing and access. All platforms and stairways shall have a minimum clear width of 1000 mm. All platforms, stairways, landings etc shall have SS316 railings and guards.

### 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. Nor shall any pipe be adversely affected by the fluid being conveyed through that pipe.

The Contractor shall provide a table for the components of all process units and the ancillaries with their required materials of construction and recommended coating.

Pipework and valve materials for the following duties shall be as follows or to the approval of the Engineer:

**Table ‎3‑22: Materials for Pipes and Valves**

|  |  |
| --- | --- |
| **Application / Location** | **Material** |
| Coagulation solution | GRP, HDPE or cPVC |
| Hypo-chloride dosing line | GRP, HDPE or cPVC |
| Raw Sea Water, brine discharge, Intake Pumping, Piping in Pre-Treatment | GRP AWWA C950/HDPE  Pipe and fitting for low pressure system and reject (low pressure) shall be GRP of minimum pressure rating PN10. The piping material for permeate water shall be GRP of minimum pressure rating PN25. |
| RO High Pressure and all high-pressure piping, valves and equipment in the RO system | Super Duplex with PREN ≥43 and Crevice Corrosion Factor ≥35 |
| Instrument air, all materials (pipe, Flange, fittings, valves) for air | SS-316 L |
| Wastewater drain line – drain network inside a building | HDPE or uPVC |
| All nuts, bolts, screws and studs for gland joints, couplings joints,flanges and any other fittings.  Prior to assembly, all threads of stainless fasteners shall be coated with a nickel-based anti-seize compound. Where anchors, threaded rods, nuts, washers and fasteners etc. to be embedded in concrete shall be manufactured in Type 316 stainless steel. Wherever possible, chemical set fasteners shall be used. | Type 316L stainless steel |
| All structural components, not exposed to a corrosive environment, (e.g. walkways, fasteners) | hot-dip galvanised iron / GRP |

### Welding

In all cases where welds are liable to be highly stressed, the Contractor shall supply to the Engineer before fabrication commences detailed drawings of all welds and weld preparations proposed. No such welding shall be carried out before the Engineer has signified his approval of the details proposed. No alteration shall be made to any previously approved detail of weld preparation without prior approval of the Employer.

Welding shall comply with B.S. 5135.

Approval of welding procedures shall be as per International / B.S. EN 288-3:1992 standards. Welders shall be qualified to ASME / B.S. EN 287-1:1992. All aspects of fabrication and examination procedures, including pre/post-heating treatment, electrodes, non-destructive Tests (NDT) shall be subject to the approval of the Engineer.

Following codes shall apply for the NDTs:

* B.S. 2600: Radiography;
* B.S. 3923/IS 13311: Ultrasonic Test;
* B.S. 6072: Magnetic Particle Test;
* B.S., 6443: Penetrant Test.

## Instrumentation and Control Works

The entire desalination plant shall be designed for automatic operation to minimize the requirement for manual intervention. Flow rates of main streams, seawater to the pre-treatment section, RO trains’ feed water, permeate product water, and so on shall be controlled as per the flow rates and shall be continuously monitored by the flow meters.

The plant’s information and operation control system proposed shall be based on the network control system. The Distributed Control System (DCS) shall be configured in redundant control mode deployed and distributed in the field areas of the plant by process locations. The DCS shall function independently and autonomously, such that failure of any one element will not affect the operations of the other elements in the entire system. As a result, the system provides maximum availability and reliability for the operation.

The specifications under this section shall be read in conjunction with the specifications provided for specific discipline of the works elsewhere in the contract. In the event of any conflict between this and requirements elsewhere in the contract, the most stringent specifications for all the parts, equipment and works shall apply or as per the consent of the Engineer.

The Proposed DCS system at Desalination Plant with the following features:

* Automation, Monitoring, Process Control, Management & Engineering or machine interface
* Reliable User Guidance
* Redundancy Levels in terms of Controller, Power Supplies, Communication & Operator Work Station except for IO channel Redundancy.
* Uniform operation
* Modern Object-Oriented Software Structure
* Communication with external system and intelligent field equipment
* Integrated diagnosis & documentation system
* Communication support

The DCS will have the following sub-systems/functions.

* Measurement system
* Control system including closed-loop controls, interlock, protection and sequential control system
* Data bus system for control and communication with the process
* Shall be self-diagnostic both module level and channel level diagnostic
* Man-Machine interfacing system
* Maintenance Engineer’s station
* Historical data & retrieval facility
* Alarm management system & Sequence of event recording
* Interfacing with other 3rd party control systems and equipment
* External interfaces to stake holders
* External network interfaces shall be through an industrial firewall
* Dynamic mimic display, alarm monitoring, report trending, logs calculation and printing outs logs, reports and trends.
* All Peripheral hardware failures are hardwired & system status changes through the soft link as per OEM standard for Alarm logging in DCS.
* Time Synchronization with DCS and all other package PLCs.
* The required instrumentation shall be provided for the Units/Facilities to facilitate the smooth plant automation, alarm, monitoring and recording.
* The automation shall be provided to all the processes at the plant such as for but not limited to the following units/facilities of the plant.
  + Seawater intake system
  + All chemical dosing systems
  + Lamella and DAF sludge discharge system
  + DMF backwash systems
  + Pre and Post-chlorination - dose rate shall be controlled based on the level of residual chlorine
  + RO with CIP system
  + Remineralization system and pH adjustment
  + Sludge treatment and waste disposal system
* Alarms and Report Generations - Apart from the above, DCS system shall receive a signal from all instrumentation, units and processes on a real-time basis at the interval selected by the operator, and it shall generate alarms & various Plant Operation Reports.
* Contractor shall provide the functional specification detailing the operation of equipment in manual and automatic mode, description of interlocks and alarms, and description of inputs and outputs signals.
* The system shall provide an orderly shutdown in the event of the operation of a protective device or an equipment failure. There shall be a means of capturing the sequence of the failures and transmitting them to the Central Station for Root Cause Analysis.
* A list of alarms and other important I/O signal (for determining the root cause of failures) shall be provided for review/modification by the Employer and PMC.
* A written process control narrative describing the local and remote operation, interlocking, sequencing, and trip logic shall be provided.
* A list of both hardwired and interface I/O signals shall be provided in electronic format (MS Access or Excel)
* Electronic copies of the PLC program, HMI configuration files (if applicable), and a sample of local HMI display screens (if applicable) shall be provided.
* In the event of operating air or electric power failure, design controls, components shall go into fail-safe condition.
* All alarms shall be configured for “closed” under normal operating conditions and “open” to alarm. Alarm contacts provided for the Employer’s use shall be wired to easily accessible terminal blocks for field connection.
* Separate Routing: Provide separation for each of the following systems:
* 240 VAC power and control wiring.
* Low voltage DC signal wiring, including milliamp, voltage, thermocouple, and Resistance Temperature Detector (RTD) signals.
* Data communications cables such as coaxial, Ethernet Category 6, two or four-wire RS-232/RS-485.
* Prior to shipment from the manufacturer’s facility, the Programmable Logic Controller/Operator-Interface Terminal (PLC/OIT) control systems, I/O modules, panels and other peripheral devices shall be staged and energized for operational testing and demonstration. The Contractor’s testing procedures shall be submitted for Employer’s review and comment.

### Redundancy Levels of DCS system:

1. Controller Level : Required set of Redundant Controllers have been considered as a minimum.
2. Communication Level:- The communication redundancy for DCS shall be applied as follows,
   * 1. Controller to IO Modules -Redundant (communication protocol shall be as per OEM standard)
     2. Controller to Operator/Engineering Stations - Redundant Ethernet
     3. DCS to third party control system - Redundant OPC/ MODBUS TCP-IP/ RS 485
     4. Time Synchronization with GPS Master clock - Redundant through NTP
     5. DCS to MOV’s - Simplex Profibus/Profinet
     6. DCS to Intelligent Master Control Centers (I-MCC’s) - Redundant Profibus/Profinet
3. Power Supply Level

The Redundancy shall be applicable on Power Supply modules which are located at main Controller. Bulk power supply shall be redundant. The system power supply is isolated from field device power/ interrogation supplies.

### Central Control Room (CCR) System

The Central control room of Desalination plant shall be facilitated with below,

1. **Operator Work Stations (OWS’s)**

The Redundant Operator Workstations shall be interfaced with DCS controllers by using Redundant Data Bus, and the same will be proposed in Central Control Room of Desalination plant.

1. **Historical Storage and Retrieval system (HSR)**

The Redundant Historical Storage stations shall be proposed for storage and retrieval facility will collect and store data and parameters including trends, alarms and events from plant unit DCS database periodically and automatically to removable data storage devices once every 24 hours.

1. **Engineering Station & Laptop**

The Engineering station and Laptop shall be proposed in Central Control Room for the operator’s immediate updation on Logic & Graphics without affecting Real-time Process monitoring & control.

1. **Printers**

The Printers shall be proposed in Central Control Room for Printing of Reports, Trends etc. and those are to be interfaced with Hot Redundant LAN so that operators can take prints from multiple stations as and when required with credentials of Administrator.

* One Number of A3- Colour LaserJet Printer
* A-3 / A-4 Black & White LaserJet Printer
* All in One LaserJet Printer

1. **Large Video Screen**

Two numbers of Large Video Screens shall be proposed inside the Central Control Room for operator monitoring of entire plant screen systems.

### Critical Operation Points

The below table shows the Critical Operation points for the Proposed Perur DSP.

**Table ‎3‑23*:* Critical Control Points**

| **Control Points** | **Location** | **Parameter** |
| --- | --- | --- |
| CCP -0 | Filtrate from DMF | Turbidity < 0.5 NTU, TOC < 2 mg/L, SDI < 3 (95% of time), SDI < 4 (100 % of time) |
| CCP -1 | RO feed pump discharge (Cartridge Filter outlet) | Turbidity < 0.2 NTU, ORP -300 mV, TOC < 2 mg/L, SDI < 3 (95% of time), SDI < 4 (100 % of time) |
| CCP – 2 | SWRO permeate | TDS < 350 mg/L (derived value from Conductivity), Boron < 1.0 mg/L |
| CCP - 3 | Product water storage tanks discharge line for both the streams | TDS ≤ 450 mg/L,  Residual Chlorine < 1.0 mg/L,  Boron < 1.0 mg/L,  Turbidity < 1.0 mg/L |
| CCP - 4 | Outfall tank discharge line to sea\* | TSS < 100 mg/L  Iron < 3 mg/L  Residual Chlorine < 1 mg/L  Temperature – Shall not exceed 5°C above receiving water temperature |

Note : \* - The values are discharged are based on General discharge standards of CPCB. TNPCB.

### Online Monitoring Locations

The Table below indicates the minimum envisaged online monitoring locations of water quality for the proposed Perur DSP.

**Table ‎3‑24*:* Major Sampling and Monitoring Locations of Water Quality**

| **S. No.** | **Parameter** | **Raw seawater** | **Filtered**  **water** | **Potable**  **water** | **Marine Outfall** |
| --- | --- | --- | --- | --- | --- |
| 1 | Silt Density Index | ✓ | ✓ | **--** | **--** |
| 2 | pH | ✓ | ✓ | ✓ | ✓ |
| 3 | Total Dissolved Solids | ✓ | ✓ | ✓ | ✓ |
| 4 | Temperature | ✓ | ✓ | ✓ | ✓ |
| 5 | Electrical conductivity | ✓ | ✓ | ✓ | ✓ |
| 6 | Turbidity | ✓ | ✓ | ✓ | ✓ |
| 7 | Residual chlorine | ✓ | ✓ | ✓ | ✓ |
| 8 | Boron content | ✓ | ✓ | ✓ | **--** |
| 9 | Langelier Saturation index | **--** | **--** | ✓ | **--** |
| 10 | Oxidation-reduction potential | **--** | ✓ | **--** | **--** |
| 11 | Alkalinity | **--** | **--** | ✓ | **--** |

Monitoring through Online Analysers of all the above parameters and any other important parameter as needed, shall be provided, and the real-time readings will be obtained.

Auto Samplers shall be provided at all sampling locations to collect 24 hourly composite samples for analysis in the plant laboratory.

## General Requirements

The Contractor shall provide all necessary services to complete the plant construction Works and to make a fully working plant as per the Employer’s Requirements; these services may include:

* All necessary design as well as all necessary inclusions/accessories to provide a complete and operating system irrespective of whether or not all items are specifically mentioned in the specifications or drawings. All materials offered must be suitable for the environment at the plant site in Perur, Chennai and suited to their duties.
* Equipment identification and pipe markings to clearly identify all components for installation, operation and maintenance purposes.
* Platforms, stairs, handrails, and supports to allow safe access to all equipment, tanks and instrumentation requiring inspection, maintenance or calibration.
* The equipment shall be sited in an indoor environment and will not be subject to exposure. Manufacturer’s standard painting systems shall be considered suitable if approved by the Employer.
* Erection of all the items, equipment, instruments and other accessories to form a complete functional water treatment plant system capable of performing all the duties required by these specifications and any additions that Contractor needs to provide for a complete functional seawater desalination plant with sludge treatment facilities.
* Contractor shall provide easily accessible water quality sampling points, on each process tank inlet line and/or outlet line, as required by the Employer. Convenient means shall be provided including all interconnecting pipework, sampling pumps and taps, adequate sink and drainage as required to obtain samples manually and locally from all tanks and inlet/outlet lines. Each sampling point shall be provided with an outlet convenient for the collection of samples for laboratory testing and the connection of a portable quality measuring meters.
* Noise levels shall be contained by the appropriate equipment design. Acoustic enclosures should be used only if other appropriate engineering measures are not practical. Noise at t**he steady-state operation at peak capacity, start up, and shutdown shall not exceed 85 dB (A) for the blowers and compressors and 65 dB(A) for the pumps.**
* Freeboard in new units shall generally be not less than 500 mm. Freeboard if necessary, shall be higher such that in the event of excess flow (flow up to +25%) no overflow takes place and marginal freeboard up to 25 mm shall remain. Freefall shall be kept adequate and meet criteria that in the event of excess flow up to +25%, marginal free fall up to 10 mm shall remain.

The specifications under General Requirements shall be read in conjunction with the specifications provided for specific discipline of the works elsewhere in the contract. In the event of any conflict between this and requirements elsewhere in the contract, the most stringent specifications for the parts, equipment and works shall apply or as per the consent of the Engineer.

### Service Water System

The Contractor shall construct a plant service water system. The service water storage tanks shall be provided over chemical buildings and sludge treatment buildings for chemical makeup/preparation, inline chemical dilution and chemical laboratory. The service water shall be fed by duty/standby service water pumps located at RO permeate tank. The storage tanks shall provide at least one-hour storage of service water at average usage rates.

The product water shall be used from the product water tank for the following services:

* housekeeping
* emergency showers and eyebaths in the chemical building, sludge dewatering building, laboratory, chlorination buildings and any other locations
* fire-extinguishing system
* cleaning and flushing
* domestic water system – administrative and all other area/buildings at the plant premises.

Product water storage tanks of RCC shall be provided at all the buildings where there is the frequent use of service/product water. All service connections shall be provided with isolation facilities to permit work to be carried out at one point of supply without affecting other users. Independent power and control panels shall be provided for the service water systems. Status annunciation shall be carried out using discrete indicator lights located on the pump starter enclosures.

The following alarms shall be provided at the control panel and the central HMI.

* duty pump failure
* system failure (i.e. both pumps failed or a similar occurrence which prevents the system from working)
* storage tank high level

### Piping, Pipe Fittings and Valves

The pipes, fittings and valves shall meet the following:

* All process pipework including valves, fittings, and accessories shall be fabricated of and jointed by materials unaffected by and compatible with the conditions of service anticipated.
* All piping shall be designed based on the maximum anticipated flow rates. In general, the pump suction line shall be designed for the maximum velocity at 0.9 m/s and the discharge line at 1.5 m/s. The velocity in other pipes shall be about 1 m/s.
* Pipe, fittings, and valves shall be made of suitable corrosion-resistant material for the purpose of use. Control valves shall be Type 316L stainless steel or other comparable corrosion-resistant material and be tight shutoff and flanged with pneumatic actuators. Actuators shall fail to a safe position.
* All pipe spools shall be factory tested per current requirements. Piping larger than two inches in diameter shall be flanged.
* Instrument lines shall be Type 316L stainless steel unless the fluid requires a more resistant material.

### Dismantling Joints

Dismantling joint shall be provided for ease of erection and dismantling of pump/valves/ flowmeters. The body, counter flanges shall be of Ductile Iron / Cast Iron. Bolts and Nuts of the joint shall be of stainless steel. The joint must allow the dismantling of the valve, pumps, meters, etc., without causing stress to the joints of the attached pipes. The pressure class of the dismantling joint shall be the same as that of the pipe and valve. The seal of rubber shall be NBR. The axial flexibility of not less than 25 mm, and the radial flexibility of minimum 2mm shall be provided. It shall be double flanged with a collapsible arrangement. Flanges shall conform to the flanges of connecting pipe/valve. Dismantling joints on pump delivery and pumping mains shall be subjected to a hydrostatic test pressure of 1.5 times the delivery pressure. Detailed drawings of the dismantling joint shall be submitted to the Engineer for approval. The joints shall be painted with corrosion-resistant coating as per specification given for exposed pipes.

### Conveyance Channels/Overflows

The arrangement of all conveyance channels and drain piping inter-connecting the units shall ensure that the units will be capable of taking maximum flow. During emergency conditions, excess flow shall be directed to drain until control is regained in order to avoid flooding and protect the various structures. Based on the same, overflow arrangements shall be made at all units and structures where required.

All overflows will be sized for the maximum flow. Overflows will be discharged by gravity to Plant Outfall tank.

### Intercom System

An intercom system shall be provided between the following points within the treatment plant:

* control room
* pump and compressor room with the adjacent main distribution panel room
* laboratory
* chemical buildings
* chlorine buildings
* sludge treatment building
* electrical/ MCC rooms
* Seawater intake facility
* RO building
* Pump stations including backwash pump rooms
* Security Guard House
* Administrative building

### Chemical Laboratory

The Contractor shall provide a well-equipped chemical laboratory with new meters/equipment to analyse all the required water quality parameters, including the following chemical and bacteriological routine analyses:

* temperature
* pH
* conductivity
* alkalinity
* turbidity
* suspended solids
* total dissolved solids
* residual chlorine
* ammonia
* nitrate and nitrite
* phosphate
* e-coli counts
* BOD/COD
* Oil and grease
* TOC Analysis – based on combustion method
* All relevant cations and anions

The Contractor shall supply an advanced multi-analysis kit with chemical reagents and equipment for batch tests on coagulation and flocculation (Jar test simulator). In addition, the Contractor shall provide the laboratory test glassware such as burette, auto-pipette, flask, beakers (of 25 to 500 ml capacity), graduated cylinders of varying sizes and other equipment and reagents for above chemical analyses. The testing methods shall be as simple as possible and the equipment as robust as possible. The Standard methods shall be described in a Test Manual.

### Integrated Security System

#### General

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 specification shall be read in conjunction with the specifications provided in Chapter 9, ICA Requirements and elsewhere in the contract. In the event of any conflict with the requirements elsewhere in the contract, the most stringent specification shall apply or as per the consent of the Engineer shall be obtained.

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 the correct response to any if detected. The Integrated Security System (ISS) shall comprise following discrete systems:

1. CCTV Surveillance System
2. Access Control System
3. Identity Management system
4. Security Control Point
5. Public Addressing System
6. 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.

#### 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:

1. 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.
2. Intrusion Detection & Assessment System (IDAS) based on CCTV system, other trending and proven technologies if any shall be proposed by the contractor.
3. 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.
4. Identity Management System (IDMS) in line with the Access Control System with computer-based security system for ID badge, security administration, event/alarm management, recording of all the information, etc.
5. Integration with public address and telephone.
6. Security Control Centre (SCC) including all security equipment.
7. All programmable equipment must be supplied with software, hardware communication protocol and documentation and necessary licenses.
8. Cable, cable trays, conduits, channels and related accessories as required.
9. 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.
10. Complete design and installation
11. 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.
12. Training for the operation and maintenance of the system
13. Commissioning of the system
14. Preparation of the complete project documents such as wiring diagram, as built drawing and factory acceptance test reports.

### Machine, Equipment & Tools for Workshops

The Contractor shall construct one workshop and one warehouse of metallic structures– and supply the minimum equipment and tools listed in the table below for the workshop. The machine, equipment and tools supplied shall be used for the maintenance of the plant. The Contractor shall arrange for any machine, equipment and tool required for his use in the operation and maintenance of the plant during the O&M Contract. At the end of the contract, all machines, equipment and tools shall be handed over to the Employer in good working condition. In case the machines, equipment and tools are worn out and not in its original operating/ performing condition, new machine, equipment, or tool shall be provided by the contractor.

**Table ‎3‑25: Heavy Duty Machines for Workshop**

| **S. No.** | | **Description** | **Quantity** |
| --- | --- | --- | --- |
|  | **Heavy duty high speed lathes, 250 mm centre height, 1500 mm** between centres including main spindle with taper roller bearings, bed with gap, hardened bed ways, complete with electrical equipment, including motor, motor protection switch, lead screw with metric pitch, longitudinal feeds and cross feeds, screw cutting without gear change, metric threads, inch threads, module threads, change gear with accessories, universal faceplate, stationary and travelling steady, coolant supply equipment, complete with electric pump, contactor and switch and machine lamp attachment. | | 1 |
|  | **Heavy duty high speed lathes, 200 mm centre height, 1500 mm** between centres including main spindle with taper roller bearings, bed with gap, hardened bed ways, complete with electrical equipment, including motor, motor protection switch, lead screw with metric pitch, longitudinal feeds and cross feeds, screw cutting without gear change, metric threads, inch threads, module threads, change gear with accessories, universal faceplate, stationary and travelling steady, coolant supply equipment, complete with electric pump, contactor and switch and machine lamp attachment. | | 1 |
|  | **Heavy duty high speed vertical lathes**, 2000 mm table diameter, working piece diameter 2300 mm, working piece height 1400 mm, working piece weight 20000 kg, with accessories | | 1 |
|  | **Horizontal boring, drilling and milling machine**, work spindle dia.100 mm, self-acting traverse of spindle at one setting 700 mm, with standard morse taper, clamping surface of table 1000 x 1200 mm, maximum distance between faceplate and steady 2800 mm, speed step less adjustable, table feeds endwise and crosswise, spindle head feeds up and down, with rapid travel, for metric threads, inch threads, including motor and motor protection switch, and standard accessories | | 1 |
|  | **Surface grinding machine wet grinding**, grinding wheel diameter/ width 250/25 mm, distance table to centre of spindle approx. 500 mm, table clamping area 900 x 250 mm, steeples adjustable including electrical equipment with motor and standard accessories | | 3 |
|  | **Column grinder**, with 2 wheels 300 x 40 x 76 mm for wet grinding, left hand side with normal rest, right hand side with adjustable workpiece support table and angle stop, with graduation in degrees for grinding tools, articulated machine lamp, 2 eye protection shields with mountings, complete with electric motor, motor protection switch and standard accessories. | | 2 |
|  | **Universal milling machine**, table size 1300 x 400 mm, steeples feed drive in all three table directions, longitudinal travel of table 1000 mm, cross travel of table 340 mm, chip tray, second counter support head, centralized lubrication for all three movements, main spindle drive, motor protection switch , accessories, vertical milling head with stepless V-belt drive and separate motor, including overarm adjustment, universal dividing head, machine lamp, milling arbors, cutter arbors, taper sleeves, cutter chuck, collets for above. | | 2 |
|  | **Vertical milling machine**, table size 1900 x 400 mm, steeples feed drive in all three table directions, integrated automatic lubricating system, cooling system, main spindle drive, motor protection switch , controls integrated on panel, accessories. | | 1 |
|  | **Heavy duty high speed shaping machine**, 725 mm ram stroke, 725 x 340 mm table size, shaping width 600 mm, complete with electric motor equipment, automatic vertical feed of the tool holder, main switch, motor protection switch, rotary concentric machine vice, with standard accessories. | | 1 |
|  | **Screw threading machine**, with solid steel frame, including pole- changing 3-phase motor for pipe and whitworth thread from 1/4 to 2", metric threads M6 to M52, with motor protection switch and standard accessories. | | 1 |
|  | Heavy duty power hacksaw, fully hydraulic 4 stroke, cutting range in round material 225 mm, for mitring from 450 mm, complete with electric motor equipment, stock support 500 mm high with heavy material Toller, accessories. | | 2 |
|  | **Heavy duty circular column drilling machine**, drilling capacity in steel up to 35 mm, in cast iron up to 45 mm, 350 mm column-spindle distance, column diameter approx. 160 mm, stepless, with at least.3 kW electric motor, motor protection switch, coolant supply pump, accessories. | | 1 |
|  | **Bench drilling machine**, drilling capacity in steel up to 10 mm, radius 200 mm, with high-capacity high-speed chuck to 10 mm, adjustable rectangular table, drilling depth 60 mm, column diameter 70 mm, base plate 170 x 170 mm, complete with electrical equipment and motor, motor protection switch and standard accessories. | | 2 |
|  | **Electric pipe bender**, complete with all necessary tooling required for cold bending heavy gauge steel pipe of up to 100 mm inside diameter to the smallest radic possible, limited only by the pipe bore and wall thickness, without flattening. | | 2 |
|  | **Universal folding press**, for hand operation, including base frame, for 3 mm plate thickness, 2000 mm working width, 45° angle bar, 3 mm rad. round bar, steel rail for the bending beams, accessory holders with standard accessories. | | 2 |
|  | **Combined plasma welding and metal cutting set**, cutting range from 2 to 25 mm in steel, provisions for connecting to argon, nitrogen or hydrogen gas bottles complete with welding and manual cutting torches, pressure regulators and one year's supply of welding rods and gas bottles. | | 2 |
|  | **Mobile work benches 1500 x 700 mm surface area**, suitable for containing one set of mobile work bench tools each. | | 2 |
|  | **Steel tool cupboards 500 x 500 x 1000 mm high**, including 125 mm leg height, with upper steel drawer and two removable trays, door latch for padlock, including lock. | | 4 |
|  | **Steel tool cupboards with double doors, 1000 x 500 x 1000 mm high** including 125 mm leg height, with centre partition, each side separately lockable with two steel drawers and two removable trays, door latches for padlocks, including padlocks. | | 6 |
|  | **Work benches with 1500 x 700 x 50 mm** plywood top, backboard, angle iron supporting frame, one steel plate drawer, with safety lock and two keys, one shelf underneath of extra strong construction, with six (6) all-steel parallel vices, 150 mm jaw width with bolts for through attachment to the benches. | | 10 |

**Table ‎3‑26: General Equipment and Tools for Mechanical and Electrical** **Workshop**

| **S. No.** | **Description** | **Unit** | **Qty** |
| --- | --- | --- | --- |
|  | Vertical drilling machine | Nos. | 2 |
|  | Hacksaw machine | Nos. | 2 |
|  | Bench Grinder | Nos. | 2 |
|  | Miscellaneous items and hand tools with safety equipment | Nos. | Lot |
|  | Toolboxes | Nos. | 10 |
|  | Portable Noise level tester | Nos. | 4 |
|  | Portable vibration tester | Nos. | 4 |
|  | Magnetic base dial gauge | Nos. | 4 |
|  | Portable temperature meter | Nos. | 4 |
|  | Filler gauge | Nos. | 4 |
|  | Precision spirit level | Nos. | 4 |
|  | 415V, 3 phase, 50hz, 40kVA portable DG set (trolley mounted) including all necessary metering & protection unit, battery, manual control panel, plug & socket, etc., with cable and accessories. Acoustic enclosure which complies with all environmental regulations shall be included as a part of the supply. | Nos. | 2 |
|  | Toolbox with all necessary tools fixed spanner, ring spanners, screwdrivers, adjustable jaw spanners, etc. | Sets | 5 |
|  | Hand trolley (500kg capacity) | Nos. | 4 |
|  | Tripod with chain pulley blocks of 1 Ton capacity (6.0m legs) | Nos. | 4 |
|  | Welding set, 400 amp, three-phase regulator type, air-cooled, wheel mounted with 15 m welding cable, 2 m. welding cable for earthing, one welding holder, one welding screen with glass and 3 cable lugs, one pair hand gloves and one wire brush | Nos. | 2 |
|  | Portable hand drill (heavy duty) of capacity 13 mm to 23 mm with ½” drill chuck but with drill bits and drill stand | Nos. | 4 |
|  | Tong tester, 1000 Amp | Nos. | 4 |
|  | Hand crimping tool with dies suitable for cable joining up to 95 sq. mm. | Nos. | 2 |
|  | Hydraulic crimping tool, suitable for cable joining from 25 to 400 sq. mm. | Nos. | 4 |
|  | Hydraulic jack, 5 Ton capacity | Nos. | 4 |
|  | De-watering pump sets of 5 kW with 50 meters hose pipe | Nos. | 4 |
|  | Motorized and handle operated insulation resistor tester, 5 kV (multi-range setting), with battery pack | Nos. | 4 |
|  | Handle-operated insulation resistor tester - 1000 Volts | Nos. | 4 |
|  | Megger, 1000 volt | Nos. | 2 |
|  | Megger, 5000 volts (motorized) | Nos. | 2 |
|  | Insulating oil tester and filter | Nos. | 2 |
|  | Hand grinder (Angle 7”) | Nos. | 2 |
|  | Clamp-on Digital Meter (0 - 1000 Amperes) | Nos. | 2 |
|  | Multi-meter (Digital) | Nos. | 2 |
|  | Micro-Ohm meter | Nos. | 2 |
|  | Portable vacuum cleaner/blower (industrial type) | Nos. | 4 |
|  | Aluminium folding ladder - 8 meters | Nos. | 4 |
|  | 4 terminal Earth Tester (digital) | Nos. | 4 |
|  | Rubber gloves (110 kV rating) | Sets | 12 |

The contractor may use all the above machine, equipment and tools for the maintenance of the plant. He may employ other tools and equipment for fitting, welding or blacksmith workshop and also for tin smithing, carpentry, mobile tools/equipment, any other mechanical/ electrical/ I&C tools or painting and gardening tools/equipment. At the end of the operation and maintenance period, the Contractor shall turn over all such machine, equipment and tools in good serviceable condition to the Employer.

### Heating, Ventilation and Air Conditioning

#### General

The works described in the following section shall include for the heating, ventilation and air-conditioning (HVAC) systems, including all details, accessories, electrical and other associated services, etc. required for the complete installation and satisfactory operation of the whole systems, whether these details are specifically mentioned in the specifications or not. The Contractor shall supply all necessary HVAC equipment with the consent of the Engineer that may be required at the buildings under the Specification of this Contract. The specification shall be read in conjunction with the specifications provided in Chapter 7, Mechanical Requirements and elsewhere in the contract. In the event of any conflict with the requirements elsewhere in the contract, the most stringent specification shall apply or as per the consent of the Engineer.

The performance shall be in strict accordance to the latest standards recommended by American Society of heating, refrigerating and Air-conditioning engineers, Inc. (ASHRAE) and to the best engineering Code of Practice and to the relevant requirements of the CMWSSB.

The supply shall include – but not be limited to – all auxiliary work and material necessary for the complete plant ready for satisfactory operation, including:

* AC and refrigeration equipment
* Air Handling Unit
* Packaged Air Conditioner
* Split AC unit
* Pipe work
* Paint work and surface treatment
* Electric/electronic installation
* Electric cabling to motors, heaters, control equipment, distribution and control boards and the connection thereof
* Insulation work
* Commissioning and hand-over to Employer

#### Specific Impositions

1. All equipment shall be designed for marine environment.
2. The supply air temperature into occupied rooms and other air-conditioned areas shall not be more than 10º C below the design room temperature.
3. No return air shall be taken back into the system from battery rooms, or from any other polluted rooms.
4. Battery rooms shall be provided with a 100% run / standby forced air ventilation system, as a back-up to the main air-conditioning system in order to maintain a negative pressure at all time. If lead batteries are used, then all ventilation equipment shall be explosion proof.
5. Adequate spare capacity and standby plant (chillers, Air handling Units (AHU’s), pumps etc.) shall be provided for systems serving control rooms, computer rooms, electronic rooms, relay rooms, communication room, switchgear rooms and any other areas where failure of any air- conditioning plant will affect the performance (≤50 TR) shall be 100%, i.e. 1 run + 1 standby.
6. For “larger” systems (>50TR) a partial standby capacity shall be provided, i.e. 2 or 3 run + 1 standby, etc.
7. Above standby criteria applies to air conditioning units, fans, blowers, pumps, drives, etc.
8. Bidder should ensure that HVAC loads are optimized and included in power source.
9. Additional extract fan shall be provided for toilets of air-conditioned buildings and a minimum of 10 air changes per hour shall be provided.
10. All cable basements shall be ventilated via a forced air ventilation system with 50% spare capacity standby plant.

Each air conditioning, ventilation and heating plant shall be a self- contained, functionally reliable unit, which shall be suitable for the appropriate building, with respect to performance and choice of system and also with respect to the spatial arrangement, the dimensions and the weights, as specified to suit the building and its purpose. It is therefore expressly required that reference shall be made to the appropriate building drawings in addition to this specification.

Furthermore, all the information regarding the nature of the building, the size of the windows, geographical directions etc., necessary for determining the external cooling loads, shall be taken from the building drawings.

The internal cooling and heating load shall be determined by the anticipated number of occupants, as well as the equipment to be installed.

For the refrigeration only air-cooled chillers or air-cooled condensing units shall be provided. Pipework from the chillers or condensing units to the air handling units shall be regarded as part of the refrigeration system.

For the purpose of providing the “basic cooling load” for the project, air-cooled chillers including stand-by units shall be positioned in the “central chilled water plant”, together with the required chilled water pumps, chilled water pressurization & make- up unit, as well as “automatic chemical dosing equipment for maintaining the necessary chilled water quality.

Separate plant rooms/areas shall be provided for the air handling and ventilation equipment. Alternatively, this equipment may be placed on the roof, or at ground level next to the respective building. In this case, the equipment shall be fitted out for “tropical outdoor installation”.

All equipment shall be placed in such a manner that sufficient space (as recommended by the manufacturer) is available for servicing and maintenance.

Isolated or geographically remote guard houses, etc., may be served via independent DX-systems.

Control rooms shall be served via precision systems for full control of temperature and humidity.

The Contractor is fully responsible for the exact calculation and the dimensioning of the air conditioning and ventilation systems as well as for the installation works at all buildings in the plant and getting approval for the requirements from the Engineer.

All ventilated or air-conditioned buildings shall be pressurized by supplying more air (approx. 15%) into the building than extracting from it.

Air conditioning shall be provided for:

* All buildings or rooms in which waste heat occurs which is not removed by other means and where, due to the installed equipment, temperature limitations exist, for example switchgear, control gear rooms, battery rooms, control rooms, etc.
* All the buildings or rooms intended for human occupation whether for working, living or assembly purpose. Offices, assembly hall, etc. are examples of this type of buildings such as administrative, computer laboratory etc.

For the above, the air conditioning includes filtering, cooling, heating, humidification and de-humidification of the supply air and the supply of fresh air.

Ventilation shall be provided for:

* All the buildings or rooms in which waste heat occurs which has to be removed but where temperature ranges do not necessitate air conditioning, for example Workshop, machine hall, pump rooms etc. Air washers using the principle of evaporative cooling shall be provided for ventilation of these rooms.
* All washing and changing rooms (if existing) which are occupied only for a short period of time, where air conditioning is not necessary and the like, to the extent necessary with regard to the nature of the work or of the materials stored.

Suitable facilities for smoke release (in case of fire) shall be provided for all control, relay, electrical, cable rooms, cable ducts, etc.

No window or mini-split units shall be installed in buildings where central air conditioning units supply other parts of that building.

### Fire Fighting System, Detection & Alarm System

#### General

This section of the specification describes the technical requirements for the Fire Fighting System for 400 MLD SWRO Desalination Plant and covers the minimum requirements for design, engineering, manufacture, erection and inspection and testing. The specifications in this section shall be read along with the specifications in Part-2 Chapter 7 & 9 and elsewhere in the contract. In the event of any conflict between the requirements in the contract, the most stringent specification shall apply or as per the consent of the Engineer.

The Fire Fighting System consists of Fire Protection System and Fire Detection System.

The Fire Protection System equipment shall be complete in every respect and suitable for safe and reliable operation.

Preferably, the whole firefighting 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.

However, installation and testing of equipment shall remain under the scope of the individual packages.

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.

Firefighting system covers the whole area of 400 MLD SWRO Desalination Plant site, where required duty has to be performed.

Fire protection system shall cater for all potential risks from fire and provide correct response to any fire detected.

Automatic and manual extinguishing systems operation is anticipated.

#### Fire Fighting and Detection System Description

The SWRO Desalination Plant shall be designed and built with provision of a safe operating environment for equipment and personnel. This shall be achieved by separation and segregation of equipment with sufficient distances and by selection of suitable equipment and materials.

Hazardous areas shall be identified, and suitable equipment shall be selected for use in such areas. Different firefighting systems shall be adopted according to the operational characteristics of the particular plant areas and buildings to be protected.

The firefighting protection and detection systems for the Desalination Plant, including the diesel storage tank and buildings shall be designed in accordance with NFPA codes, International Building Code (IBC) and International Fire Code (IFC).

**Table ‎3‑27: Main Areas for Fire Fighting Protection**

|  |  |  |  |
| --- | --- | --- | --- |
| **S. No.** | **Building/Area/ Equipment** | **Fire Fighting Installations** | **Detection Systems** |
|  | Intake pump station | Indoor hydrants. Portable extinguishers. | Smoke detectors. Automatic fire alarm system and manual fire alarm stations |
|  | Potable/permeate Water Pump Station | Indoor hydrants. Portable extinguishers. | Smoke detectors. Automatic fire alarm system and manual fire alarm stations |
|  | Chemical Buildings | Manual water spray system and indoor hydrants. Portable extinguishers. | Smoke detectors. Linear heat detectors. Automatic fire alarm system and manual fire alarm. Gas detector. |
|  | Chemical Stores | Automatic water spray fixed system and indoor hydrants | Smoke detectors. Linear heat detectors. Automatic fire alarm system and manual fire alarm |
|  | HV, MV, LV Switchgear Buildings housing switchgear.  Electrical Buildings-RO building | NOVEC systems designed as per NFPA 2001 or a comparable and suitable system | Smoke detectors. Automatic fire alarm system and manual fire alarm stations |
|  | All Oil Filled Transformers | Automatic water spray fixed systems, Portable extinguishers and CO2 extinguisher. | Fusible bulb/quartzoid bulb as well as sprinkler head heat detectors. Automatic fire |
|  | Diesel Generator | Automatic foam/water spray fixed system and mobile 50 kg dry-powder extinguisher | UV/IR detectors. Smoke detectors. Automatic fire alarm system and manual fire alarm stations. |
|  | RO Buildings  DAF/DMF buildings | Automatic water spray fixed systems, Portable extinguishers | Automatic fire alarm system and manual fire alarm stations. Smoke detectors. |
|  | Workshop/ warehouse | Indoor hose reel. Portable extinguisher and CO2 extinguisher | Automatic fire alarm system and manual fire alarm stations. Smoke detectors. |
|  | Storage buildings (RO membranes, mechanical, etc.) | Automatic water spray fixed systems, Portable extinguishers | Automatic fire alarm system and manual fire alarm stations |
|  | Local Control, Computer, Electronic and Switchgear Rooms | NOVEC systems designed as per NFPA 2001. Portable extinguishers and CO2 extinguishers. | Smoke detectors. Automatic fire alarm system. |
|  | Cable Floors, Shafts and Tunnels, including 110 kV cable tunnels | Automatic water spray fixed systems | Smoke detectors for ventilated cable floors and tunnels. Linear heat detectors for non- ventilated cable floors and tunnels. Automatic fire |
|  | Battery rooms | Portable extinguisher and CO2 extinguisher | Automatic fire alarm system and manual fire alarm stations. Smoke detectors. |
|  | Administration Building / Engineering – Operation building / Laboratory/ computer building | Indoor hose reel. Portable extinguishers, sprinklers system | Smoke and heat detectors.  Automatic fire alarm system |
|  | All other buildings and areas | Outdoor hydrants and indoor hose cabinets | Manual fire alarm stations |

Any building or area which is protected by a “wet” firefighting installation must in addition be provided with an “external fire brigade connection”.

The “Siamese Breaching inlets” shall be housed in stainless steel cabinets with “wire glass” doors, located around the perimeter of the protected area.

They must be so placed as to allow ready access by the fire brigade tanker. Upstream of the above fire brigade connection, suitable non-return valves in the main and branch line must be provided, in order to facilitate pressurization of the “installation” from the 2 different sources.

Extinguishers shall be sized, rated and spaced in accordance with NFPA 10 and or equivalent IS code. Local buildings fire alarms, automatic fire detectors and the fire signalling panel shall be in accordance with NFPA 72 or equivalent IS code.

It shall be assured that a dedicated two (2) hour fire water supply to cover the system design flow rate is available for the facility in accordance with NFPA or equivalent IS code.

### Crane and Lifting Equipment

#### General

This section covers the minimum requirements for the design, engineering, manufacture, erection and inspection and testing of cranes and lifting systems. This should be read in conjunction with the requirements provided in Part-2 Chapter 7 & 8, and elsewhere in the contract. In the event of any conflict between the requirements elsewhere in the contract, the most stringent specification may apply or as per the consent of the Engineer.

Cranes and lifting equipment shall be complete in every respect and suitable for safe reliable and continuous operation.

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.

In addition, motor operated hoists and manual hoists shall be provided with runway girder where necessary for lifting purposes during maintenance works and where the equipment are not in the reach of mobile crane.

Cranes and lifting equipment are to be located all over in the buildings, structures and areas of the project site, where hoisting during maintenance and repair is required.

#### Scope of Works

This section sets out the scope of the equipment and services as well as specially requested supplies and services but it in no way excludes other necessary components and services not specifically mentioned herein.

The Contractor shall provide and supply the cranes and lifting equipment complete, including all necessary components, spare parts and services.

**Table ‎3‑28: Details of Cranes and Lifting Equipment**

|  |  |  |  |
| --- | --- | --- | --- |
| **S. No.** | **Location** | **Type of cranes** | **Manual/ Electrically operated; controlled** |
|  | Low pressure pumping station | Bridge Crane | Electrical; pendant switch |
|  | Filters backwash pumping station | Bridge Crane | Electrical; pendant switch |
|  | RO Building | Bridge Crane  (Two sides) | Electrical; pendant switch |
|  | RO Building (cartridge filters) | Bridge crane | Electrical; pendant switch |
|  | RO Feed pumping station | Bridge Crane | Electrical; pendant switch |
|  | Chemical Handling | Bridge Crane | Electrical; pendant switch |
|  | Service water and pumping station | Motor hoists | Electrical; pendant switch |
|  | Store buildings and workshop | Motor hoists | Electrical; pendant switch |
|  | Mechanical Workshop | Bridge Crane | Electrical; pendant switch |
|  | Submerged pumps with weight < 20 kg | Lift hoist | Electrical; pendant switch |
|  | Any other as needed | Bridge Crane/Motor hoist/Lift hoist | Electrical; pendant switch |

Scope of supply and services shall include the design, manufacture, construction, factory testing, packing for transport, transport and delivery to site, unloading at site, storing, complete erection, testing at site, painting, commissioning, putting into normal operation, reliability and performance testing of cranes and hoists and associated equipment including but not limited to:

* overhead travelling cranes
* motor hoist with trolley
* manual hoist
* runway rails and beams
* control, monitoring and electrical supply
* complete detail labelling of all installation
* consumables such as first fill of lubricants and greases
* set of special tools and equipment for maintenance, inspection and repair
* all standard equipment and accessories which are normally included in the supply schedule but which are not separately listed.
* detail design and calculation
* compiling and local collection of required data
* training, inspection and supervision services by the Manufacturer
* spare parts and wear-and tear parts
* complete documentation as specified
* numbering of all equipment
* test loads as required
* testing of all equipment as required by the regulation.

### Package Sewage Treatment Plant

Bidder shall provide a Package Sewage treatment plant for treatment of domestic sewage from toilets and Canteens at the plant premises building.

The minimum capacity of the plant shall be 13.5 KLD. The reclaimed water from the package sewage treatment plant shall be used for Landscaping and toilet flushing.

The required reclaimed water quality for reuse shall be as indicated below:

**Table ‎3‑29: Quality of the Treated Domestic Sewage**

|  |  |  |
| --- | --- | --- |
| **Parameter** | **Units** | **Minimum Outlet Parameter** |
| BOD | mg/l | <50 |
| COD | mg/l | <250 |
| Total suspended solids | mg/l | <100 |
| Total coliform bacteria | MPN / 100 ml | <100 (desirable) |
| Residual Chlorine | mg/l | 1 |

Bidder shall select a suitable treatment technology to treat the domestic sewage to meet the above-reclaimed water quality. All system shall be designed with equipment and materials suitable to withstand the saline environment. Bidder shall provide inlet and outlet Electromagnetic flowmeters for measurement of wastewater entering Package treatment facility and reclaimed water respectively.

Contractor to submit basic engineering documents of the packaged sewage treatment facility to the Employer for review and approval before execution.

## Quality Assurance

All equipment, materials and Works shall comply with the relevant Indian Standards. Where suitable updated Indian Standards are not applicable or appropriate as per the understanding of the Engineer, approved International standards such as BS 5750 or an equivalent shall be used.

### Policy

As per the Conditions of Contract of Part-3, the Contractor shall apply the formal requirements of Quality Assurance to the design, supply, construction and maintenance of the Works. This shall be achieved through the implementation of a Quality System compliant with the requirements of BS 5750 or an equivalent International Standard. A positive commitment to Quality Assurance shall be expressed in a formal policy statement given in the Contractor's Quality Manual and to be certified by an external certificate.

It shall be the stated aim of the Contractor to achieve and demonstrate the achievement of quality as expressed by `due care and diligence' of the design, supply, construction and maintenance of the Works as defined by the Employer's Requirements. The criteria to define `due care and diligence' shall be explained in the Contractor's Quality Plan and shall embody all of the design, supply, construction and maintenance requirements of the Works.

### Quality System

The Quality System shall be fully integrated for all of the Works. This system will be defined by the organisational structure, responsibilities, activities, resources, and events that together demonstrate the capability of the Contractor to meet the stated quality requirements. The Contractor shall ensure that all sub-contractors and sub-consultants establish quality systems and shall supply to the Employer such evidence as is necessary to demonstrate the effective implementation of a quality system in each subcontractor or sub-consultant organisation.

The Quality System of the Contractor and of his sub-contractors and sub-consultants will be subject to periodic audits undertaken by the Employer’s Representative. The Employer’s Representative will give one weeks' notice of such audits that will involve a full assessment of the performance and efficiency of the Quality System and will include review of the feedback and records derived from the Contractor's monitoring and internal reviews. On a day-to-day basis the Contractor shall afford reasonable availability of staff and documentation for the Employers Representative to assess the implementation of the Quality System. The Contractor shall ensure that all relevant personnel and documentation are available for such audits.

### Quality Assurance Plan

The implementation of the Quality System shall be through the establishment of a comprehensive Quality Plan issued to and approved by the Employer’s Representative. The documented procedures shall include but not be limited to:

- Management Procedures;

- Design;

- Manufacturing;

- Supply/Procurement;

- Construction;

- Putting to work/Commissioning/Reliability Trial/Performance Test;

- Operator Training and Maintenance;

- Interface Control;

- Quality Performance, Monitoring and Review.

There shall be procedures to control transmission of information across all interfaces both internally (that is, within the Contractor's Quality System) and externally. Those of the latter shall include all Statutory Bodies, Authorities and the Employer’s Representative. Formal assessment of any non-compliance with the Quality Plan shall be achieved through periodic reviews undertaken by a team appointed by the Contractor. All deficiencies shall be recorded and appropriate corrective measures shall be assessed, within an appropriate timescale, through subsequent formal reviews undertaken by the Contractor.

### Quality Feedback

The system shall include for the reporting back, recording and incorporation into the system of deficiencies noted during the control of the project.

## Environmental Protection

The Contractor shall minimize, as far as is practically possible, the effects of all his and his Subcontractors’ activities upon the environment and shall implement and monitor measures to prevent:

(a) Contamination of surfaces, ground, groundwater, surface water and rivers,

(b) Emissions to air, including smells, gases, smoke, and dust.

(c) Unsanitary or unsafe storage or discharge to drain, sewer and surface waters,

(d) Unsanitary or unsafe storage or discharge of solid wastes,

(e) Noise,

(f) Visual intrusion, and

(g) Excessive energy and water consumption.

These requirements shall be met through the constant and careful attention of the Contractor’s management of all Site and off-site activities, and by instruction to all staff and labour in these matters.

The Contractor shall appoint an Environmental Control Manager for the Works, who shall be responsible for preparing an Environmental Management Plan and ensuring its implementation by the Contractor after obtaining approval of the Engineer.

Implementation shall include for monitoring and reporting on the results of the above measures. Monitoring reports shall be in writing and submitted on a monthly basis as part of the monthly report referred to above. The report shall include a listing and summary of daily monitoring results on all aspects listed above.

All potentially affected areas of the Site, other areas used for or affected by the works and all adjacent or affected waterways shall be monitored and, where instructed by the Engineer, tested.

The Environmental Management Plan (EMP) shall identify the potential environmental impacts from the various construction and operations and maintenance activities to be undertaken in the Contract and set out in detail the approach be adopted in mitigating these environmental impacts to ensure that the residual impacts are minor and confined to a short period. The details of the EMP is provided in Chapter-15, Part-2.

The EMP shall consider but not be limited to the following:

* The methods of materials delivery, storage, usage and disposal; equipment usage; and site activities to ensure they have minimal impact on the environment,
* Only environmentally safe products and practices shall be adopted in performing his works, and
* The Contractor shall comply with all of the statutes regarding environmental effects.

The EMP shall provide separate descriptions of its proposals for minimizing any adverse environmental impacts/effects during the construction phase and the subsequent operations and maintenance phase. The contractor to prepare a comprehensive Environmental Monitoring plan (EMoP) during construction and operation phase.

The EMP and EMoP shall be provided in draft form within 28 days from the Notice to Commence and shall be updated from time to time by the Contractor as agreed or required by the Engineer to ensure the objectives of environmental protection are fully met.

## Safety at Site

The Contractor shall prepare a Safety Plan and submit the same to the Employer’s Representative for review within 28 days of signing of Contract Agreement. The Safety Plan shall be followed at all times by the Contractor and shall contain adequate control measures, in accordance with the relevant protection of property and local laws and regulations as well as internationally accepted good practice, for the prevention of accidents, fires and public nuisance. The Safety Plan shall be implemented properly and diligently throughout the execution of the Works and during the operations and maintenance period.

Contractor’s Safety Plan shall make safety provision for, among other things:

(a) Offshore works.

(b) The deep excavations and collapsing sides in trench excavations,

(c) Scaffolds and overhead working,

(d) Working in confined spaces,

(e) Working in seawater/water,

(f) Contractor’s Equipment, especially cranes,

(g) Handheld power tools,

(h) Electrical equipment,

(i) Hazardous chemicals, gases and fuels,

(j) The use of protective clothing, and noise protection

(k) The provision of first aid facilities

The Safety Plan shall be developed to ensure zero fatal accidents and zero hazardous incidents/occurrences in all construction works. The Safety Plan shall include descriptions of the company’s standard policies and procedures regarding its site organization and procedures, methods and frequency of conducting safety audits at the Site(s), record keeping and reporting, providing safety training for its personnel (including subcontractors), issue and mandatory use of safety equipment, and details of the qualifications and experience of the Bidder’s proposed Health & Safety Engineer to be deployed at the Site(s). The Contractor shall provide separate descriptions in its Safety Plan covering the construction phase and the subsequent operations and maintenance phase.

The Contractor shall appoint a Full-Time English-speaking Health & Safety Engineer for the Works having experience in this field, who shall be responsible for implementing the Safety Plan. He shall be supported by at least two safety officers who are qualified for such safety works, out of which at least one should be well versed/ have complete knowledge of Hindi and Tamil. The Contractor shall ensure that his staff and labour and his Subcontractors are all fully trained in and aware of good and safe working practices. The Contractor shall ensure that all precautions are taken to safeguard the general public and construction/operating staff from any danger.

All temporary and partially completed works shall be protected by way of barricading, lights, notices and the like. Proper lighting shall be placed for offshore works while jacking through the shore. All excavations and the like are to be protected by barricades at all times and adequately illuminated at night. Warning and diversion signs concerning roadwork shall be suitably placed to give motorists ample warning. During the movement of heavy vehicles across roads or onto roads, men, bearing red flags, shall be in attendance to warn other road users and to generally control traffic safely.

The Safety Plan shall also consider requirements for warning and protection for other risks including overhead and underground cables, pipes or obstructions, or voids, openings, pits and trenches. The Contractor shall ensure that all appropriate measures are implemented. The Safety Plan shall include a policy statement signed by the CEO or equivalent authority of the Contractor declaring that safety and loss prevention shall be given the highest practicable priority in all aspects of the Contract. The Safety Plan shall be updated as necessary to cover the activities to be undertaken for operations and maintenance.

## Risks or Hazards

The major risks anticipated in the desalination facility are Fire, explosion, toxic release and natural calamities like Cyclone, Flood, Earthquake and Tsunami. Fire would result from Storage vessels which stores chemicals. Explosion is another risk which primarily depends on the rate of which the energy is released. It could result in thermal effects, missile effects and injury to personnel. Toxic release of chemicals is another major risk where the release in form of gas or vapour can pose a major hazard if proper care is not taken into consideration. The risk due to toxic release primary depends on the duration of exposure which ranges from sudden exposure at high concentration to a prolonged exposure at lower concentration.

Natural disasters viz. cyclones striking the project area could not be ruled out. All equipment and buildings in the desalination facility are to be designed in such a way that withstands to maximum wind speed during cyclones. The storm surge of 1.3 m height has been predicted for a cyclonic wind speed of 180 kmph for this region. As the project area is required to be elevated and the impact may not be severe.

Although earthquake is not a regular phenomenon, the possibility of its occurrence cannot be ruled out. Earthquakes will pose a major risk to the equipment/ buildings and pipelines, life of personnel and environment. The effect of earthquake includes ground lateral displacement, ground shaking and ground uplift, ground uplift, ground settlement, soil liquefaction and fires.

The risk associated with flood are water entering the desalination facility/ process units, danger to life of operating personnel and outbreak of epidemic and other contagious diseases. Flood warning systems from the local meteorological department on flood warning and specific actions to be taken during those occasions are to be considered in the Disaster control preparedness plan.

The occurrence of a Tsunami along the Indian coast is an extremely rare event with a very low frequency of less than once in 500 years. One worst Tsunami occurred on 26th December 2004 along the Tamil Nadu coast and the destruction was more near the project region. The project region is located on the notified area of Tsunami impact, as the offshore tectonic plates are alive in Andaman Island. The presence of sand dunes (> 3 m) on the coast may to some extent, dissipate the strength of tsunami but cannot totally protect from tsunami run-up.

A detailed Disaster Control Preparedness Plan to be prepared by Contractor considering multidisciplinary approach by involving government agencies at Central and State level, Fire services, Civil defence, Medical, Police, Army, Voluntary organisations etc. This plan is required to provide guidance to stakeholders to take appropriate action to prevent accidents involving hazardous substances and to mitigate adverse effects of accidents that do nevertheless occur. This plan should cover both Onsite Disaster management plan as well as Offsite Disaster management plan.

## Standards

All work performed and equipment supplied shall comply with the appropriate standards, codes and legislative requirements.

Where there is an apparent ambiguity or conflict between any of the applicable Standards and this Specification, the Engineer shall be notified in writing whose decision shall be binding.Regulations, Laws and Permitting

The details of regulatory compliance requirements for the proposed Perur DSP project are furnished in the table below. The table below shall be considered minimum and not limited to:

**Table ‎3‑30: Regulations, Laws and Permitting**

| **S.**  **No.** | **Construction activity** | **Statutory authority** | **Regulatory**  **requirement** | **Implementation**  **responsibility** | **Supervision** |
| --- | --- | --- | --- | --- | --- |
| 1. | Intake and Outfall pipe laying, Pumping station and Desalination plant | Ministry of Environment and Forests and Climate Change (MoEF & CC) | Coastal zone regulations, 2011 | CMWSSB | --- |
| 2. | Construction of Desalination facility | Tamil Nadu Pollution Control Board (TNPCB) | Consent to Establish from State Pollution Control Board under Water Act 1974 & Air Act 1981 | CMWSSB | --- |
| 3. | Generation of Brine and Sewage, potential to emit air pollution (including but not limited to diesel generators and vehicles) | Tamil Nadu Pollution Control Board (TNPCB) | Consent to Operate from the State Pollution Control Board under the Water Act 1974 & Air Act 1981 | Contractor | PIU -CMWSSB |
| 4. | Generation of Municipal solid waste | Tamil Nadu Pollution Control Board (TNPCB) | Authorization under MSW (M&H) Rules 2016 | Contractor | PIU-CMWSSB |
| 5. | Noise generation | Tamil Nadu Pollution Control Board (TNPCB) | Noise pollution (Regulation and Control) rules, 2000 and its amendments, 2010 | Contractor | PIU-CMWSSB |
| 6. | Generation of Hazardous waste | Tamil Nadu Pollution Control Board (TNPCB) | Hazardous and Other Wastes (Management and Transboundary Movement) Rules, 2016 | Contractor | PIU-CMWSSB |
| 7. | Construction of Desalination facility | Divisional Fire Officer, Kancheepuram | NOC from Fire dept., Tamil Nadu Fire Service Act, 1985 | Contractor | PIU-CMWSSB |
| 8. | Intake and Outfall pipe laying, Pumping station construction | Tamil Nadu Maritime Board | Consent for the erection of offshore structure to be obtained Tamil Nadu Maritime Board as per Tamil Nadu Maritime Board Act, 1995 | Contractor | PIU-CMWSSB |
| 9. | Engagement of Labour | Office of the Labour Commissioner | - Labour license from labour commissioner office as per  The Contract Labour (Regulation and Abolition) Act, 1970.  The Inter-State Migrant Workmen (Regulation of Employment and Conditions of Service) Act, 1979 | Principal Employer – labour license | PIU-CMWSSB |

### Discharge Permit

The regulatory compliance requirements for proposed DSP are identified for the proposed Perur project, and they are related to waste management and disposal, and ambient noise pollution regulation and control is furnished in the table below. The Contractor is required to adhere to the condition of the discharge limit. It is in the scope of the Contractor to achieve the required permits with the help of the Employer.

**Table ‎3‑31: Discharge Permit**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **S. No.** | **Project Stage** | **Compliances/ Requirements** | **Remarks** | **Agency** |
| 1. | Construction/ Operational Phase | Consent to Operate from State Pollution Control Board under Water Act 1974 & Air Act 1981 | Statutory | TNPCB |
| 2. | Construction/  Operational phase | Authorization under MSW (M&H) Rules 2016 (State Pollution Control Board) | Statutory | TNPCB |
| 3. | Construction/ Operation phase | Noise pollution (Regulation and Control) rules, 2000 and its amendments, 2010 | Statutory | TNPCB |

## Plant Commissioning

### Commissioning Plan

The Commissioning Plan shall include:

* The sequence of commissioning activities, including interdependencies, durations and undertakings to verify the Completion of the Contract has been achieved
* Appropriate Risk Assessments for the proposed undertakings
* Inspection and Test Plans (ITPs) shall be submitted 30 days prior to conducting the tests/checks.
* Lists of equipment, plant, and systems to be commissioned, including the asset numbers allocated to them, and a schedule for commissioning them. These lists must be prepared at least two weeks before the proposed date of commissioning.
* Non-conformance and corrective action procedures
* Emergency and contingency procedures during commissioning activities
* A list of names of the members of the Contractor constituting the commissioning team formed to implement the Plan and their CVs and qualifications.

### Commissioning Team

The Contractor, along with the Employer’s Representative, shall form a commissioning team. The members of the Contractor constituting the commissioning team shall include, but not necessarily be limited to, the following:

* Contractor’s Representative(s) including the Commissioning Manager; Commissioning Engineer, Commissioning Specialists and equipment suppliers (if required).
* Nominated representative(s) of the Employer’s representative and PMC.

During commissioning, the Contractor shall coordinate the activities of the Commissioning Team. The Contractor shall provide the expertise necessary to commission the equipment, plant, systems and take measures, within the scope of this Contract, to complete the commissioning successfully.

### Stages of Commissioning

The plant commissioning and testings shall be read along with the Part-2, Section VI, Chapter-10 Inspection and Testing Requirements and the provisions in particular conditions of the Contract. The Contractor shall submit a detailed commissioning procedure for review and approval of the Employer’s Representatives. Typically, the commissioning shall be completed in four stages, followed by the Process Proving Test. These stages are:

1. pre-commissioning checks
2. dry commissioning
3. wet commissioning
4. initial performance tests
5. process proving

Total estimated period for commissioning and process proving is 6 consecutive months (180 days). The first three phases (i.e., pre-commissioning checks, dry commissioning and wet commissioning) shall be carried out in two and half months (75 days) and then initial performance testing shall be conducted in 15 (fifteen) days. After a successful initial performance test, the process proving shall be carried out for the consecutive 3 (three) months duration. During this period, the performance of all the process units, particularly the RO system, shall be evaluated. The propensity of the membrane fouling and the effectiveness of the CIP cleaning shall also be evaluated during the process proving test.

Tests and inspections, unless otherwise specified or accepted, shall be in accordance with the accepted ITPs, Inspection & Testing requirements (Chapter-10, Part-2) and relevant Indian standards.

All necessary resources to enable effective testing, including but not limited to all necessary labour, materials, equipment, and instruments, shall be arranged prior to the tests. Where equipment items or systems are duplicated in the design to provide ‘Duty’ and ‘Standby’ facilities, all items of equipment and/or systems of both the ‘Duty’ and ‘Standby’ facilities shall be fully tested in accordance with the suppliers’ requirements.

All relevant information and experience gained during these tests, including readings such as flow, noise, odour, vibration, power draw, etc. shall be integrated into the Installation Instruction and Operation & Maintenance Manuals, Standard Operating Procedures (SOPs), Unit Process Guidelines (UPGs) and work-as-executed drawings, including P&I diagrams.

The procedures within the Commissioning Plan shall define how non-conformances shall be managed and rectified. Should the equipment not perform the required function to the level of performance required by design during any test, such failure shall be deemed a defect, and the Contractor shall promptly initiate the non-conformance and corrective action procedures required by the Contractor’s Quality Assurance System.

A Commissioning Report shall be prepared at each phase of commissioning to demonstrate the assurance that all the activities associated with the commissioning phases have been successfully completed according to the relevant Standards as stated above and to the satisfaction of the Employer’s representatives. All Commissioning Reports shall be prepared within seven days after completion of each phase and submitted to the Engineer for approval.

All costs of the commissioning with the initial performance test and process proving tests including chemicals, power, equipment, spare parts, manpower and all consumables shall be borne by the Contractor. The bidders should include these costs in their price bids for the Works (Design & Build) Contract.

#### Pre-commissioning Checks

After completion of all mechanical and electrical installation, all equipment and instrumentation shall be inspected to verify that they are ready to operate. This includes checking that all bolts are properly tightened, safety guards fitted, no signs of damage are visible, lubrication has been completed, electrical point-to-point testing is successfully completed, operation certificates from statutory authorities are obtained, and generally everything has been checked in readiness for operation.

#### Dry Commissioning (offline)

After successful installation and pre-commissioning checks, all instruments where possible, including pressure differential transmitters, process analysers, and flow meters shall be field calibrated. Instruments which cannot be field calibrated shall be checked for accuracy in the field.

Once a written certification of proper installation has been issued by the Contractor, dry commissioning (functional testing) shall be initiated for all equipment. To perform the Functional Test, all valves, controls, and other devices shall be operated to ensure they are functional and ready for wet commissioning and performance testing. 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.

The purpose of the Dry Commissioning tests shall be to demonstrate, as a minimum, the effectiveness of the following system components and features:

1. Automatic and Manual START/STOP of all equipment using local panel and SCADA
2. Automatic backwashing at various time intervals
3. Automatic shutoff and alarm for various failure modes
4. Monitoring and recovery of operating data
5. Proper operation of the equipment and instrumentation systems
6. Monitoring and control from a remote workstation
7. Automatic switchover from normal power to emergency power, and emergency power to normal power
8. All control functions, both at local system and remote workstation
9. Operation of all monitoring instruments

#### Wet Commissioning (on-line)

Commissioning on-line shall commence with the approval of the Employer. Where practical, the process tanks shall be filled with water, and the control sequences shall be re-tested. A continuous operation of the component for a period of two days to the satisfaction of the Engineer will be deemed to demonstrate satisfactory completion of the wet commissioning of that component. The pre-commissioning checks, dry commissioning and wet commissioning period shall proceed for at least 75 consecutive days or as long as is required to establish the process and meet the required plant performance. As a minimum, the following shall be verified during on-line commissioning:

* Local and automatic operation of all equipment and protection systems
* Operator adjustable set-points
* Alarm initiation
* Demonstration of the system under equipment failure scenarios
* Verification of conformance to specified or guaranteed performance as far as is practical at the initial loading.

All the necessary adjustments and tuning shall be conducted until the water treatment plant functions as specified under operating conditions. Tests shall be carried out to verify that the water treatment plant shall operate under the full range of operating conditions, meet the performance requirements of the Contract and the design.

Start-up tests shall be conducted as part of the wet commissioning. The start-up test shall be carried out for each process areas across the plant, which verifies the completeness of the Plant and to all ancillary equipment, and of no known defects or outstanding works.

Upon successful completion of the start-up tests on the plant, trial run of the full plant shall be carried out for a period not less than 24 hours or as long required to confirm the operability of the plant with successful testing on the plant start, stop, switchovers, recovery change and varying production loads.

#### Initial Performance Testing

After the wet operation has been successfully proven and satisfactorily documented, and all necessary approvals are in place, the initial performance of the plant shall be tested. Successful completion of the Initial Performance Test shall be defined as 15 days of operation without a significant failure in the system and demonstration that system meets all performance requirements established herein. The Contractor shall operate the plant and collect and summarize data to demonstrate that the system meets the performance test requirements for production quality and quantity, pressure limitations, membrane permeate quality, and chemical and power usage.

A major failure in the system is one that fails to produce product water of the required quality or decreases production capacity below 97 per cent of design capacity for more than 24 hours due to equipment failure or any other reason even though the quality of the product water is maintained as required during the failure. If the inlet system/Lamella/DAF/DMF/RO system/ Limestone filter or any other system fails to perform successfully during the Initial Performance Test, the Contractor shall have the option to fix the problem and repeat the test for additional 15 consecutive days. If the system fails to successfully complete the Initial Performance Test during the second test period, the Contractor shall prepare a written plan within seven days for modifying the system to meet all test requirements. All the cost of this test and fixing the problem shall be borne by the Contractor. Moreover, the penalty for delay damage shall be levied as per the conditions of the Contract (Part-3).

Reports on the performance of the plant shall be provided every week to the Employer to demonstrate that the system meets the performance test requirements. The reports shall contain the following as a minimum:

* Automatic operation of the system
* Raw seawater quantities and qualities
* Water quantity and quality monitoring at Lamella Settler, DAF, DMF, RO, Limestone filters and Product water tank
* Sludge quality and quantity at thickener and BFP
* Other qualities of process importance
* Chemical usage
* Power usage
* Product water production
* All maintenance work log record
* Any “failures” and rectification log
* Any other relevant information

#### Process Proving

Process Proving shall be carried out as soon as is reasonably practical after the successful Initial Performance Testing of the plant. The product water produced during process proving shall be distributed to the household consumers after certifying the product water quality meets the required drinking water guidelines. The Contractor shall give to the Engineer not less than 7 days’ notice of the date after which the process proving test will be carried out.

The Process Proving Period is a continuous operation of a desalination plant for 90 days. During this period, the plant should run without any deterioration of the product water quality and quantity, and other performance requirements. In the event of a failure when the System or any of the facilities does not satisfactorily achieve the required performance standards during this period, the proving period shall be extended until the Contractor has satisfactorily rectified any deficiency as may be necessary to satisfy the performance requirements and completed the rest of the proving period, at the risk and cost of the Contractor. A failure in the system is one that fails to produce product water of the required quality any time; decreases system overall production capacity below 97 per cent of the design capacity in 72 hours due to any reason including equipment/unit failure. In the case of more than two events of failure or performance deterioration (deviation from the Contractor’s performance guarantees), the proving test shall be deemed as failed, and the test shall be terminated. The Contractor shall fix the problem first and then repeat the process proving test with the consent of the Engineer for 90 days at their own risk and cost. The event of failure is defined as more than 3% reduction in production with no deterioration of product water quality in terms of TDS, Boron and other vital parameters as per BIS10500-2012 in a consecutive 72 hours. The penalty for the delay damage shall be levied as per the Contract provisions.

During the Process Proving Test, the Employer’s representatives will observe the operation of the desalination plant, but the Contractor shall hold the responsibilities for the complete operation and maintenance of the desalination plant with waste disposal. All costs of operation and maintenance, including power, chemicals, spare parts, component replacement and waste disposal as required during the process proving period shall be borne by the Contractor. In case of excess consumption of the power and chemicals beyond the guaranteed values given by the Contractor in his technical proposal, the Contractor shall be required to change the concerned equipment/units with more efficient system. The penalty for excess power consumption shall be paid by the Contractor during O&M period as per the contract provisions.

The Process Proving Test shall verify the complete operation and functionality of the system when automatically controlled and achieving the guaranteed performance. As a minimum, the following shall be verified:

* Automatic operation of the system (including changeover between duty and standby equipment items)
* Recording and trending of all data
* Demonstration of all equipment at full design capacity
* Recorded flow rates
* Differential pressure at RO membrane
* Projected consumption of chemicals and power
* Verification of conformance to the specified or guaranteed performance
* Guaranteed product water quality: If the system fails to comply with requirements for product water quality, the Contractor shall provide a written plan of modifications in plant or operation to achieve compliance with the requirements. Upon implementation of a plan of modifications, Process Proving test shall re-commence in its entirety.

The Contractor shall be issued the Commissioning Certificate only after the successful completion of the Process Proving Test. The successful completion of Design-Build Period is a pre-requisite for the Issue of the Commissioning Certificate and subsequently marks the commencement of the O&M Period.

### Plant Operation & Maintenance

After successful completion of the Process Proving and submission of all the required documents by the Contractor, the first phase of the contract for construction of the plant (Design- Build) will be completed and the O&M phase for 20 years will commence. During the O&M period, the cost of the power will be given by the Employer within the guaranteed limit provided by the Contractor in its functional guarantees. Any extra consumption of power above the guaranteed limit that is required to meet the quality and quantity of the product water, shall be borne by the Contractor as per the provisions specified in the conditions of contract. The consumption of chemicals shall be monitored to ensure the smooth operation of the plant and extended asset life. The details of the plant Operation and Maintenance are provided in the Part-2, Section VI, Chapter-13.

## Documentation

The Contractor shall finalise documentation (such as FDS, SOPs, UPGs, O&M Manuals, control philosophy, P&IDs, etc.) as soon as practicable at the start of the Process Proving Test. The documentation shall apply to all processes, facilities and equipment supplied under the Contract. The documentation shall include the following as a minimum:

1. Functional Design Specification describing the functionality of the PLC, including the process control philosophy.
2. Unit Process Guidelines (UPGs): One for each unit process, giving the underlying principles of the unit operation and troubleshooting guidelines for bringing the operating parameters within the specified limits.
3. Standard Operating Procedures (SOPs): One for each unit process covering the start-up and shutdown procedures for each piece of equipment, including all steps and actions, both at the HMI screen and in the field. Problem-solving guidelines for tracing equipment faults must be included.
4. Installation Instructions and Maintenance Manuals, including data sheets to clearly identify the particular model and optional fittings and features of the equipment provided.
5. PLC Program
6. System Control and Data Acquisition Manual
7. A combined maintenance schedule for all equipment showing all activities required daily, weekly, monthly, quarterly, biannually, annually or at other intervals as specified by the manufacturers. All details of lubricants and other consumables must be included. The activities in the schedule are to be completed and documented by the contractor during the operations period to ensure full compliance with the manufacturers’ warranty conditions.
8. As-built Drawings (both in AutoCAD, PDF and .SHP files) along with hard copies
9. The list of assets commissioned, including the asset numbers and description of the assets and commissioning dates.
10. Commissioning Report
11. Process Proving Report
12. Training of the Employer's Operations and Service Provider personnel

The Process Proving Report shall be a compilation and summary of the previous reports required for Contract Completion. It shall follow the history of the commissioning, i.e. chronological diary log of findings, incidents and activities completed and checked including:

1. Plant operating peculiarities and observations
2. Any measurement, checks and settings which may be required by operating and maintenance personnel.
3. Results of any testing and inspection
4. Copies and a listing of all electronic media files such as photos, DVDs and the like
5. A comparison between the actual performance measured during the Process Proving Test with the Contract requirements
6. All non-complying points and limitations arising from the commissioning.
7. All formal commitments from the suppliers or subcontractor(s) to rectify faults uncovered during commissioning.
8. Certification by the Contractor’s Designers that the equipment meets its design performance and is ready for the ongoing operation.
9. All changes to the operating and maintenance requirements found essential after process proving, shall be reflected in the appropriate sections of the O&M Manuals, UPGs and SOPs which shall be updated at the end of the Process Proving Test.

Delivery of the documentation shall be as follows:

* + All Commissioning, Performance Testing and Process Proving Reports shall be prepared by the Contractor within 7 days after completion of each task.
  + Seven complete sets of the final documents and one complete set in the latest MS Office and AutoCAD format and in Adobe Acrobat Reader format on USB drive shall be provided to the Employer within 15 days after the end date of the Process Proving Period. This final version shall incorporate all information updated as a consequence of operation during the proving and operations periods.

**CHAPTER-4**

# GENERAL REQUIREMENTS

## Introduction

This part of the Specification sets out the general requirements/ standards of plant design /materials to be supplied and the workmanship required to be ensured by the Contractor. All component parts of the Works shall, unless otherwise specified in the particular documents, comply with the provisions of this part or be subject to the approval of the Employer’s Representative. Particular attentions shall be paid to a neat, orderly and well-arranged installation carried out in a methodical competent manner.

All information pertaining to the Works to be executed including the information about suppliers, procedures, performances, capabilities, factory acceptance test (FAT) reports and other significant data shall be furnished for review and acceptance by the Employer’s Representative, who shall have discretion to reject any parts which in his opinion are unsatisfactory or not in compliance with the specifications and such parts shall be replaced by the Contractor at no extra cost to the Employer.

## Scope of Work

The detailed scope of work for the Contract has been described in Part-2, Section VI, Chapter-1 and Chapter-3 of Employer’s Requirements along with technical details of the different components, and the Drawings in Part 2.

## Technical Standards and Regulations

Except where otherwise specified, Plant materials and workmanship shall comply with the requirements of the relevant Indian Standards (hereinafter referred to as IS) issued by the Bureau of Indian Standards, other equivalent International Standards such as those issued by the International Organisation for Standardisation (ISO) may be substituted by the Contractor (so long as they are more stringent than the equivalent IS) at the sole discretion of the Engineer or as may have been agreed in the Contract. If relevant IS standards are not available then at the discretion of the Employer, Contractor shall be allowed to use international standards such as ASTM/ANSI/AWWA/DIN/JIS/BS. All standards used shall be the current version and most safe and subject to the acceptance of the Engineer.

All materials and workmanship not fully specified herein or covered by an approved standard shall be of such kind as is used in first class work and suitable to the climate and conditions in the project area.

Where the requirements of any such standard specification or regulation conflict with the requirements of the Employer’s Requirements or any item on the Drawings, the Contractor shall refer to the Engineer for clarification before proceeding with that portion of the Works.

## Plant Commissioning

After execution of all mechanical and electrical installations, the Contractor shall execute the commissioning as per the procedures indicated below and in Part 2 Section VI Chapter-3. The total period for commissioning shall be 90 consecutive days including Initial Performance Test. In the first 75 days, pre-commissioning checks, dry commissioning and wet commissioning shall be conducted. In the final 15 days, initial performance of the plant operation shall be tested. A commissioning team shall be formed which will include the representatives of the Contractor and the Employer. The details of the commissioning and the process proving are provided in Chapter-3 and Chapter 10 of the Part-2 document.

## Details and Data by the Employer

The Employer has the following data available and used these in formulation of the Tender Documents. They are listed below and shall be used only as guidelines. The Employer does not, however, guarantee either the sufficiency or accuracy of the data provided. The Contractor has to undertake all investigations needed to finalize the process, civil, electrical and mechanical design.

1. Topographical Survey Data
2. Environmental and Social Baseline Data
3. Meteorological Data and Tidal Data
4. Ground Investigation and Ground Condition Data (i.e. Geotechnical Data, Geological Data)
5. Land Ownership Data

Contractor shall carry out a fresh survey, investigation and testing/and all other details necessary for proper planning and work execution. The Contractor shall be required to provide full details of the investigations and analysis for approval of the Engineer.

## Precedence of Works’ Requirements

The requirements specified in the respective Particular Requirements, shall be in addition to those specified in the General Requirements. In case of conflict between the parts, the requirements of the respective Particular Requirements parts shall take precedence.

## Units of Measurement

All designs, drawings, specifications and manuals shall use SI (kg m s) units and all measurements, dimensions and performance data shall be quoted in those units.

## Programme

In accordance with Clause 8.3 of the Conditions of Contract, the Contractor shall within a time specified in the Contract Data, submit a detailed programme for the review by the Employer’s Representative and Project Management Consultant (PMC) and the approval by the Engineer which shall include details of all temporary and permanent works, construction procedures and methodologies.

In addition to the requirements set down in the Conditions of Contract, the programme shall include the following details, but not limited to:

1. Contractor’s project organisation structure for the including details of all site supervisors and their responsibilities.
2. A statement giving the numbers and categories of supervisory and technical staff and skilled and unskilled labour to be employed on the Works.
3. A list and type details of major constructional plant (including vehicles) which the Contractor proposes to employ on the Works, including programmed dates for order and delivery.
4. Details of the Contractor's methods of working for all operations.
5. A statement giving the proposals for location or locations and sizes of offices, workshops and stores at the Site.
6. A complete resource allocation showing the number of units and allotted times for each unit of constructional plant, materials and labour allocated to each part of the Works.

The programme shall be co-ordinated to consider the requirements of climatic, groundwater and other conditions to provide for the completion of the Works in accordance with the Contract. The programme shall be prepared using MS Project or Primavera software and shall be submitted in both soft and hard copies (editable copy).

## Important Inputs Required from the Contractor

### Topographical Survey and Soil Investigation Agency

The Contractor shall reconfirm the topographical surveys, soil investigations, environmental conditions and all other site conditions available with the Tender Documents. The Contractor shall ensure that the work starts within 14 days of the Commencement Date with the qualified agencies whom the Contractor will use for the purpose.

The Contractor shall also conduct additional investigations and land development as are normally necessary to ensure full and satisfactory designs and safety. The surveys shall be carried out with Total Stations and necessary software shall be used for creating the required drawings.

### Field Laboratories

The Contractor shall be required to establish a field laboratory as approved by Engineer, suitably equipped to carry out tests as stipulated in the QA/QC Manual, including all specialized equipment which will be required for testing the material and equipment being supplied under the Contract.

Suitable trained laboratory staff shall be posted with full facility of computerized record keeping. The minimum equipment to be provided in the laboratory shall be as listed below. Additional equipment as may be deemed necessary may be added to the same in due course on requirement of the Employer/Contractor.

In addition to the equipment in the laboratory, the Contractor shall also provide field testing equipment as directed by the Engineer on the various sites where work is in progress.

The Contractor shall provide a laboratory at a suitable site as approved by Engineer for the testing of materials. The laboratory shall have the following facilities required for sampling and testing materials and concrete in the field.

The following equipment with operators shall be made available at Engineer’s request (all must be in serviceable condition).

**Table ‎4‑1: List of Equipment to be provided for Civil Laboratory by the Contractor**

| **S. No.** | **Description** | **Quantity** |
| --- | --- | --- |
| 1. | Concrete cube testing machine suitable for 15 cm cubes of 100 tonnes capacity with proving calibration ring | 1 No. |
| 2. | Cast iron cube moulds 15 cm size | 50 Nos. (Min) |
| 3. | Slump cone complete with tamping rod (as required to suit concrete plan) | 2 sets |
| 4. | Laboratory balance to weigh up to 5 kg with sensitivity of 10 gm | 1 No. |
| 5. | Laboratory balance of 2 kg capacity and sensitivity of 1 gm | 1 No. |
| 6. | IS Sieves for coarse and fine aggregates | 2 Set |
| 7. | Set of measures from 5 litres to 0.1 litre | 2 Set |
| 8. | Electric oven with thermostat up to 120oC | 2 No. |
| 9. | Flakiness gauge | 2 No. |
| 10. | Schmidt Hammer | 2 Nos. |
| 11. | Elongation index gauge | 2 No. |
| 12. | Sedimentation pipette | 2 No. |
| 13. | Pycnometer | 2 No. |
| 14. | Calibrated glass jar (1 litre capacity) | 4 Nos. |
| 15. | Glass flasks and metal containers | As required |
| 16. | Chemical reagents like sodium hydroxide, tannic acid, litmus papers, etc. as required | As required |

Arrangement can be made by the Contractor to have the cubes tested in an approved laboratory in lieu of a testing machine at site at his expense, with the prior consent of the Engineer. The outside laboratory shall also be used for routine testing of cement, reinforcement, coarse and fine aggregate and other items.

### Supervisory Staff for Contractor

The Employer places great importance on the quality and authority delegated to the Contractor’s key staff deployed in the field to execute and supervise the works. The Contractor is required to ensure deployment of qualified and experienced staff in sufficient numbers on site to ensure quality.

There shall be supervisory staff deployed at the Site in sufficient numbers to ensure day to day quality supervision of the work.

The minimum number of supervisory staff to be deployed at each plant stream is shown in the table below.

**Table ‎4‑2: Minimum Supervisory Staff**

|  |  |
| --- | --- |
| **Works** | **Minimum Supervisory Staff** |
| Civil  Electrical  Mechanical  Instrumentation  Safety Engineer  QA/QC Engineer | 4  2  2  2  2  2 |

The staff as mentioned above and the key personnel shall be maintained at the Site when the works on the relevant field are being actively carried out. The Contractor shall arrange and maintain sufficient experienced workers and foremen and other support staff as required on sites in sufficient numbers.

### Minimum Construction Equipment to be brought by Contractor on Site

The Contractor shall assign the minimum equipment on site for ensuring quality and timely progress of works. The minimum equipment, including but not limited to the equipment described in this Subsection, and shown in the table below, shall be mobilized by the Contractor at the Site for each plant stream of 200 MLD SWRO desalination plant in working condition. The Contractor should submit the equipment mobilization program in the Tender schedules.

**Table ‎4‑3: Minimum Equipment to be mobilized by the Contractor at the Site**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Sl. No** | **Description of Equipment** | | **Capacity/Type** | **Minimum Number to be Mobilized** | |
| **A** | **Excavation, Transportation, Handling and Erection** | | | | |
| 1. | Dozer/JCB/ Excavators | 250 HP | | 4 |
| 2. | Crawler crane |  | | 2 |
| 3. | Crane – 10 T Hydra |  | | 4 |
| 4. | Tipping Trucks |  | | 4 |
| 5. | Ripper |  | | 2 |
| 6. | Tripods and Chain Pulley Blocks |  | | 4 |
| 7. | Dewatering Pumps | |  | 20 | |
| **B** | **Concreting** | |  |  | |
| 1 | Concrete Batching Plant (Semi-Automatic) | | 20 cu m | 2 | |
| 2 | Concrete Batching Plant (Automatic) | | 20 cu m | 2 | |
| 3 | Concrete Mixers | | 10/7 and 14/10 cu ft | 10 | |
| 4 | Needle Vibrators | |  | 20 | |
| 5 | Plate Vibrators for Bedding | |  | 10 | |

## Completeness of the Offer

The Contractor shall be fully responsible to ensure that the whole of the Works, including each individual component, is designed and constructed in a manner so that the system as a whole operates as a fully integrated system which is capable of achieving the required output in an efficient and economical manner, and to include all plant, equipment and accessories required for the safe and satisfactory operation of the facilities. To achieve this, the Contractor shall ensure that each individual component performs in a manner which is complimentary to that of all other components.

Any accessories which are not specifically mentioned in the specifications, but which are usual or necessary for completion of the Works and successful performance of the System and facilities shall be provided by the successful Tenderer within the tendered cost.

The Contractor shall, to the maximum extent practical and feasible, endeavour to standardize on the manufacture and supply of plant and equipment so as to minimize the operation and maintenance requirements. The Contractor shall ensure that his designs are "maintenance-friendly" and that all items of plant and equipment are designed and installed in a manner which will facilitate routine and periodic maintenance operations.

## Time for Completion

The whole of the Works, including mobilization, reconnaissance, survey, sub-soil investigations, design, manufacturing, transportation, construction, installation, commissioning, testing and process proving shall be completed within the scheduled Time (Milestone) for Completion as set out in the Tender Documents Part 2, Section VI, Chapter-1. The physical completion of the system and facilities shall be achieved before commissioning.

## Milestones

The Employer wishes to ensure consistent pro-rata progress on all components of the Contract during the entire Contract period as given in Part-2, Section VI, Chapter-1, Clause 1.13, Milestone. Further breakup to the key Milestones set out may be proposed by the Contractor and agreed by the Employer at the time of tendering. The milestone timeline shall be periodically reviewed for the progress of various components. These milestones provide the stages when any delay in implementation of a particular component of work will be determined and subsequently a decision may be taken towards the application of the provisions of Clause 8.0 of the Conditions of Contract.

## Contract Management

The Contractor shall be responsible for administration of the Contract from award of Contract through design, manufacture, manufacturer's works testing, and delivery of Plant to the Site, installation, commissioning, testing and performance proving. For this purpose, the Contractor shall nominate a Contractor’s Representative in accordance with Sub-clause 4.3 of the General Conditions of Contract who shall be fully responsible for and undertake this administration.

Specific responsibilities of the Contractor’s Representative shall be:

1. The sole representation on behalf of the Contractor in all discussion, correspondence and matters relating to the Works.
2. The co-ordination and monitoring of Contract progress, which shall include the preparation of the Contract programme, monitoring of progress and submission of monthly progress reports. At the discretion of the Engineer, regular meetings shall be called at which the Contractor’s Representative shall give a full account of the Contract progress and programme.
3. The co-ordination and checking of designs, drawings and submissions. The Contractor’s Representative shall be responsible for co-ordinating the design, technical information and data between sub-contractors. All calculations, drawings and information submitted to the Engineer shall be checked by the Contractor’s Representative and certified as having been checked before submission.
4. Contract communication between the Engineer and the Contractor. The Contractor’s Representative shall attend all meetings involving the Contractor and the Engineer.
5. The co-ordination and programming of manufacturer's works tests and the submission of test certificates.
6. The co-ordination and programming of Plant delivery.
7. The co-ordination and programming of the installation of Plant at the Site, site tests and take over trials. The Contractor’s Representative, although not necessarily based at the Site, shall be responsible for the various sub-contractors. At the discretion of the Engineer regular site meetings will be held during which the Contractor’s Representative shall give full account of site progress and programme.
8. The Contractor’s Representative shall also be responsible for producing in advance of the work being undertaken, detailed method statements of any work, which involves or affects the performance of existing equipment, processes, or disruption to existing water supplies.
9. The co-ordination and preparation of As-Built Drawings and operating and maintenance manuals.
10. Soft copies of all submissions should be in editable form.
11. The preparation and co-ordination of training.
12. The submission of applications for payment.

## Meetings

From time to time, the Engineer will call meetings in his office or at the Contractor's office, or at the Site, as he deems necessary, to discuss progress and any technical points requiring settlement. The Contractor's Representative or responsible representative shall attend such meetings. The Contractor shall prepare and submit to the Engineer a daily activity report summarising the main activities undertaken each day.

## Photographs

In accordance with the requirements of Clause 4.21 of the Conditions of Contract the Contractor shall supply digital photographs of such portions of the Works, in progress and completed, as may be directed by the Engineer and specified herein. The photographs shall be the property of the Employer and JPEG files shall be delivered to the Engineer with the prints. No prints of these photographs shall be supplied to any other person without the written permission of the Engineer.

The photographs shall be of the following categories:

* progress photographs
* record photographs
* digital video recording

Photographs shall be properly referenced to the approval of the Engineer, and on the back of each print shall be recorded the date and time of the photograph, the direction in which the camera was facing, an identifying description of the subject and the reference. Similarly, the titles of JPEG files shall include the date and time, and an identifying description of the subject.

Photographs taken for record purposes as ordered by the Engineer or as specified herein shall be supplied with MPEG files, JPEG files and three (3) prints, with one print having the signatures of the Contractor and the Engineer (or their authorised representatives) on the reverse side for the purpose of attestation. If required, the Contractor may at his own expense have an additional print similarly attested for his retention. Digital video files shall be supplied to the Engineer in a format approved by the Engineer.

Photographs of the Works by the Contractor for any other purpose whether for use in India or in any other country shall not be carried out without written approval from the Engineer.

## Erection of Plant

Erection of Plant equipment shall be phased in such a manner so as not to obstruct the work being done by other contractors. 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, lines or dimensions to the notice of the Engineer.

Plant shall be erected in a neat and workmanlike manner on the foundations and at the locations shown on the Approved Drawings. Unless otherwise directed by the Engineer, the Contractor shall adhere strictly to the aforesaid drawings.

The Contractor shall be responsible for setting up and erecting the Plant to the line and level required and shall ensure that all Plant is securely held and remains in correct alignment before, during and after grouting-in. This responsibility shall not be passed to any other contractor.

Any damage caused by the Contractor during the course of erection to new or existing plant or building or any part thereto, the Contractor shall at his own cost, make good, repair or replace the damage, promptly and effectively as approved by the Engineer and to the Engineer's satisfaction.

## Site Labour and Supervision

The Contractor shall provide all the skilled and unskilled labour required, and all necessary tools and equipment, to erect, test and commission the Works within the period agreed in the programme. The Contractor shall not remove any supervisory staff from the Site without the Engineer's prior approval.

## Sub-letting

The Contractor shall not sub-let the whole of the Works. Where, any design or manufacture is sub-let, the Contractor shall not be relieved of his obligation under the Contract. The Contractor shall be responsible for the acts, defaults and neglect acts in manufacture or design of any sub-contractor, as if they were his own.

Where the Engineer has consented to supply of Plant or execution of work by manufacturers or sub-contractors proposed by the Contractor, such manufacturers or sub-contractors shall not be changed without the prior approval in writing of the Engineer.

A copy of every sub-order shall be sent to the Engineer at the time the order is placed each clearly marked with the title of the Contract and the Contract Number.

## Temporary Works

Not less than 14 days before commencing any portion of the Works, the Contractor shall submit to the Engineer for his approval comprehensive drawings and calculations for all Temporary Works which the Contractor proposes for the construction of that part of the Works.

Notwithstanding approval by the Engineer of any design for the Temporary Works, the Contractor shall be entirely responsible for their safety, efficiency, security and maintenance and for all obligations and risks in regard to such Temporary Works specified or implied in the Contract.

## Languages

All design and drawings (including patented), instructions, signs, notices, name-plates, etc. for use in the design, construction, operation and maintenance of the Works shall be in English. All site sign boards and warning signs shall be in Tamil, Hindi and English.

## Drawings and Information

### General

The drawings that are prepared and issued for this Contract shall be classified as follows and where relevant shall be to a scale which is suitable for the representation of those details illustrated.

The term Drawing shall be deemed to include all drawings, schedules, lists, software documentation, descriptive text and calculations necessary for the design, construction, operation and maintenance of the Works and referred to in this clause. The Contractor shall submit all the drawings (A1 size) and documents on (A4 size) in hard as well as soft (editable) format.

### Pre-Contract Drawings

The Pre-contract Drawings are those issued to Tenderers either with the Tender Documents for the purpose of illustrating and clarifying the Works described in the Employer’s Requirements or later during the tender period as part of an Addendum to the Contract Documents.

Such drawings shall be deemed to have been issued for the guidance of Tenderers and shall, for the purpose of executing the Works, be superseded by the Construction Documents.

### Tender Drawings and Documents

The Tender Drawings and Documents are those furnished by a Bidder with his Bid for the purpose of illustrating, detailing, and clarifying his proposals which will be used in the bid evaluation. These shall include:

* Construction program with milestone
* General plant layout plan
* Process flow diagram with flow data
* Hydraulic profile
* Building preliminary GA
* Description of the proposed Intake/Outfall system, Pre-treatment, SWRO Desalination, Post-treatment Processes, Waste Treatment and Disposal system, Building, Tanks and all allied works
* Process and Instrumentation Diagram (P&IDs)
* DCS overall System Architecture
* Overall Single Line Diagram and Electrical Load List
* Chemical Usage
* Major Equipment Make/ Type / Origin List
* Generic testing Plan

The above information is important and shall be mandatorily submitted along with the bids by the bidders.

### Construction Documents

The Construction Documents are certified Drawings submitted by the Contractor to the Employer’s Representative during the course of the Contract for approval. The Contractor shall supply five (5) hard copies each and soft copy of the initial design calculations for the process and sizing of all components of the System including architectural, structural, process, mechanical, electrical and instrumentation equipment, supported by design calculation (excel spreadsheets), flow diagrams and general arrangement drawings for approval to the Engineer. It is a matter of high priority that the Contractor ensures the submission and finalization of such designs and drawings in the stipulated time schedules as elaborated.

It is the intention of the Employer to ensure that the approval of such submissions is made expeditiously and in time. The Contractor is therefore required to setup his project office in Chennai (fully equipped and staffed) to enable continuous submission, interaction and timely clearances.

The Employer shall arrange to send observations if necessary, within twenty-one (21) days of receipt of the design and drawings for modifications to the Contractor. The Contractor shall incorporate all necessary comments of the Engineer in the above design and drawings, if any, and shall re-submit further five (5) hard copies each and soft copy of the revised design and drawings within ten (10) days for final approval of the Engineer.

The Contractor shall thereafter submit seven (7) copies each of the approved design and seven (7) hard copies and soft copy each of the approved drawings together with one copy each of the reproducible tracings. The Engineer will return two (2) approved copies to the Contractor and retain five (5) for the Engineer’s office and field use.

If the submissions require more than one round of revision on account of incomplete compliance from Contractor, the delay shall be on account of the Contractor. If new observations are given by the Engineer based on the earlier submission, the Contractor shall be entitled to take an additional ten (10) days period for compliance. Further design calculations and drawings shall be submitted in sequence as per a schedule to be drawn and agreed upon mutually, immediately after submission of the general arrangement drawings.

A blank space 90 x 50 mm shall be provided immediately above the title block for the approval stamp. If required, the detailed design and the execution drawings shall be submitted only after verification by an Institute approved by the Employer. The Contractor shall be responsible for the preparation of working drawings and the construction documents for Works, as specified in the Contract. All costs for the verification shall be borne by the contractor.

The Engineer may require the Contractor to submit for approval additional drawings if they are necessary to enable him to satisfy himself that the items are well designed, that they comply with the Employer’s Requirements and that they are suitable for their intended purpose. These drawings shall form the agreed basis for the execution of the Works. If an approved drawing is revised, revised copies shall be submitted for approval as above and no such revised drawing shall be used for the purposes of the Contract until it has been approved in place of the earlier issue of the drawing.

Approval of drawings by the Engineer shall not be held to relieve the Contractor of his responsibilities under the Contract. The Engineer will not permit construction to start on a part or section of the Works unless Construction Documents for that part or section have been approved.

### Drawings for Approval

Drawings for approval shall be submitted in two (2) phases both in hard as well as in soft (editable) formats. The first phase shall be the Preliminary Drawings. Drawings submitted during this phase shall be of sufficient details for the Employer’s Representative and PMC to understand in outline the Contractor’s proposals for the design and construction of the Works.

The Preliminary Drawings shall inter alia comprise:

* comprehensive description of the process, the plant offered, its operation
* Operational and control philosophy
* treatment works hydraulic profile including hydraulic calculations
* chemical process and mass balance & flow calculations
* treatment works flow diagram including details of flows in each area of the plant
* preliminary process and instrumentation diagrams (P&ID); the diagrams shall indicate in symbolic form (to BS 1646 and BS 1553) the process, plant and systems of measurement, control and automation
* site layouts including information on levels detailing the location of:
* buildings
* process plant
* storage tanks
* transformer enclosures
* roadways
* buried pipelines
* main cable routes
* civil works plans, elevations and main sections of all buildings
* site drainage details
* contract interface details
* general arrangements and main sections of all plant areas
* electrical single line diagram based on approved mechanical and process load list showing CT & PT details, starter details, cable sizes, feeder metering and protection details, equipment capacity and sizes, feeder Interlock operation logic, DG set starting and stopping operation logic, panel cable entry details, panel busbar capacity and sizes etc.

a description of building services provisions proposed for the Works

* + control system architecture
  + load schedule
  + instrument schedule
  + I/O schedule for each PLC

The Preliminary Drawings shall be submitted by the Contractor for approval as a single submission.

The second phase shall be the detailed design phase and shall comprise the submission of the Construction Documents. These shall be submitted after approval of the Preliminary Drawings by the Engineer. The Construction Documents shall be used for the construction of the Works and shall inter alia comprise.

#### Materials, Plant and Equipment

The Contractor shall place orders for the material and the equipment only after approval of the Engineer. The Contractor shall submit the detailed drawings from the approved manufacturers, and the procedure of submission, review and revision shall be as specified herein below.

The Contractor shall inform the Engineer about the likely dates of manufacturing, testing, and dispatching of any material and equipment to be incorporated into the Permanent Works. The Contractor shall notify the Engineer for inspection and testing, at least twenty-eight (28) days prior to packing and shipping and shall supply the manufacturer's test results and quality control certificates. The Engineer will decide whether he or his representative will inspect and test the material/equipment or whether he will approve it on the basis of the manufacture’s certificate.

The following inspection and test categories shall be applied prior to delivery of the equipment, of various categories as indicated in the technical specifications for each type of the equipment:

**Category A: -**The drawing has to be approved by the Employer’s Representative before manufacture and testing. The material has to be inspected by the Engineer and PMC at the manufacturer’s premise before packing and dispatching. The Contractor shall provide the necessary equipment and facilities for tests and all the related costs for the inspection thereof shall be borne by the Contractor.

The Equipment covered under this category includes all pumps, motors, chemical injection system, chlorination systems, RO system, safety equipment, electric hoists and cranes, screens, strainers, manual hoists of capacity 1 ton and above, valves, gates, nozzles, mixers, agitators, pipes and fittings, meters, actuators, belt conveyor, thickener drives and sludge scraping mechanisms, belt filter presses, DCS, metering instruments, Analyzers, all switchgears, 230kV/110kV/11kV/415V transformer, LT panels, distribution boards, MCC, capacitor bank with APFCR, diesel generator set, VFD, battery, battery charger with DCDB and cables.

**Category B: -** The drawings of the equipment shall be submitted and approved by the Engineer prior to manufacture. The material shall be tested by the manufacturer and the manufacturer’s test certificates shall be submitted for approved by the Engineer before dispatching of the equipment. Notwithstanding the above, the Engineer, after examination of the test certificates, reserves the right to inspect the testing or instruct the Contractor for retesting, if required, in the presence of the Contractor’s representative

The Equipment covered under this category includes sampling pumps, drain pumps, manual hoists less than 1-ton capacity, ventilation system, exhaust fans, instrument air compressor, filter media, dismantling joints, air-conditioner and lighting fixtures.

**Category C: -** Samples of the materials and/or equipment shall be submitted to the Engineer for pre-construction review and approval in accordance with the provisions of Sub-Clause 7.2 of General Conditions of Contract. Following approval by the Engineer, the material shall be manufactured as per the approved standards and delivered to the Site.

For material/equipment under Category “A” and “B”, the Engineer will provide an authorization for packing and shipping after inspection.

The testing and approval for dispatching of the equipment/plant shall not absolve the Contractor from his obligations for satisfactory performance of the plant.

#### Civil

The Contractor shall comply with the provisions of the requirement of the Specifications for Civil Works, as applicable.

The civil construction drawings shall comprise but not limited to the following:

* site layouts providing information on levels and detailing the location of
* buildings, architectural drawings/renderings
* storage tanks
* process plant
* transformer enclosures
* roadways
* drainage
* buried pipelines
* cable routes for direct in ground and ducted systems
* plans, elevations and main sections of all structures, foundations and buildings
* general arrangements and main sections of all plant areas
* drainage provisions
* general arrangement drawings showing the location of each Plant item
* detail drawings of:
  + cable and pipework chambers
  + buried pipework
  + pipework connections
  + contract interface
* reinforcement drawings
* bar bending schedules
* The structural design calculation with computer input & output files for the design package program such as STAAD etc.

#### Hydraulic

* hydraulic profile
* hydraulic calculations

#### Process

Drawings:

* process flow diagram
* comprehensive P&ID s including details of:
* pipeline sizes and materials;
* valve size and type;
* instrumentation & critical interlocks;
* identification of controlling PLC.

Calculations for:

* process mass flow;
* process calculations for all processes
* RO projections
* plant load calculations
* Room ventilation
* chemical processes
* process drains
* plant service water
* Pump sump design calculations

#### Electrical

Drawings

* All Switchgears

1. Dimensional Layout Drawing.
2. Complete assembly drawings of the Switchgear showing plan, elevation and typical sectional views and location of cable boxes and control cable terminal blocks for external wiring connections, etc.
3. Foundation plan showing the location of channel sills, foundation, anchor bolts and anchors, floor plans and openings.
4. Schematic power and control wiring diagrams with control, interlocks, relays, instruments, space heaters, bus bar rating with material, Current transformers, potential transformers etc.

* 230kV/110kV/11kV/415V Main Transformer

1. General arrangement drawing shall indicate the overall dimensions, net weights, quantity of oil, crane requirements for assembly and dismantling of transformers and the general constructional features.
2. General arrangement drawing of the transformer, showing plan, front elevation and side elevation complete with all accessories and fittings, detailed dimensions, net weights, quantity of, crane lift for un-tanking, size of lifting lugs and eyes, clearances between EHV terminals, between LV terminals, between EHV and LV terminals, between EHV & LV terminals and ground etc.
3. Rating, diagram and terminal marking plates, complete with polarity and vector group
4. Control wiring diagram for marshalling box
5. Foundation drawing with position of foundation bolts and depth

* RTCC Panel for Main Transformer

1. General arrangement drawing shall indicate the overall dimensions, net weights, and the general constructional features.
2. Wiring diagram with tap position details and logic for on line operation

* L.T Panels, Distribution Boards, Power Control Centres, Power Motor Control Centres, Motor Control Centres etc

1. Dimensional layout drawing
2. Complete assembly drawings of the switchboard/distribution board / MCC showing plan, elevation and typical sectional views and location of cable boxes and control cable terminal blocks for external wiring connections, etc.
3. Foundation plan showing the location of channel sills, foundation, anchor bolts and anchors, floor plans and openings.
4. Schematic power and control wiring diagrams with control, interlocks, relays, instruments, space heaters, starter details Bi-metallic relay ratings and contactor ratings, bus bar rating with material, current Transformer, potential transformer etc.

* L.T Capacitor bank with Automatic Power Factor Correction Relay

1. Dimensioned general arrangement drawings of capacitor and capacitor control panel
2. Justification for number of steps for switching.
3. Fully dimensioned general arrangement drawings of capacitor and capacitor control panel with elevation, side view, sectional view and foundation details
4. Complete schematic and wiring diagrams for capacitor control panel

* Battery and Battery Charger with D.C. Distribution board

1. Dimensioned general arrangement drawings
2. Fully dimensioned general arrangement drawings of battery and battery charger with elevation, side view, sectional view and foundation details
3. Complete schematic and wiring diagrams

* Cabling System

1. Details of Installation of Cables in Trenches, on cable trays, directly buried etc at all locations inside the treatment plant.
2. Cable routing lay out inside and outside the plant.
3. Bill of quantities of cables, lugs and glands.
4. Cable termination and mounting Kit Layout drawing as required.

* Lighting system

1. Detailed Room wise Lighting Layout with Type of fixture details and Circuit diagram showing phase wise load distribution and interconnection between switches, fixtures, Lighting panel, receptacles etc.
2. Conduit layout showing room wise routing of wires from lighting panel to lighting fixtures, receptacles etc.
3. Internal road Lighting and Area lighting layout with type of mounting details and fixture details.
4. Street Light pole details with Foundation details

* Earthing System

1. Details such as material, sizes, etc. of the earth conductor and electrode pits
2. Earthing layout drawing showing routing of main grid inside and outside the plant with interconnection of equipment earthing to the grid and earth pits

* Substation Building Layout showing Panel locations, Transformer locations and Trench Layout
* Electrical Equipment and Panel Layout inside and outside the plant

Schedules

* cable schedules
* load and power consumption schedule
* junction box schedule
* protection relay setting schedule
* panel/MCC schedule

Calculations for:

* Cable sizing
* Fault level and Voltage Dip Calculations
* Co-ordinated protection study
* Standby generator sizing based on equipment finalized by Mechanical and Process
* Transformer Sizing Based on equipment finalized by Mechanical and Process
* Room wise Lighting Calculation as per Lux level given in the specification
* Earthing Sizing Calculation
* Panel Busbar Sizing Calculation
* light/lux calculation

#### Control, Instrumentation and Monitoring System

Drawings:

* power supply distribution single line and schematics diagrams (see note 1) for each control panel
* internal and external (see note 2) general arrangement for each control panel (dimensional)
* control and instrumentation loop drawings (see note 3)
* instrument installation detail drawing (hook up, see note 4)
* cable block diagrams
* cable routing/installation drawings
* foundation and fixing details and trenches drawings
* schematic diagram for system configuration of PLCs, operator stations, engineering stations, large screen, training station, report station, printers etc.
* HMI dynamic screens of process flows, diesel generator set and EHV power incoming panels etc.
* format of reports, alarms etc.

Schedules:

* cable schedule
* cable interconnection schedule
* control and instrumentation load schedule for each control panel
* I/O schedule for each PLC
* control and monitoring item schedule for each PLC and operator station
* alarm schedule
* junction box schedule
* instrument schedule
* instrumentation, process control set point schedule
* instrument data sheets

Documentation:

* functional design specification (FDS) (see note 5)
* factory acceptance test document (FAT)
* site acceptance document (SAT)

Notes:

1. Schematic drawings shall include a comprehensive schedule of the components used in each switchboard, MCC and control panel including details of the type, manufacturer and rating of each component
2. The external arrangement of each switchboard, MCC and control panel shall show the arrangement of all components including details of panel section, switch and instrument labels
3. Control and instrumentation loop drawings shall show on a single drawing of the complete circuit associated with an instrument or device, including details and location of power supplies, cabling and terminations
4. Hook up drawings shall detail how an instrument or device is installed
5. See details later for requirements of the FDS
6. Electrical control schematics, loop diagrams and schedules shall where practical be A3 size drawings; all other drawings shall be A1 size

#### Mechanical

Drawings:

* general arrangement of plant and pipework including sections
* isometric views of pipework systems
* detail drawings of proprietary and fabricated plant items

Schedules:

* pump curves
* plant performance details
* pipeline schedules
* Valve schedules

Calculations for:

* pump sizing
* pipeline sizing
* compressor sizing
* torque calculations
* Ventilation system
* Actuator sizing

#### Mechanical Building Services

Drawings:

* single line schematics for water and sludge handling system and drainage systems
* general drawings showing the location of each mechanical building service plant item
* general arrangement of ventilation systems
* fixing details

Schedule:

* plant data sheets
* pipeline schedules
* valve schedules

Calculations for:

* system sizing
* plant/equipment

### Drawing Format and Numbering

All drawings shall be prepared using an identical title block format. This shall be approved by the Engineer and shall identify the project, drawing title, the Employer, the Contractor, Sub-contractor, if applicable, and the Engineer.

A formalised drawing numbering system shall be adopted with digits of each number, referencing location, revision, drawing type and size. The numbering format and allocation of drawing number blocks shall be approved by the Engineer. The Contractor shall provide a sequential numbering system for all Construction Documents.

All drawings shall be submitted to a formalised checking procedure prior to submission to the Contractor. Drawings not so checked will not be approved.

### Information required on As-Built Drawings

The As-Built Drawings shall consist of the fully up-dated versions of the approved Construction Documents incorporating any additional information which will assist the Employer in operating, maintaining and if necessary, modifying or extending the Works at a later date. These drawings should extend and supplement the information given in the Operating and Maintenance Manuals.

### As-Built Drawings

These drawings shall be compiled by the Contractor and shall constitute a permanent record of the Works as executed. These shall include all such drawings, schedules, documentation and calculations as necessary for a complete understanding of the Works design, operation and maintenance.

Draft As-Built Drawings shall be submitted sixty (60) days prior to the commencement of Tests on completion. The Engineer will signify his approval or disapproval of the As-Built Drawings within twenty-eight (28) days of submission.

The Contractor shall supply to the Engineer five (5) hard copies and soft copy of the As-Built drawings. The Contractor shall incorporate all necessary comments of the Engineer in the above drawings, if any, and shall re-submit further five (5) hard copies each and soft copy of the revised drawing within ten (10) days for final approval of the Engineer. The Contractor shall thereafter submit seven (7) hard copies each and soft copy of the approved As-built drawing with one copy each of the reproducible tracings. The Engineer will return two (2) approved copies to the contractor and retain five (5) for the Engineer’s office.

A3 and smaller sized As-Built Drawings shall be provided on durable paper for reproduction by the photocopier. As-Built Drawings larger than A3 shall be provided as a paper copy and also produced in the form of black lines on a durable translucent film from which further paper prints can be taken by others as required. In addition, drawings shall be provided as an AutoCAD, SHP and PDF soft copy. Text shall be provided in an industry standard word processing, spreadsheet or database format as appropriate (Editable copy).

### Control System Development

Within the time scale detailed in the Contract Programme, the Contractor shall submit a control system Functional Design Specification (FDS) for approval by the Engineer. FDS shall be the basis for automation of the total system, process control, and alarms. The FDS shall include as a minimum the requirements described as follows:

* a comprehensive description of the functions to be performed by the control system
* an overview of the control system hardware configuration and indication of the functional responsibilities of all the major hardware components
* the control system functionality description
* hardware configuration (system architecture) block diagrams and software block flow diagrams to provide an understanding of the overall capability of the control system
* a functional description of each part of the control system
* description of the communications functionality
* description of the communication functionality checks
* schedule of all hardware components, including the manufacture's name, model number, weight, dimensions, etc.
* electrical power supply requirements of all hardware
* electrical power supply schematic
* general arrangement control panels, furniture etc.
* equipment rack layout drawings
* room layout drawings

The following schedules for the PLC’s:

* I/O schedule
* database schedule

The following schedules for the HMI’s:

* screens types and reference numbers
* screens navigational structure
* alarms
* alarms directory structure
* events
* set points
* PID parameters
* trended variables including grouping details (real time and historic)
* archived variables

The FDS shall be divided into separate sections. A typical structure would be as follows:

Section 1 General Description;

Section 2 Detailed System Architecture;

Section 3 Control Philosophy

Section 4 System Functionality PLCs;

Section 5 System Functionality HMI’s;

Section 6 Communications;

Section 7 PLC and HMI Schedules.

The FDS shall comprise an overall description of the plant, its functions, control and a detailed description of each section of the control system covering modes of operation, manual over rides, set point and parameter selection & adjustments. FDS shall describe the “fail-safe” features incorporated into the design for the event of failure of a plant item or a system or loss of an input signal affecting a control loop or a process sequence. FDS shall describe the control actions taken and monitoring functions which remain available during a sequencing, which take place during system start-up & shut-down.

## Pre-dispatch Inspections Inside and Outside the Employer’s Country

In the event the Contractor proposes to procure material which requires pre-dispatch inspection of the Employer’s representative (up to maximum 4 engineers) from inside and outside of the Employer’s country, the Contractor shall arrange and provide for the cost of the travel to the Manufacturer’s place, accommodation, local transport and other expenses for the engineers.

## Hot Line

During the Contract Period the Contractor shall maintain a 'Hotline' for trouble shooting purposes through which the operators can be contacted in case of problems.

## Operating and Maintenance Manuals

### General

The Contractor shall compile, operating, maintenance and overhauling instructions for the whole of the Plant, and shall consist of separate volumes. The manual shall not be only the collection of the manufacturers’ manual but it should include a tailored document for operation, maintenance and troubleshooting of the plant systematically and user friendly. The Contractor shall submit a minimum of seven copies of the Operation and Maintenance (O&M) manuals. The manuals shall consist of:

1. general descriptive text (including drawings for illustration) of the Works described section by section.
2. comprising the complete operational instructions for the treatment plant. This shall be termed the Operators Manual. It shall be aimed at the operational staff and shall be written in clear unambiguous text complete with drawings where necessary for clarification of any issues. The manual shall comprehensively detail what to do on a day to day basis and also what to do in the event faults developing. It shall in addition, provide a complete list of the process maintenance tasks the operator should carry out, including the intervals between these tasks.
3. the essential instructions for mechanical and electrical maintenance of the Plant. These instructions shall be short and concise and set out in a consolidated schedule the inspection, lubrication, cleaning and any other type of servicing operations required. The Contractor shall prepare typical maintenance log sheets that the Employer can subsequently use for daily, weekly, monthly or other periodic maintenance and shall form record sheets of plant maintenance operations.
4. instructions for use of skilled maintenance personnel in fault location, carrying out routine replacements, withdrawing, dismantling, overhauling, re-assembling and testing the various items of Plant.
5. manufacturer’s Technical Documentation subdivided into categories for:

* civil
* process
* electrical
* electrical building services
* mechanical building services
* instrumentation and control

1. Civil As-Built Drawings.
2. comprising the FDS and PLC code.
3. electrical As-Built Drawings. The electrical drawings shall be complete sets including all information necessary for maintenance and spares replacement.
4. control and instrumentation As-Built Drawings. The electrical drawings shall be complete sets including all information necessary for maintenance and spares replacement.
5. mechanical As-Built Drawings. The mechanical drawings shall be complete sets including all information necessary for maintenance and spares replacement.
6. electrical and mechanical building services As-Built Drawings. The drawings shall be complete sets including all information including performance curves necessary for maintenance and spares replacement.
7. FAT records for the Works.
8. SAT records for the Works

Each volume shall be subdivided (relating to areas of plant) into sub sections or sub-volumes in order to ease the location of plant details. Each volume or sub-volume shall be provided with a comprehensive index for the volume or sub-volume concerned and the O & M manual as a whole.

Draft copies of the O&M manuals shall be submitted to the Engineer for his approval at least sixty (60) days prior to the commencement of Tests on Completion.

The Contractor shall supply to the Engineer 5 (five) hard copies and soft copy of the O & M manuals. The Contractor shall incorporate all necessary comments of the Engineer in the above manuals, if any, and shall resubmit further 5 (five) hard copies each and soft copy of the revised manuals within 10 (ten) days for final approval of the Engineer. The Contractor shall thereafter submit 7 (seven) hard copies each and soft copy of the approved manual together with one copy each of the reproducible tracings. The Engineer will return 2 (two) approved copies to the Contractor and retain 5 (five) for the Engineer’s office.

Each volume shall be enclosed within A4 and A3 ring binders have tough grease resistant covers suitable for use on site and designed to permit the easy removal and insertion of the contents. The front cover and spine of each volume shall show details of the project, Employer, Engineer and a volume title.

Text shall generally be enclosed in A4 ring binders, A3 drawings shall be enclosed within A3 ring binders except where it accompanies A4 text in which case it shall be folded. A1 drawings shall generally be folded and enclose an A4 box files. Where A1 drawings accompany text they shall be folded and enclosed in an A4 plastic wallet, one wallet per drawing.

## Notice of Operations

The Contractor shall give full and complete written notice of all-important operations to the Engineer sufficiently in advance to enable the Engineer to make such arrangements as the Engineer may consider necessary for inspection and for any other purpose. The Contractor shall not start any important operation without the written approval of the Engineer.

## Reinstatement and Compensation for Damage to Persons or Property

The Contractor shall reinstate all properties whether public or private which are damaged in consequence of the construction and maintenance of the Works to a condition as specified and at least equal to that obtained before his first entry on them.

If in the opinion of the Engineer, the Contractor shall have failed to take reasonable and prompt action to discharge his obligations in the matter of reinstatement, the Engineer will inform the Contractor in writing of his opinion, in which circumstances the Employer reserves the right to employ others to do the necessary work of reinstatement and to deduct the cost thereof as certified by the Engineer from any money due or which shall become due from the Employer to the Contractor.

The Contractor shall refer to the Employer without delay all claims, which may be considered to fall within the exceptions listed in the Conditions of Contract.

## Protection of Existing Installations

The Contractor shall apply to the Engineer in writing at least 28 days before starting any work that involves interference with existing structures, equipment, etc at and around the site. The Contractor shall not execute such work until he has received permission to proceed, in writing from the Engineer.

The Contractor shall ensure that no earth, debris or rock is deposited on public or private roads or rights of way as a result of the Works and all vehicles leaving the Site shall be cleaned accordingly.

## Protection of Existing Public and Private Services

The Contractor shall notify all public authorities, utility companies and private owners of proposed works that will affect them not less than two weeks before commencing the works.

The Contractor shall adequately protect, uphold, maintain and prevent damage to all services and shall not interfere with their operation without the prior consent of the public authorities, utility companies, private owners, or the Engineer as appropriate.

If any damage to services results from the execution of the Works, the Contractor shall immediately:

1. Notify the Engineer and appropriate public authority, utility company or private owner.
2. Make arrangements for the damage to be made good without delay to the satisfaction of the public authorities, utility company, private owner or Engineer as appropriate. The Contractor shall be liable for all costs for making good such damage.

The Engineer may issue instructions or make other such arrangements as he deems necessary, to repair rapidly any essential services damaged during the execution of the contract at the cost of the Contractor.

## Spare Parts

The spares shall comprise an adequate stock of the parts likely to be needed as routine replacements together with any major items or components which it may be desirable to hold in order to facilitate or expedite repair for a period of 24 months. The Contractor shall supply spare parts required for the continuous operation of the works during the O&M period. The Contractor shall supply the details of spare parts and quantity required for the continuous operation of the plant for 2 years before 1 year of the end of the O&M period. The Contractor shall support the Employer in the procurement of the spare parts .

All spare parts available at the plant shall be packed separately from the main Plant in packages or containers designed to preserve the spares from the effects of long-term storage under the ambient conditions specified. Any items that cannot be packed in this way must be protected from corrosion by applying temporary protective coatings and shielded from mechanical damage. All items shall be clearly labelled with brief descriptions and part numbers.

## Diesel Generator

Emergency diesel generators (DG) shall be provided, for the power supply of electrical loads to take the plant to shutdown without suffering damage. Two DG sets (1 duty + 1 standby) shall be provided for each stream and also one DG set for minimum lighting and illumination of the buildings and streets within the site boundary to the satisfaction of the Engineer. The capacity of the DC and safe AC system shall cover loads for the safe shut down of the plant. Automatic starting of the diesel generators during power failure shall be programmed and tested.

Also, the DG capacity should be sufficient to provide charging the voltage for the UPS chargers, minimum lighting to all buildings and the streets in case of power failure. The complete diesel generator system shall be remotely controlled and monitored by the DCS system. The DG set shall be housed in a DG room of the Electrical building.

## Spillage and Leakage

Chemical preparing, dosing and transfer equipment shall be designed and arranged so that any leakage and spilling can be controlled and cannot enter ducts, channels, etc. and have a corrosive impact on pipes, cables or other equipment of the plant.

At all lubrication or greasing points grease trays or pans shall be provided to collect excessive lubricant or spillage onto the equipment or into water.

## Special Tools and Appliances

The Contractor shall supply two complete sets of the special tools, lifting tackle, access equipment (ladders, scaffolding etc.) and greasing equipment necessary for the maintenance, repair, testing and overhaul of the Plant. The cost of all tools and test equipment shall deemed be covered under the O&M cost in the price schedule. All tools and tackles shall be handed over in fully working condition to the Employer after completion of the O&M period.

The Contractor will be permitted to utilise the overhead gantry cranes, supplied under this Contract for the purposes of installing the equipment in his supply. The Contractor shall be responsible for making all arrangements for the electricity supply to operate the cranes and for their service, maintenance and repairs. On completion of the installation, the Contractor shall restore the cranes to as new condition by the replacement of all worn or defective components.

All special tools and test equipment necessary for overhauling the Plant and testing its performance shall be included and mounted in the warehouse at site with lockable doors. Racks and clips shall be provided for individual items with outline markings and labels to show where any equipment is missing.

## Packing and Protection

Before any Plant is despatched 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, 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.

The RO membrane shall be packed, transported and stored at site as per the instruction of the manufacturer. The RO membrane should not be brought at the site and stored for long period of time. The membrane shall be dispatched to site with the approval of the Engineer and in accordance with the recommendations of the manufacturer. The RO membrane shall be kept at the site in the control environment as per the manufacturer’s instruction so that the warranty remains intact.