



CHENNAI METROPOLITAN WATER SUPPLY & SEWERAGE BOARD



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JICA FUNDED PROJECT

BIDDING DOCUMENT

FOR

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

PART-II

(EMPLOYER'S REQUIREMENTS)

(VOLUME 3 OF 5)

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

INTERNATIONAL COMPETITIVE BIDDING

PROJECT MANAGEMENT CONSULTANTS

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

SUPERINTENDING ENGINEER

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

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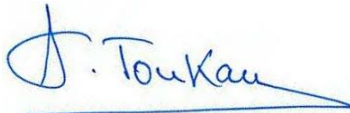
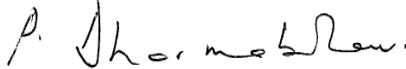
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CHAPTER - 10

10. INSPECTION AND TESTING REQUIREMENTS

10.1 Inspection and Testing During Manufacture

10.1.1 General

All items of Plant shall be inspected and approved before despatch. Detailed Manufacturing Quality Plan indicating various stages of inspection for each item / equipment shall be submitted to the Employer for review and approval. Unless otherwise authorised by the Engineer, the Contractor shall arrange routine and functional tests to demonstrate to the Engineer, conformity with the Specification and appropriate Standards. Factory Acceptance Test (FAT) Procedures and Site Acceptance Test (SAT) Procedures for major electrical equipment shall be submitted to the Engineer for approval.

Inspection and testing witnessed by the Engineer and PMC (termed witness testing) shall be carried out at the manufacturer's works in accordance with the relevant clauses of Clause 7 of the Conditions of Contract.

CMWSSB shall have the right to have their representatives, PMC and any other identified engineer present during inspections and tests of the major equipment and plant systems off-site, on-site tests and during construction. Unless otherwise specified, the Contractor shall submit to CMWSSB the procedure and a testing schedule for workshop testing and construction testing of all major equipment and systems of the RO Plant at least fifteen (15) Working Days prior to the commencement of such testing. The Contractor shall provide regular updates regarding such testing schedules to CMWSSB. The Contractor shall be responsible for all expenses incurred by the Engineer or Employer's representatives in attending inspection and tests of Plant carried out during manufacture within India and abroad. Maximum 2 persons from PMC and maximum 2 persons from Employer's representative will witness the inspection and testing said above.

Witness testing will normally be waived on standard types of equipment such as small motors made by approved manufacturers, individual standardised instruments, small mass produced components used in the manufacture of Plant items, small bore pipework and fittings, minor installation materials and low voltage cable. This shall not relieve the Contractor of his obligation under the Contract to ensure that all Plant is tested at the manufacturer's works prior to delivery to Site.

The Engineer will require to witness test of the following, but not limited to the Plant items listed below:

Electrical and Instrumentation:

- power transformers (above 0.415kV)
- 230kV, 110kV & 11kV switchboards
- MCCs and switchboards

- Capacitor banks with APFCR
- Motors above 20 kW
- Battery and battery charger with DC distribution board
- Power and control cables
- Control and instrumentation
- Plant control and HMI software systems
- DSC/SCADA and PLC
- Control panels
- HMIs
- UPSs

Mechanical:

- All process equipment/ units
- HDPE & GRP Pipes, travelling screen and pumps
- Tube settler media
- Clarifier rotating bridge, flocculator and scraper assembly
- Flash mixer
- DAF system
- Filter underdrain system and media
- RO membranes, microfilters, vessels, skid, ERD and pumps
- Metallic tanks and steel structure for warehouse
- Thickener drive, scraper mechanism
- All Chemical dosing systems
- Pumps and blowers including their motors rated at greater than 20 kW
- Valve and valve actuators
- Valves greater than 300 mm diameter
- Sluice gates and gate actuators
- Chlorination system
- Agitators, mixers, static mixers
- Cranes 2 ton and above
- Belt filter press and associated plant
- Piping & specials above 300mm diameter

The Engineer reserves the right to be present during the testing of all Plant items. The

Contractor shall carry out tests as per the current appropriate Indian Standards; performance tests and such other tests as are necessary, in the opinion of the Engineer /Employer's representatives, to determine that the Plant/equipment complies with the Employer's Requirements and as per the Performance Guarantees either under test conditions in the manufacturer's works, or on site.

The Engineer reserves the right to require the Contractor to meet any costs which are occasioned by failure of the Contractor, in the opinion of the Engineer to take sufficient care before presenting the Plant for inspection or tests. If unauthorised delivery has taken place, the Contractor may be required to arrange for the equipment/units to be returned to the manufacturer for inspection and/or witness testing by the Engineer at the Contractor's expense.

If the tests are beyond the resources of the manufacturer he shall make arrangements for these to be carried out elsewhere having authorized accredited facility. Any variation of this requirement shall be agreed and confirmation in writing obtained from the Engineer.

Test certificates including check sheets shall be submitted as part of the QA/QC plan. These shall include all test results, calculations, performance graphs and curves, etc and shall be endorsed by representatives of the manufacturer and the Contractor. No inspection or passing by the Engineer of Plant items shall relieve the Contractor of his obligations under the Contract. Material test certificates shall have traceability.

All apparatus, instruments and connections required for the tests shall have been tested and calibrated for accuracy and safety and certified as such within the preceding six months.

Any equipment used in the testing of the Plant shall in all respects comply with the appropriate safety regulations and/or requirements regarding electrical apparatus for the safety of the Plant and the personnel working thereon.

10.1.2 Factory Acceptance Test Document/Quality Assurance Plan

Sixty (60) days prior to commencement of inspection of each Plant/equipment item the Contractor shall supply a Factory Acceptance Test (FAT) Document/Quality Assurance Plan (QAP) with reports at various inspection stages for review and approval. This shall comprise four copies of the following:

- unpriced copy of the Contractor's order for the Plant item concerned
- details of the inspection and test procedures to be carried out

The FAT Document shall provide comprehensive details of the tests to be carried out, the purpose of each test, the equipment to be used in carrying out the test and the methods to be adopted in carrying out the tests. The FAT Document shall provide space within the documentation for results of the tests to be added and for each test and for the FAT Document as a whole to be signed off by the Contractor and the Engineer.

On completion of the tests the Contractor shall provide four copies of all test certificates,

curves etc. for the inspected Plant items. To remove doubt test certificates shall be provided for the Plant items as a whole plus certificates for the relevant component parts such as:

- Power transformers (all ≥ 0.433 kV)
- 230kV, 110kV & 11kV switchboards
- MCC s and switchboards
- Capacitor banks with APFCR
- Motors
- Battery and battery charger with DC distribution board
- Power and control cables
- pumps
- instruments
- DCS
- gear boxes
- integral control and switchgear panels
- valve gear
- castings
- all types of filter and settling media
- all types of process units
- microfilters
- RO membranes
- RO vessels

Where witness tests are not required the test certificates check sheets and curves etc. shall be forwarded to the Engineer within two weeks of the tests being completed.

The Contractor shall not deliver Plant to the site without the Engineer's approval in writing. This permission will not be given unless amongst other things a valid Contractor's test certificate and completed FAT Document for the item of Plant concerned is in the possession of the Engineer.

10.1.3 Inspection and Testing Programme

The Contractor shall submit to the Engineer not later than sixty (60) days prior to the commencement of the first inspection and test during manufacture, a schedule/programme detailing the inspection dates for all equipment/units/plants. Those items of Plant that the Engineer has specifically identified for witness testing, shall be highlighted in the

programme.

The Contractor shall keep the Engineer/ Employer's representative informed of any changes to the programme.

The Engineer/ Employer's representative shall not be requested to inspect an item of Plant until the Contractor has satisfied himself that the equipment meets all requirements of the Employer's Requirements.

The Contractor shall inform the Engineer in writing at least 21 days in advance regarding readiness for carrying out inspection of equipment/material etc. at manufacturer's works or at places of inspection. The programme for inspection shall be finalised by the Engineer after the receipt of the above. In case inspection cannot be carried out due to non-readiness of equipment/material, etc. a subsequent date shall be finalised for carrying out the inspection and all expenses of the Engineer / Employer's representative for such visits shall be incurred by the Contractor. In case equipment/material, etc. is found not to comply with the specification, dates for re-inspection shall be finalised and expenses incurred by the Engineer for such visits shall also be recovered from the Contractor. Contractor's Representatives shall be present during all inspections. The following information shall be given in the inspection call letter mentioned above:

- (a) Name of manufacturer/supplier
- (b) Address of place where inspection is to be carried out
- (c) Proposed date/s and equipment to be inspected
- (d) Name(s) of contact personnel at manufacturer's/supplier's works with their telephone and fax numbers and e-mail address
- (e) Name of Contractor's Representative who will be present during the inspection
- (f) Confirmation that internal testing has been completed
- (g) Testing Procedure with relevant codes and standards
- (h) Confirmation that the testing procedure has been approved

The Contractor shall provide all the necessary instruments to carry out the tests after assembly. All instruments used for such tests shall be calibrated and certified by and approved by an independent testing authority not more than six months prior to the tests in which they are used. Calibration certificates for instruments used for such tests shall be produced for the approval of the Engineer and if necessary, instruments shall be recalibrated before the commencement of the tests.

No material shall be delivered to the Site without inspection having been carried out or unless waived in writing by the Engineer. If during or after testing, any item of Plant fails to achieve its intended duty or otherwise proves defective, it shall be modified or altered as necessary and retested and re-inspected as required by the Engineer at the cost of the Contractor.

10.1.4 Manufacturer's Works Acceptance Tests on Mechanical Equipment

The Contractor shall carry out further specified tests (but not limited to) as follows in

addition to any tests stated or implied by the foregoing sections of this clause.

10.1.4.1 Pumps

Manufacturer's test certificates will be acceptable for small centrifugal pumps rated for powers of 20 kW or less.

All other pumps shall be tested individually in accordance with the relevant IS or International Standard. Site conditions shall be simulated as near as possible including the NPSH condition. Pumps shall be tested with their own prime movers. Where it is impractical to include the full length of the connecting shaft, the Contractor shall state the allowances to be made for the losses incurred by its omission and shall demonstrate the accuracy of the allowances to the satisfaction of the Engineer.

Each centrifugal pump shall be tested on the manufacturer's premises individually, in accordance with the provisions of IS 9137/BS EN ISO 9906:2000 with clean, cold water.

Each and every rotating part/assembly/sub-assembly shall be dynamically balanced as per grade G6.3 of ISO 1940/1 - 1986.

Each pump shall be tested at its guaranteed duty point and over its full working range from its closed valve condition to 20% in excess of the specified quantity at minimum head. Tests shall provide information for performance curves to be drawn for: head/capacity, efficiency/capacity and power absorbed/capacity.

Pump casings shall be subject to a pressure test at 2.0 times the pressure obtained with the delivery valve closed. The positive suction head shall be taken into account in determining this pressure. Performance characteristics of motors used during testing shall be furnished prior to commencement of tests.

In addition to confirming the hydraulic performance of the pump set as specified, the test shall demonstrate that vibration is within the specified limits and that the mechanical performance is satisfactory. However, for the purpose of the Performance Guarantee, noise and vibration levels shall be demonstrated at site to be within acceptable limits.

10.1.4.2 Valves

Test certificates will be acceptable for low pressure valves sized 300 mm diameter or less.

All valve bodies shall be hydraulically tested closed ended to (minimum) 1.5 times the rated pressure and at rated pressure for seat and duration as specified in IS:14846.

Satisfactory operation of manual/motorised and pneumatic actuators with valves shall be demonstrated.

Butterfly valves' body and disk with rubber seats shall be tested to the pressures and duration as specified under IS:13905.

10.1.4.3 Penstocks

Check for smoothness of operation and integrity of seal. Leakage tests shall also be carried

out as per appropriate standard. Satisfactory manual and motorised operation of penstocks shall be demonstrated.

10.1.4.4 Pipework

The inspection and testing of all pipework shall be carried out in accordance with the appropriate standards approved by the Engineer.

10.1.4.5 Cranes & Hoists

Cranes shall be completely assembled and tested for all operations in accordance with the relevant international standard. Internal Test certificates shall also be furnished.

Hoists and lifting equipment shall be assembled and tested at the place of manufacture in accordance with IS:3938.

Each and every rotating part/assembly/sub-assembly shall be dynamically balanced as per grade G16 of ISO 1940/1 - 1986.

10.1.4.6 Compressors

Tests shall be carried out in accordance with the relevant international standard. All compressors shall be tested with their ancillaries to confirm design performance particularly in respect of flow and pressure. The test shall demonstrate that vibration and noise are within the specified limits and that the pressure relief valve operates correctly.

Air receiver shall be tested in accordance with the relevant section of B.S. 5169. Air dryers shall also be tested as per relevant standards.

All pressure vessels shall be inspected and hydro water tightness tested.

10.1.4.7 Process Plant Items

All process Plant items shall be tested to ensure they meet the Employer's Requirements for quality of workmanship, construction and performance.

10.1.4.8 Chlorine Piping

All items of Plant shall be tested at manufacturer's works and test certificates shall be provided.

All chlorine piping from chlorine drums to chlorinator shall be pressure tested with dry air/nitrogen to a pressure of 15 kg/sq.cm.

The chlorine piping from the chlorinators up to injectors shall be pressure/vacuum tested with dry air/nitrogen to a pressure/vacuum equal to 1.5 times the maximum pressure/vacuum to be encountered during operation.

The motive water piping shall be hydrostatically tested for a pressure of 1.5 times the operating pressure or the maximum pump discharge pressure at pump shut off whichever is higher.

10.1.4.9 Ventilation system

The ventilation system (fans 400mm and above) shall be tested at manufacturer's works to verify the design flow and pressure. For all other fans test certificates shall be furnished for review.

10.1.5 Manufacturer's Works Acceptance Tests on Electrical Equipment

The Contractor shall carry out further specified tests as follows in addition to any tests stated or implied by the foregoing sections of this clause. The contractor shall submit detailed Quality Assurance Plans for all electrical equipment and items for review and approval be the Engineer prior to start of manufacturing.

10.1.5.1 Switchgear and Motor Control gear Assemblies

Switchgear and control gear shall be witness tested as complete assemblies.

Factory built assemblies of 230kV/110kV/11kV/0.415kV switchgear and control gear shall be tested in accordance with relevant Indian Standards.

Additionally, switchgears and control gear assemblies shall be tested for the following:

- (a) Interchangeability - All components of the same rating and construction, designated as draw out or plug-in shall be demonstrated as being interchangeable.
- (b) Protection and control circuits - For all forms of current transformer protection, the following information, as applicable shall be made available to the Engineer before the time of inspection:
 - current transformer magnetising curve
 - recommended relay setting
 - calculated primary operating current at this setting
 - calculated through-fault stability values where applicable
 - values of any stabilising and setting resistors employed in the system

As far as possible, based on the completeness of the circuits, in the final manufactured form within manufacturer's premises, the satisfactory operation of associated control and protection circuits shall be proved by the following tests as applicable.

- To ensure the correct operation of all relays and coils at the recommended setting by current injection
- To ensure the correct polarity between current and voltage elements of power relays, meters and instruments
- To ensure the correct operation of control circuits at normal operating voltage by operation of local control switches and simulation of operation from remote control positions

Note: Checking the operation of protection relays and control circuits shall be carried out

at site with all relevant circuits energized at their normal rated voltage.

The following tests shall be carried out but not limited to:

- Dielectric tests at an approved voltage/s
- Primary injection tests to ensure correct ratings and polarity of current and voltage transformers and of the current operated protection relays and direct acting coils, over their full range of settings
- Tests on auxiliary relays at normal operating voltages by operation of associated remote relays
- Correct operation of sequencing and control circuits at normal operating voltages by operation of local control switches, and simulation of operation from remote control positions
- Correct functionality of the equipment in all modes of control

10.1.5.2 Transformers

Transformers shall be subject to works routine and acceptance tests as defined in the relevant standard. Type test certificates issued within the past three years shall be provided for the following:

- impulse voltage withstand
- temperature rise

10.1.5.3 Capacitor Bank with APFCR

The capacitor bank with APFCR shall be subject to works routine and acceptance tests as defined in the relevant standards

10.1.5.4 Battery and Battery Charger with D.C Distribution Board

The battery and battery charger with D.C distribution board shall be subject to works routine and acceptance tests as defined in the relevant standards.

10.1.5.5 Cables

All cables and armoured cables shall be subject to routine and acceptance tests in accordance with the relevant Indian Standards. Test certificates shall be provided against each drum and/or cable length. The tests carried out on every cable length and/or drum at manufacturer's premises shall include:

- high voltage DC insulation pressure test, between cores, each core to earth, metallic sheath or armour as applicable
- insulation resistance test
- core continuity and identification

- conductor resistance test

10.1.5.6 Motors

The manufacturers type test certificate and an individual motor test certificate shall be provided for all motors. All type test certificates shall have been issued within the past three years.

Electric motors shall be subjected to routine and acceptance tests in accordance with relevant Indian Standards.

It shall be responsibility of the Contractor to select sizes, and types of motors to suit the starting and running characteristics of driven equipment with due consideration for specified margin over the requirement of the driven equipment at duty point. Motors not complying with the above shall be replaced by the Contractor at his own cost by appropriate motors. Replacement motors shall undergo testing and inspection as per the provisions in the contract. Cost of such testing and inspection shall be to Contractor's account.

The motor rotor assembly shall be dynamically balanced as per grade 6.3 of ISO 1940/1-1986.

10.1.6 Manufacturer's Works Acceptance Tests on ICA Equipment

The Contractor shall carry out further specified tests as follows in addition to any tests stated or implied by the foregoing sections of this clause.

The tests shall be carried out on the fully assembled control panel containing the PLC and associated equipment in order to demonstrate correct functional operation of the hardware and software systems.

The Contractor shall prepare for the approval of the Engineer a detailed Factory Acceptance Test (FAT) document that shall fully detail the scope of the tests to be carried out and the tests themselves.

The tests shall encompass the normal modes of operation and failure modes and shall demonstrate correct functionality of the system or systems in accordance with the Functional Design Specification (FDS).

The test shall include the following but not limited to:

- Hardware Verification and Functional checks
- Software verification checks and functional checks
- Communication verification and redundancy checks
- Network Loading checks
- Redundancy checks on Hardware and Communications
- DCS Controllers Loading test
- DCS Controllers Functionality checks

- DCS self-diagnostics tests
- 3rd Party Communication and Control interface test
- Stakeholders interface test
- Automation logic checks
- Data Archiving checks
- Response time checks
- Any other functional checks described by the PMC/Employer

The DCS program or programs shall be tested by means of a test rig designed to input and receive digital and analogue signals. Using this test rig it shall be possible to fully simulate the operation of the controlled equipment in order to demonstrate correct functional operation of the hardware and software systems.

The analogue to digital conversion shall be tested by means of a calibrated current source, digital to analogue outputs shall be tested by means of ramping the output channel and measuring the current by means of a calibrated current meter.

All inputs and outputs to the Controller and associated equipment shall be made through the field terminal connections of the control panel containing the Controller and associated equipment.

10.1.7 Manufacturer's Works Acceptance Tests on Uninterruptible Power Supplies

The Contractor shall carry out further specified tests as follows in addition to any tests stated or implied by the foregoing sections of this clause.

The tests shall be carried out on the fully assembled unit utilising the batteries that are to be supplied with the unit.

The Contractor shall demonstrate the following:

- change-over from full load with mains present to full load on battery supply
- carry out a discharge test on the system at full load and for the specified duty bridging time period
- carry out recharge test after operation for the specified duty bridging time at full load, the UPS shall supply the full load during the recharge cycle

10.2 Inspection at Site

Detailed Field Quality Plan (FQP) shall be submitted by the contractor to the engineer for review and approval prior to commencement of work at site. All disciplines of site works shall be covered in the FQP. All site works shall be performed strictly in line with the approved FQP. Any deviations found will be recorded in the form of NCR's or Punch List and shall be corrected as instructed by the Engineer.

During erection of the Plant, the Engineer will inspect the installation from time to time in the presence of the Contractor's Supervisor to establish conformity with the requirements of the Specification. Any deviations found shall be corrected as instructed by the Engineer.

10.2.1 Plant Protection on Site

Factory finished Plant shall be adequately protected both before and during installation against damage to finished surfaces, fitted components, and the ingress of dust. It may be necessary for structural finishing operations to be carried out in the vicinity of installed Plant before it is taken over and the Contractor shall take this into consideration in complying with the requirement of this clause.

10.2.2 Erection Staff

The Contractor shall provide at least two approved senior English speaking working erectors to supervise the erection of all Plant in the Contract.

The Contractor shall also provide sufficient erectors skilled in electrical, mechanical and instrument engineering, with such skilled, semi-skilled and unskilled labour as are necessary to ensure completion of the various sections of the Contract in the time required. The Contractor shall not remove any supervisory staff or labour from the site without the prior approval of the Engineer.

The Contractor shall make all the necessary arrangements to ensure that sufficient Plant has been or is about to be delivered to site, so that there shall be no delay to the start of erection.

It shall be the responsibility of the Contractor to obtain necessary License/Authorisation/Permit for work from the Licensing Boards of the locality where the work is to be carried out. The persons deputed by the Contractor's firm should also hold valid permits issued or recognized by the Licensing Board of the locality where the work is to be carried out.

10.2.3 Erection and Building In

10.2.3.1 General

The installation work shall comply with the latest applicable Standards, Regulations, Electricity Rules and Safety Codes of the locality where the installation is to be carried out. Nothing in this specification shall be construed to relieve the Contractor of this responsibility.

It shall be the Contractor's responsibility to obtain approval/clearance from local statutory authorities including Electrical Inspector, wherever applicable for conducting of any work or for installation carried out which comes under the purview of such authorities.

The Contractor shall carry out the complete erection of all Plant, including the provision of all necessary skilled and unskilled labour, material, transportation, supplies, power and fuel, Contractor's Equipment and appurtenances necessary, for the complete and

satisfactory erection of the Plant.

The Contractor shall have a separate cleaning gang to clean all equipment under erection and as well as the work area and the project site at regular intervals to the satisfaction of the Engineer. In case the cleaning is not up to the Engineer's satisfaction, he will have the right to carry out the cleaning operations and any expenditure incurred by the Engineer in this regard shall be to the Contractor's account.

10.2.3.2 Erectors

The Contractor's employees shall include skilled erection staff in sufficient number, who shall arrive on the site on or before the respective dates set out in the approved work programme and prior to delivery of any item of Plant to the Site. The Engineer will not entertain any claim by the Contractor in respect of delayed erection due to a delay in the delivery of any items of Plant to the Site.

10.2.3.3 Contractor's Equipment, Materials and Appurtenances

The Contractor shall have available on the Site sufficient suitable equipment and machinery, as well as all other materials and appurtenances required by him, of ample capacity to ensure the proper erection of Plant and to handle any emergencies such as may normally be expected in work of this character.

The Contractor shall be responsible if any installation materials are lost or damaged during installation. All damages and thefts of equipment/component parts, after takeover by the Contractor, till the installation is taken over by Engineer shall be made good by the Contractor.

10.2.3.4 Workmanship

Plant shall be erected in a neat and workmanlike manner on the foundation and at the locations and elevations shown on the approved drawings and other engineering documents. Unless otherwise directed by the Engineer, the Contractor shall adhere strictly to the aforesaid drawings and no departures there from shall be permitted.

All Plant shall be correctly aligned, levelled and adjusted for satisfactory operation and shall be installed so that the proper and satisfactory connection can be made readily between the various units and pipework and equipment installed under the Contract. The mounting arrangements for pump sets shall be such that the alignment offset between motors and the driven equipment shall be well within 0.1 mm.

10.2.3.5 Building-in

Before commencing any erection work, the Contractor shall check the dimensions of structures where the various items of Plant are to be installed, and shall bring any deviations from the required positions, lined or dimensions to the notice of the Engineer and shall take such measures as are necessary for their correction.

The Contractor shall take particular care for the correct positioning and alignment of all

puddle pipes which are required through concrete structures prior to, and during the pouring of concrete.

The Contractor shall pin and plug in the holes prepared, all small clips, plugs, screws, nails, sleeves, inserts, etc. required for fixing electric wires and conduits, small pipework and all other apparatus.

The Contractor shall align all equipment and holding down bolts and shall inform the Engineer before proceeding with grouting-in the item or item concerned. The Contractor shall ensure that all equipment is securely held and remain in correct alignment before, during and after grouting-in.

The Contractor shall properly bed in cement grout each item of Plant or its supporting base resting on foundations, and shall grout-in where required holding down bolts placed in the holes prepared in the foundations. The materials and workmanship used in grouting shall be such as will result in a solid anchoring of foundation bolts and complete filling of the gaps between the Plant or its base and the foundations, without shrinkage or cracking.

10.2.3.6 Precautions

The approval by the Engineer of the Contractor's proposals for rigging and hoisting of any item of Plant into its final position shall not relieve the Contractor from his responsibility for avoiding damage to completed structures, parts or members thereof or other installed equipment. He shall at his own cost make good, repair or replace any damaged or injured items whether structural, mechanical, electrical, architectural, or of any other description, promptly and effectively to the satisfaction of the Engineer.

No Plant or other loads shall be moved across the floors of structures without first covering the floors with timber of sufficient size so that applied loads will be transferred to floor beams and girders of steel or concrete. If it is required to reduce bending stresses or deflection, the beam and girders shall be provided with temporary supports. Any movement of Plant and other loads over the floor structures shall be subject to the prior approval of the Engineer.

10.2.4 Inspection after Erection

After the erection of any item of Plant and its associated equipment has been completed, it shall be offered to the Engineer for inspection in its static state prior to commissioning the item.

The mechanical completion of Plant under erection shall be deemed to occur if all the units/systems of the Works are structurally and mechanically complete as noted below :

- a) All rotary, static, structural equipment, piping, electrical/instrumentation and other equipment under the scope of the Contract have been erected, installed and grouted and are as per the specifications.
- b) All systems have been cleaned/washed/flushed/drained/boxed up where necessary.

- c) All system testing including pressure, hydrotesting, vacuum and non-destructive tests, no load tests and such other tests are completed with safety valves/relief valves set to operating conditions installed in position.
- d) All panels, local control desks erected with power/control cable terminations with all continuity checks, insulation checks and other installation checks are carried out.

Prior to pre-commissioning checks, the Contractor shall erect the entire Plant and ensure readiness of civil works to the satisfaction of Engineer, so that the Works are physically ready to undergo pre-commissioning checks. Pre-commissioning checks shall include checks like no-load running of machinery, checks on instruments and electricals including calibration and loop checks, functional checks, inter-lock checks etc.

At the stage of mechanical completion of erection, the Contractor shall ensure that all the physical, aesthetic and workmanship aspects are totally complete and the Plant is fit and sound to undergo pre-commissioning checks.

The following documentation shall be completed before the Contractor notifies Mechanical Completion of Erection to the Engineer :

- All shop inspection records compiled and bound in 4 (four) copies.
- All erection and commissioning procedures duly approved.
- All instruction manuals in draft form - with each sheet bearing a stamp to indicate "DRAFT FOR REVIEW ONLY" submitted in 4 (four) copies.

Upon achieving mechanical completion, the Contractor shall notify the Engineer of such completion of section/units/systems and readiness for inspection for acceptance of mechanical completion of erection. The Engineer shall proceed with inspection of such sections/units/systems within 10 days of such notice.

Consequent to inspection, the Engineer will inform the Contractor a list of deficiencies mainly on the NCR and Punch list items for rectification and the Contractor shall complete the rectification work within a jointly agreed period prior to start of pre- commissioning tests. The erection period allowed by the Contractor shall include all activities of mechanical completion as noted above.

10.2.5 Site Acceptance Test Document

Sixty (60) days prior to commencement of tests, the Contractor shall supply a Site Acceptance Test (SAT) Document for approval. This shall comprise four copies of the details of the inspection and test procedures to be carried out in testing the Works.

The SAT Plan shall provide comprehensive details of the tests to be carried out, the purpose of each test, duration of test, acceptance limits/criteria, tolerance limits, the equipment to be used in carrying out the test and the methods to be adopted in carrying out the tests. The SAT shall provide space within the documentation for results of the tests

to be added and for each test and for the SAT as a whole to be signed off by the Contractor and the Engineer.

The SAT shall categorise tests as follows:

- Pre Commissioning Checks
- Dry Tests
- Wet Tests
 - hydraulic tests
 - process tests (Manual and Automatic)
- Trial runs
- Initial Performance Tests

Dry tests are those tests carried out without process fluid being present.

Wet tests are those tests carried out with raw seawater or product water in order to prove the hydraulic capability of the Works. Process wet tests are those tests carried out with raw water as the feed stock to prove the process capability of the various equipment and Works.

Trial runs are carried out across the Plant for each process areas which verify the completeness of the Plant and to all ancillary equipment, and of no known defects or outstanding works. The trial run tests are also carried out as a whole plant test, which aims at testing the Plant at various load settings and operating conditions, including Starts, Stops, and Switchover for different mode of operation.

Initial performance tests are carried out after Dry and Wet tests and trail runs to check the performance of the complete process of the Plant as a whole. Both water treatment processes and wastewater treatment processes shall be tested. The tests are described in detail below.

All tests shall comply with relevant approved National and/or International standards/codes.

It shall be assumed that the co-operation of other contractors in the carrying out of Tests on Completion will not be unreasonably withheld.

10.3 Tests On Completion

The Tests on Completion referred to in Clause 11 of the General Conditions of Contract shall be read in conjunction with the Clause 3.12 of Chapter-3 of Section VI, Part 2. The purpose of Tests on Completion shall be to demonstrate and confirm that the Works can fulfil all the mechanical, electrical and process & control requirements of the Specification. This includes all commissioning and initial performance tests.

Prior to the commencement of Tests On Completion, the Contractor shall submit for approval the following along with all the documents required as given in the Part-2,

Chapter 3 document:

- Site Acceptance Test Documents
- As-Built Drawings
- Operation and Maintenance Manuals
- Punch List Status

Tests on Completion shall not be commenced until the aforementioned documents are prepared by the Contractor and approved by the Employer.

The initial stocks of oil, grease, chemicals, membrane etc. necessary for Tests shall be kept ready and to be provided by the Contractor. The costs of chemicals, power, spare parts and any other ancillaries used for the Tests shall be met by the Contractor.

The Contractor shall carry out all tests on the Plant and shall supply five hard copies of all test results with one soft copy to the Engineer. The test report shall include recordings of power and chemical consumption and Plant performance/ behaviour pattern.

All tests shall be to the approval of the Engineer who may require them to be repeated, prolonged or modified as may be necessary to ensure that any or all items of the Plant conform with the Contract. The Engineer shall be permitted to inspect all systems which are undergoing tests.

If any item of Plant fails during or after testing to achieve its intended duty or otherwise proves defective, it shall be modified or altered or replaced with the capacity/rating of Plant item as necessary and suitable and shall be re-tested and re-inspected as required by the Engineer.

Apart from process performance, the vibration/noise level tests shall be carried out at site which will form basis for acceptance of the equipment. If the Contractor is not in a position to meet the requirements given below as per ISO 10816 – 1995, the equipment may either be rejected or the Contractor shall carry out all necessary modifications to keep vibrations/noise within the acceptable limits specified in table below.

Table 10-1: Noise Level as per ISO 10816

Equipment	Noise Level dBA at 1.86 m from Equipment	Velocity of Vibration mm/sec
All rotating equipment not having reciprocating parts with motor kW less than or equal to 15 kW	85	1.12
All rotating equipment having reciprocating parts with motor kW more than 15 kW and less than or equal to 75 kW	85	1.8
All rotating equipment not having	85	2.8

reciprocating parts with motor kW greater than 75 kW		
All equipment having reciprocating parts viz. compressors, dosing pumps sampling pumps	85	-

The Contractor shall deploy required experienced engineers and technical staff for completing the testing and commissioning of the plant and equipment. As a minimum, the contractor shall have four experienced commissioning engineers, two for process and Plant and the other two for electrical/instrumentation and control works on site during all tests in order to demonstrate the Plant and to correct any faults which may occur.

10.3.1 Pre-Commissioning Checks and Dry Test Requirements

10.3.1.1 General

As a minimum requirement the following checks shall be carried out as a general requirement. However, Contractor shall submit and obtain approval for procedures for pre commissioning checks and dry test requirements

- a general inspection to check for correct assembly and quality of workmanship
- a check on the presence of lubricant, cooling medium, electrolyte, etc.
- a check on adequacy and security of Plant fixing arrangements
- a general check to ensure that all covers, access ladders, water proofing, guard railings etc are in place
- a check on damp-proofing, rust-proofing and vermin-proofing and particularly the sealing of apertures between building structures, chambers etc and the outside

10.3.1.2 Civil and Building Works

Procedure for the same shall be submitted by the contractor for review and approval by the employer.

10.3.1.3 Mechanical Works

As a minimum requirement the following dry tests shall be carried out on the mechanical systems. However, Contractor shall submit and obtain approval for procedures for pre commissioning checks and dry test requirements

- carry out preliminary running checks as far is permitted by circumstances in order to ensure smooth operation of Plant
- Monitoring and control from remote workstation.
- Automatic switchover from normal power to emergency power, and emergency power to normal power.

- All control functions, both at local system and remote workstation.
- Operation of all monitoring instruments.

10.3.1.4 Electrical Works

As a minimum requirement the following dry tests shall be carried out on the electrical systems. However, Contractor shall submit and obtain approval for procedures for pre commissioning checks and dry test requirements

- check phasing and polarity;
- carry out point to point check on all cables;
- check on security of cable termination;
- check on completeness and adequacy of earthing systems;
- check setting on protection relays, sizes of fuses and motor overload settings;
- carry out checks on cabling systems in accordance with the requirements of the relevant standards;
- check operation of main circuit breakers by secondary injection methods;
- check rotational direction of Plant.

10.3.1.5 ICA Works

As a minimum requirement the following dry tests shall be carried out on the I&C systems. However, Contractor shall submit and obtain approval for procedures for pre commissioning checks and dry test requirements

- check instrument loop integrity, functionality and calibration
- check Plant functionality
- check functionality of the central HMI and its power supply
- check functionality of the plant to other communications interface (3rd party interfaces and stake holder interfaces)

All control sequences shall be fully tested unless there is potential for damage to the equipment. All safety and protection devices (e.g. flow switches) shall be tested to ensure that they operate correctly.

10.3.2 Wet Test Requirements

Wet tests shall be carried out on completion of dry tests and shall comply with relevant approved engineering international standard/code.

Raw seawater or product water (if available) shall be used for hydraulic wet tests. The

purpose of the tests is to prove as far as is practical the hydraulic performance of the Works. In order to demonstrate this the Contractor shall ensure that each part of the Works is hydraulically loaded to its rated throughput (including a period of overload if required in order to demonstrate compliance with the Employer's Requirements) for a continuous stable operating period of not less 48 hours.

In order to ensure a sufficient supply of raw water to carry out these tests, the Contractor shall provide facilities for the disposal of wastewater off site in an approved manner.

The following tests inter alia shall be carried out for all the installations to check their functionality and integrity:

- Hydraulic test for all piped systems shall be carried out in accordance with the relevant standards
- Hydrotest of all RCC tanks for leak tests
- Hydrotest of all storage vessels.
- running of all pumped systems to check for:
 - correct functionality
 - absence of leaks
 - correct running temperatures
 - smoothness of running and the absence of undue vibration or stress
 - check drive running currents
- carry out calibration of instruments where appropriate
- carry out valving, diversions etc. to fully hydraulically load (or where there is a requirement to withstand an over load to overload) each process element
- manual operation and automatic commissioning tests of all the equipment and protection systems
- manual operation and automatic commissioning tests of all the process units including RO system
- alarm initiation
- demonstrate correct functionality of electrical, control and instrumentation systems
- Start-up tests for each process areas of the plant, verify the completeness of the Plant and to all ancillary equipment, and of no known defects or outstanding works.
- All control sequences shall be fully tested unless there is potential for damage to the equipment. All safety and protection devices (e.g. flow switches) shall be tested to ensure that they operate correctly.
- Verification of conformance to the specified or guaranteed performance as far as is practical at the initial loading

The Contractor shall simulate where practical the conditions that will prevail when operating as a process in order to demonstrate the correct functionality of process control loops etc.

During these tests, a check on the performance of Plant shall be made, as far as site facilities will allow, to compare its site performance with the factory test data and to identify any constraints on performance due to site conditions.

10.3.3 Safety Audit

After satisfactory completion of wet tests and prior to introduction of process fluid to the Plant, a safety audit shall be carried out to ensure compliance with the necessary requirement for safety and for operation of Plant. The safety audit shall be documented and shall be approved by the Engineer prior to commencement of Plant sterilisation.

10.3.4 Plant Sterilisation

On approval of the safety audit document the Contractor shall carry out sterilisation of the wetted parts of the Works. This shall also include the wetted surfaces of water treatment chemical storage and dosing systems.

The sterilisation process shall be carried out by completely filling the systems with water containing not less than 30 mg/L of free chlorine for a period not less than 48 hours. The contractor shall repeat the process if a residual chlorine stays below 10 mg/L.

The Contractor shall be responsible for the disposal of the sterilisation solution. The Contractor shall take the necessary measures to ensure that the free chlorine residual of the solution for disposal is not greater than 1 mg/L before discharge to the environment.

Areas such as the roofs of tanks not easily wetted by filling the vessel with sterilisation solution shall be sterilised using a procedure approved by the Engineer.

The Contractor shall give 2 weeks notice to the Employer of the proposed date for carrying out sterilisation.

The Contractor shall inform the Employer in writing when all wetted parts of Plant and civil structures have been sterilised.

If the Contractor carries out any work that invades a previously sterilised area the Contractor shall be required to carry out re-sterilisation of that area to the approval of the Engineer.

10.3.5 Punch List

Throughout the Start-up, commissioning and testing phase, the Contractor shall rectify minor Defects identified on a Punch List which shall be updated as items are rectified. Prior to Acceptance of the Plant, the Employer's Representative, PMC Consultant and the Contractor shall agree upon the final Punch List identifying all Defects which must be completed by the Contractor following Provisional Acceptance of the Plant together with

a timeframe for completion of each item. The punch list shall be categorized and prioritized.

10.3.6 Trial Run

After completion of the commissioning as per the agreed test program, the RO Plant, including related equipment, systems and facilities, shall be put into a minimum twenty-four (24) hour trial run at various load settings and operating conditions established mutually by the Contractor and Employer's Representative/PMC Consultant. Starts, stops and switching-over to standby equipment shall be included. The Contractor may extend the operating period if it considers this necessary to achieve the quality and stability of operation required for the Initial Performance Test.

However, after successful trial run and commissioning, the Employer at his sole discretion may commence commercial operations of the plant to meet the demand, if so is necessary in his sole discretion. During the said period the Contractor shall pay all the cost of the plant operation and maintenance and it will continue till the successful completion of the proves proving.

10.3.7 Initial Performance Test

On approval of the sterilisation process and trial run, the Contractor shall carry out initial performance tests (test on completion) as per the Clause 9 of GC of Contract. The contractor shall submit a "Initial performance test procedure" with pre-commissioning and commissioning activities for review and approval by the Engineer after which the test shall be carried out starting on an identified date. All the cost of the test including labour, power chemical, membranes etc. shall be borne by the Contractor. The product water during this period may be taken into public supply network depending on the Employer's discretion.

The Contractor shall run the Plant as a whole including RO system and sludge processing units in order to demonstrate the full functionality and performance of the Works at various throughput rates for a continuous period of not less than 15 days.

The activities necessary to complete before start-up of the Plant for the initial performance tests shall include, but not be limited to :

- i. Completion of buildings and civil works to the extent necessary for the safe and proper operation of the Works;
- ii. Successful completion of all tests associated with the civil/building, electrical, Instrumentation and mechanical works and individual process to the satisfaction of the Engineer.
- iii. Testing ventilating and air conditioning units;
- iv. Safety audit;
- v. Pressure testing, leak tests, tightness tests;
- vi. Checking of pipe hangers, supports, guides etc.;
- vii. Pipe and equipment flushing and cleaning;

- viii. Chemical protection of piping systems, if applicable;
- ix. Checking of coating, if applicable;
- x. Testing and adjustment of safety devices;
- xi. Checking and functionally testing of electrical systems according to IEC standards;
- xii. Valid calibration certificate of instrumentation is available, loop checking, functional testing of control equipment, interlocks, protection inputs, etc.;
- xiii. All equipment are in operating condition including the standby equipment as well
- xiv. Start-ups completion of relevant parts of the plant equipment, facilities and systems including automatic changeover of standby facilities
- xv. Operation of equipment for functional test.
- xvi. Process parameters achieved
- xvii. Complete Plant level Automation completed
- xviii. Operating stability verified between Minimum, Nominal and Maximum water output
- xix. Fire Fighting system completed

During the various process tests apart from the online water quality measurement, the Contractor shall take samples and carry out water quality analysis at the specified intervals or more frequent as required necessary by the Engineer in order to demonstrate that the Works is functioning in accordance with the Employer's Requirements. Each sample shall comprise two 1 litre (minimum) quantities and shall be labelled to identify the contents, where taken and time and date. One sample shall be used by the Contractor for his analysis, the other shall be handed over to the Engineer.

The Engineer reserves the right to take additional samples and to carry out his own tests or to check the samples taken by the Contractor.

The Engineer shall be given unhindered access to the premises where analysis is taking place in order to check on working practices and the procedures being adopted.

As much as possible, the pre-treatment and post treatment plant shall be operated with minimum automation for at least 3 days during 15 days initial performance test period. Manual operation shall be required to demonstrate the satisfactory operation of the whole Plant at all design flow rates whilst using the minimum quantity of automatic control and monitoring equipment. Such equipment shall be at least that required both for the maintenance of safety and for the normal mode of operation of the Plant.

During the test period; if the power supply should fail or other matters interfere outside the Contractor's control, the tests may be repeated or carried out of such number of broken days as the Engineer considers is the equivalent.

The exact date of commencement shall be subject to the approval of the Engineer and shall be dependent on the following conditions having been met:

- all pre-requisite tests satisfactorily completed
- all relevant items of Plant in approved working order
- all items of Plant correctly identified with labels
- The punch list items mutually agreed and closed
- the operation and maintenance manual is submitted and approved

10.3.8 Water Quality Criteria for Passing the Tests On Completion

The Works shall be considered to have achieved the required water quality standards for passing Tests On Completion if all samples taken during a 15 days continuous operational period comply with the criteria set down in Table 10-2 and Table 10-3 for the passing of the Tests, including criteria relating to the reliability of the Plant.

Initial performance tests shall not be commenced until all tests associated with the civil/building, electrical and mechanical works and individual process tests have been completed to the satisfaction of the Engineer. The product water during this period may be taken into public supply network depending on the Employer's discretion.

10.4 Process Proving Test

On successful completion of the commissioning with Initial Performance Tests, the Contractor shall carry out the Process Proving Tests for a period of 90 consecutive days. During these tests water produced by the Plant will be supplied to the public supply network. The process proving test conditions shall be read in conjunction of the provisions given in Chapter -3, Section VI, Part-2 of Employer's requirements.

The purpose of this test is to demonstrate the performance of the following Works:

- Intake system
- Pre-treatment system
- RO system
- Post treatment system
- Sludge treatment and disposal system
- RO membrane Cleaning (CIP)
- Power Receiving Station and Switchgears
- All allied units and buildings

Each part of the Works shall be considered separately as far as the tests are concerned.

The Contractor shall inform the Engineer in writing the date of completion of the Test on Completion (commissioning, initial performance test and the proving test). The total time for carrying out the Proving Tests shall not be less than 90 days.

If there is one event of failure, then the remedial action shall be taken and test is continued. If there is second event of failure, then the test will be stopped, and remedial action shall

be taken and the rest of the 90 days of test will be completed. If there are more than two events of failure when product water quality and quantity is not maintained as specified in the Contract during the 90 days of operation, the test shall be deemed as failed and the test shall be terminated. The Contractor shall carry out necessary remedial work to the satisfaction of the Engineer before the Employer approves to restart the test again. The event of failure is defined as the 3% reduction in product water quantity or deterioration of product water quality in terms of pH, turbidity, TDS, Boron and other vital parameters in 74 hours.

The Contractor will not be held responsible for interruptions to the desalination process as a result of grid power failures (unless as a result of any fault inside the Plant) resulting interruptions in the raw water supply etc. which are out of his control. However, the Contractor shall be required to demonstrate that the Works can cope with these inevitable interruptions in an orderly fashion and recover to a normal operational state with the minimum of manual intervention.

All manpower and consumables needed for operation of the Works during process proving period such as manpower, chemicals, power, membranes, materials, fuel, equipment, transportation of sludge off the site etc. shall be provided by the Contractor.

The Contractor shall provide all facilities and equipment not given in the contract and which are deemed necessary for the Employer to carry out and monitor the Tests on Completion. For the Employer to carry out any test to validate the performance of the Plant, the Contractor shall co-operate and co-ordinate his activities with those of the Employer and other subcontractors and bearing all the cost of the tests.

During the tests, the Contractor shall take samples to demonstrate that the Works are performing in accordance with the Employer's Requirements and as per the performance guarantees. The procedure for taking the samples shall follow as described in the Tender specifications elsewhere. Samples shall be taken at locations and intervals detailed in Table below. The results of the Tests on Completion shall be compared and evaluated by the Employer and Contractor. Also test results shall be recorded to demonstrate the power and chemical consumptions are within the guaranteed limits as committed by the Contractor in the technical schedules.

Table 10-2: Sample Locations and Intervals

Sample	Interval (hours)	Criteria for Passing Code
Raw Seawater at pump station	4	Not applicable
Tube Settler Clarifier effluent from each stream	8	Nr 1
DAF effluent from each stream	8	Nr 2
Filtered water from each stage	8	Nr 3

Sample	Interval (hours)	Criteria for Passing Code
RO feed water after micro-cartridge filter	8	Nr 4
RO permeate	8	Nr 5
Pump discharge from clear water reservoir	4	Nr 6
Sludge from sludge balance tank	24	Not applicable
Supernatant from thickener	24	Not applicable
Thickened sludge from thickener	24	Nr 7
Belt Filter Press sludge	24	Nr 8
Discharge wastewater in Sea	24	Nr 9

All above sampling and analysis shall be carried out in the laboratory established in the plant and outside agencies for result confirmation.

10.4.1 Criteria for Passing the Test on Completion

10.4.1.1 Water Quality Criteria at Different Process Units

The requirements of the water quality shall be considered to have passed the Initial Performance Test and Process Proving Test if all samples taken during the test period at different process units comply with the criteria set forth in the Table below. Also, the final product water is to meet the criteria given in Part-2 Chapter-1 document and BIS 10500 standards for drinking water quality. The water quality criteria are an absolute requirement (i.e. the stated water quality standards must be achieved).

Table 10-3: Performance Criteria Requirement

Passing Code	Performance Requirement in the Effluent
Nr 1	TSS < 15 mg/l TOC < 4 mg/l Turbidity < 10 NTU Colour < 5 Pt-Co Unit
Nr 2	TSS < 10 mg/l TOC < 3 mg/l Turbidity < 5 NTU Colour < 3 Pt-Co Unit
Nr 3	Turbidity: ≤ 0.2 NTU for 95% readings; and ≤ 0.5 NTU for rest of the time. TSS: 0.0 (Not detectable) TOC: < 2.0

Passing Code	Performance Requirement in the Effluent
	<p>pH: 7.0 to 8.5</p> <p>Residual Cl₂ < 0.2 mg/l</p> <p>Colour: < 3 units Pt/Co scale</p> <p>Iron: < 0.05 mg/L</p>
Nr 4	<p>Turbidity: ≤ 0.1 NTU</p> <p>TSS: 0.0</p> <p>TOC: ≤ 2.0</p> <p>Residual Cl₂ 0 mg/l</p> <p>Colour: < 1 units Pt/Co scale</p> <p>Iron: < 0.05 mg/l</p> <p>Manganese < 0.05 mg/l</p> <p>SDI: ≤ 3</p>
Nr 5	<p>TDS: < 330 mg/l</p> <p>Boron: < 1 mg/l</p>
Nr 6	<p>TDS: < 450 mg/l</p> <p>Boron: < 1 mg/l</p> <p>Hardness: ≥ 60 mg/l</p> <p>Faecal Coliforms 0/100 mL (Nil)</p> <p>Total Coliforms 0/100 mL (Nil)</p> <p>Taste and Odour – Unobjectionable</p>
Nr 7	Thickened sludge – 4 to 5 % solids
Nr 8	BFP waste solids – ≥ 25% solid
Nr 9	TSS <100 mg/l; metal ions as per regulatory norms

10.4.1.2 Product Water Quantity Criteria

The Works shall have fulfilled the product water quantity criteria if the Works have demonstrated that this can provide the quantity of product water detailed in the Contractors Functional Guarantee over a sustained and continuous period of 90 days during the Process Proving Tests.

The product water quality shall be sampled and tested by a Third Party every fortnight for the vital parameters to ensure the water quality meeting the requirements. The third party shall be NABL accredited laboratory in Chennai. All costs for the sampling and analysing of the product water shall be borne by the Contractor.

10.4.1.3 Sludge Quality Criteria

The sludge treatment plant shall have fulfilled the sludge quality criteria if the dried solids content of the sludge produced is as detailed Table below over a sustained and continuous period during the Process Proving Test. The sludge quality criteria are an absolute requirement (i.e. the guaranteed sludge quality must be achieved).

Table 10-4: Sludge Quality Criteria

Criteria Code	Criteria to be guaranteed
Nr 8	≥ 25 % dried solids
	@ all solids contents in feed

10.4.1.4 Operational Cost Criteria

The Works shall have fulfilled the operating cost criteria if the operating costs determined during the Process Proving Test are in agreement with or less than those detailed in the Contractor's Functional Guarantee. In case of any failure to meet the criteria as discussed in Part-2, Chapter 3 & 10, the liquidated damages and/or penalty shall be levied as per the Contract Conditions (Part-3).

10.4.1.5 Plant Reliability Criteria

Apart from the quality, quantity and operational cost criteria for the test discussed above, a part of the Works shall be deemed to have failed its test if a single item of Plant fails more than twice during the test, or more than four individual Plant items fail. An item of Plant shall be deemed to have failed if manual intervention is required in order to restore the item to its fully operational state (i.e. for example, the failure of a duty drive will be considered as one failure, if the standby drive fails to start that will be considered as a second failure).

Apart from the above, a failure of any single piece of main or auxiliary item should not cause any deterioration in quality and quantity of the plant product water. If any failure leads to a reduction in production or deterioration in product water quality, it shall be deemed as the failure of the test.

10.4.2 Completion of Design-Build

No item of Plant will be certified for completion under Clause 9.12 of the General Conditions of Contract by the Employer unless it has successfully passed the Process Proving Test.

A Commissioning Certificate for Plant shall not be issued unless 7 copies of the instruction manuals for operation and maintenance of that Plant and 7 copies of all completion (As-built) drawings with soft copies of all manual, drawing with civil structures have been received to the satisfaction of the Engineer.

The instruction manual complete including SCADA/DCS system for operation and maintenance of Plants shall be in two parts. Part 1 shall detail operation of entire Plant as a system giving sequence of operation, DO's and DONT's very clearly. The operation manual shall be user friendly so as to guide the operator faultlessly in operating the Plant. The manual shall be customized giving details of important information about operation, maintenance and troubleshooting, and it should not be mere collection of manufacturer manuals.

Part 2 of the bid document shall deal with maintenance of each component of the system,

sub-system etc. in full details giving details of construction, material, manufacturer's item code number, dismantling and assembly procedures, dimensions, routine checks to be carried out, signals and observation by predictive maintenance gadgets that can prompt maintenance, overhauling of sub-systems/systems.

The drawings shall give complete details of the systems, sub-systems like dimensions cross-sectional views, assembly details, etc. Maintenance schedules as specified by the manufacturers for each component of the system and for entire system shall be furnished.

A Commissioning Certificate defines the start of the Operation and Maintenance period but its issue does not relieve the Contractor of his obligation to the defect liability and continued satisfactory performance of the complete Works in all aspects.

10.4.3 Operation and Maintenance Period

The Operation and Maintenance Period of 20 years as defined in the Contract shall commence from the date of issue of the Commissioning Certificate, after successful completion of 90 days Proving Period. The detail of the operation and maintenance is provided in the technical requirements Chapter-13, Part-2.

10.5 Contract Completion Certificate

The issuance of a Contract Completion certificate is on the discretion of the Employer. The minimum conditions for issuance of a Contract Completion Certificate shall comprise:

- completion of the 20 years operation and maintenance of the Works to the satisfaction of the Engineer
- Operation and Maintenance Manuals have been updated following 20 years of operational experience and as approved by the Engineer.
- all defects identified prior to Taking Over and defects identified during the 20 years operation and maintenance of the Works have been rectified.
- all Tests before Handover have been completed to the satisfaction of the Engineer.
- all training detailed in the Employer's Requirements have been completed.

CHAPTER - 11

11. GENERAL PAINTING AND PROTECTION REQUIREMENTS

11.1 General

This section covers the general requirements related to the cleaning protective coating and painting of equipment, components, and system. Painting and protective coatings shall comply with the requirement of this section. The components and/or equipment shall be mechanically and /or chemically cleaned. The preparation, application and conditions for work shall comply with the recommendations of BS 5493 and BS 6150 or if the protection is of a special nature, in accordance with the manufacturer's directions.

The painting system shall be selected taking into consideration the high atmospheric salinity, humidity and temperature. The painting schemes that are in contact with potable water shall be non-toxic type food grade. The painting system that are not in direct contact with the potable water but that could cause toxicity to the potable water through the process is not allowed. Non-toxicity certificate shall be submitted for all such painting systems from a reputed international agency by the Bidder. The material selection has to be adequate to all relevant process and environmental conditions and has to be sufficient for design life.

Cathodic protection system for preventing galvanic corrosion shall be employed wherever necessary for Seawater applications.

Suitable protection for the Plant equipment and system shall be provided in form of selection and application of coating schemes. All concrete tanks in contact with sea water shall be epoxy screeded to 3 mm.

Color strip indication system should be used for pipes. These strips should be painted on the joint of pipes, entrance, valves of pipe. This pipe without outside protection layer should be marked by some color in whole length. The principal color of field equipment should be determined by the Owner/PMC and contractor during execution stage.

Paints, primers and undercoats shall be obtained from the same manufacturer and except where a definite time is specified between mixing and application, shall be ready mixed for use. They shall be compatible with one another.

Paints shall be delivered in sealed containers bearing the manufacturer's name, batch number, etc. and shall carry a label giving details of quality and instructions for use.

No site painting shall be carried out unless the surface to be painted is prepared and dried, the air temperature above 4°C and the relative humidity less than 85%. The Engineer / Employer's Representative shall approve the methods for removing all dirt, oil, grease, etc, before painting commences. No paints in any coat shall be applied until the Engineer/ Employer's Representative is satisfied that the surface is clean and dry. After cleaning when a surface is approved for painting, it must be painted immediately. Unless the manufacturer's instructions state otherwise 48 hours drying time shall elapse between successive applications of any primer

and 24 hours between applications of all subsequent coats. The surface of bituminous paints shall be left at least 3 days before further handling.

Test plates carrying finishes from the actual coating used may be required by the Engineer for inspection and test purposes.

To facilitate inspection, no consecutive coats of paint shall be of the same shade except in the case of white. Priming to two mating surfaces shall be applied prior to assembly.

All items of Plant shall be delivered to Site with the shop paint finish applied unless specified otherwise. A further coat of final finish paint shall be applied at Site, of sufficient thickness to produce a uniform colour and appearance and also to fix any damage to the painting during transport. Such painting shall be carried out within one month of successful acceptance trials for the Plant.

All paint dry film thicknesses shall be checked using an elkometer or equivalent instrument, supplied by the Contractor, for each layer of paint, to the satisfaction of the Engineer / Employer's Representative.

No paints in any coat shall be applied until the Employer's Representative is satisfied that the surface is clean and dry, and that any previous coat is satisfactory and has hardened adequately. When a surface has been approved, it must be painted immediately. Paintwork shall be rubbed down with a glass paper between coats. No paint shall be applied to a surface which is damp, dirty or otherwise inadequately prepared.

11.2 Equipment

All tools, brushes, rollers, spray guns, blast material, hand power tools for cleaning and all equipment, scaffolding materials, shot/sand blasting equipment & air compressors etc. shall be arranged by the Bidder at the site in sufficient quantity at his own cost. Bidder shall arrange at his own cost, for suitable paint thickness measuring instrument like Elkometers acceptable to the Engineer (with calibration facilities). Elkometers shall be provided to the Engineer for measurement of paint thickness. Instruments for surface finish and roughness measurement shall also be provided by the Contractor to the Engineer.

Mechanical mixing shall be used for paint mixing operations in case of two pack systems except that the Engineer may allow the hand mixing of small quantities at his discretion.

All the surface preparation, protective coating, painting of steel structures and equipment shall be suitable for prevailing site condition and particular care shall be taken for site near to or at Coastal and Marine environment condition. Contractor shall submit the surface preparation, Protective coating and painting specification for the Engineer's approval.

11.3 Extent of Works

The scope of work in this specification defines the requirements for surface preparation, selection and application of paints on external surfaces of equipment, vessels, machinery, piping, ducts, steel structures, external & internal protection of storage tanks for all services.

The following surfaces and materials shall require shop, pre-erection and field painting:

- i) All uninsulated equipment like pumps, valves, structural steel, vessels, storage tanks, pumps, compressors, electrical panels and motors etc.
- ii) All uninsulated carbon and low alloy piping fittings and valves (including painting of identification marks) ducts and stacks.
- iii) All items contained in a package unit as necessary.
- iv) All structural steel work, pipe, structural steel supports, walkways, handrails, ladders, platforms etc.
- v) Identification colour bands on all piping as required including insulated aluminium clad, galvanised, SS and non-ferrous piping.
- vi) Identification lettering / numbering on all painted surfaces of equipment / piping insulated aluminium clad, galvanised, SS and non-ferrous piping.
- vii) Marking / identification signs on painted surfaces of equipment / piping
- viii) Supply of all primers, paints and all other materials required for painting.
- ix) Over insulation surface of equipment and pipes wherever required.
- x) Painting under insulation for carbon steel and stainless steel as specified.
- xi) Repair work of damaged / protection / fabrication shop primer and weld joints at field.

The following surfaces and materials shall not be painted unless otherwise specified:

- i) Uninsulated austenitic stainless steel.
- ii) Plastic and / or plastic coated materials
- iii) Non-ferrous materials like aluminium, galvanised “piping”, “gratings” and “Handrails” etc. except G.I towers.

11.4 Colour Coding and Labelling of Pipes and Equipment

All pipes and equipment shall be colour coded to a schedule to be agreed with the Engineer before any site painting starts, or earlier if necessary, to suit manufacturing procedures. Valves and fittings shall be painted in the same colour as the pipe of which they form a part. Where a pipe enters or leaves a piece of equipment the pipe colour shall extend up to but not including the flange attached to the equipment.

All pipelines shall be identified by stick-on 90 micron thick vinyl film labels showing the name of the material to be carried by the pipeline and an arrow indicating the direction of flow. Letters of titles shall be pre-spaced on carrier tape and the complete title protected by one-piece removable liners. Titles shall be at intervals not less than 8 m, but shall in any case be provided in every space through which the pipe passes. Locations of labels shall be subject to prior approval by the Engineer. Lettering sizes shall be between 16 mm and 75 mm in height depending on the size of the pipe.

Pipes smaller than 22 mm outside diameter shall be labelled by the use of tags instead of labels. Tags shall be made of brass no smaller than 65 mm x 16 mm by 1.5 mm thick, with lettering etched and filled with black enamel. Titles shall also be provided on all equipment in locations and in sizes to be approved by the Engineer.

All paints and painting materials shall be stored only in rooms to be arranged by Contractor and approved by the Engineer for the purpose. All necessary precautions shall be taken to prevent fire. The storage building shall preferably be separate from adjacent building. A signboard bearing the words "PAINT STORAGE - NO NAKED LIGHT - HIGHLY INFLAMMABLE" shall be clearly displayed outside.

11.4.1 Colour Codes and Standards

The IS: 2379: 990 - Indian Standard for Pipeline Identification Colour Code and standards shall be followed for the work covered by this contract.

For identification of pipelines, the colour code as per the table below shall be used.

Table 11-1: Colour Coding Scheme for Pipes, Equipment, Machinery & Structures:

Description	Ground Colour	First Colour Band	Second Colour Band
Product Water	Sea Green	French Blue	Signal Red
Cooling Water	-do-	French Blue	-
Fire Water	Fire Red	Crimson Red	-
Sea Water	Sea Green	White	-
Compressed Air	Sky Blue	Signal Red	-
Plant Air	-do-	Silver Grey	-
Instrument Air	-do-	French Blue	-
CO ₂	-do-	Light Grey	-
Sulfuric Acid	Dark Violet	Brilliant Green	Light Orange
Nitric Acid	-do-	French Blue	-do-
Hydrochloric Acid	-do-	Signal Red	-do-
Caustic	Smoke Grey	Light Orange	-
Chlorine	Canary Yellow	Dark Violet	-do-

The colour code scheme is intended for identification of the individual group of the pipeline. The system of colour coding consists of a ground colour and colour bands superimposed on it.

Ground Colours as given in Table-11.1 shall be applied throughout the entire length for uninsulated pipes, ground colour coating of minimum 2 m length or of adequate length not to be mistaken as colour band shall be applied at places requiring colour bands. Colour band(s) shall be applied at the following location.

- i) At battery limit points
- ii) Intersection points & change of direction points in piping ways.

- iii) Other points, such as midway of each piping way, near valves, junction joints of service appliances, walls, on either side of pipe culverts.
- iv) For long stretch / yard piping at 50M interval.
- v) At start and terminating points.

11.4.2 Identification Sign

Flow direction shall be indicated by an arrow in the location stated above and as directed by the Engineer.

Colours of arrows shall be black or white and in contrast to the colour on which they are superimposed.

Product names shall be marked at pump inlet, outlet and battery limit in a suitable size as approved by the Engineer.

11.4.3 Colour Band

As a rule, minimum width of colour band shall conform to the following table:

Nominal Pipe Size	Width (mm)
3" NB and below	25 mm
Above 3" NB upto 6" NB	50 mm
Above 8" NB upto 12" OD	75 mm
Above 12" OD	100 mm

Note: For insulated pipes, nominal pipe size means the outside diameter of insulation. Nominal pipe size figures are to be in inches.

Colour band(s) shall be arranged in the sequence shown in Table 11.1 and the sequence follows the direction of flow. The relative proportional width of the first colour band to the subsequent bands shall be 4:1; minimum width of any band shall be as per the above table.

Whenever, it is required by the Engineer to indicate that a pipeline carries a hazardous material, a hazard marking of diagonal strips of black and golden yellow as per IS:2379 shall be painted on the ground colour.

11.4.4 Identification of Vessels, Piping etc.

Equipment number shall be stencilled in black or white on each vessel, column, equipment & machinery (insulated or uninsulated) after painting. Line number in black or white shall be stencilled on all the pipe lines of more than one location as directed by the Engineer; Size of letters printed shall be as below:

Column & Vessels	-	150 mm (high)
Pump, compressor and other machinery	-	50 mm (high)
Piping	-	40-150 mm

11.5 Inspection and Testing of Painting Materials

All painting materials including primers and thinners brought to site by Contractor for application shall be procured directly from manufacturers as per specifications and shall be accompanied by manufacturer's test certificates. Paint formulations without certificates are not acceptable.

The Engineer at his discretion may call for tests for paint formulations. Contractor shall arrange to have such tests performed including batch wise test of wet paints for physical and chemical analysis. All costs there shall be borne by the Contractor.

The painting work shall be subject to inspection by the Engineer at all times. In particular, the following stage wise inspection will be performed, and Contractor shall offer the work for inspection and approval of every stage before proceeding with the next stage. The record of inspection shall be maintained in the registers. Stages of inspection are as follows:

- a. Surface preparation
- b. Primer application
- c. Each coat of paint

In addition to above, record should include type of shop primer already applied on equipment. Red oxide zinc chromate or zinc chromate or Red lead primer etc.

Any defect noticed during the various stages of inspection shall be rectified by the Contractor to the entire satisfaction of Engineer-in-charge before proceeding further. Irrespective of the inspection, repair and approval at intermediate stages of work, Contractor shall be responsible for making good any defects found during final inspection / guarantee period / defect liability period as defined in general condition of contract. Dry film thickness (DFT) shall be checked and recorded after application of each coat and extra coat of paint should be applied to make-up the DFT specified.

11.6 Cleaning and Surface Preparation

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

11.6.1 General

In order to achieve the maximum durability, one or more of the following methods of surface preparation shall be followed, depending on condition of steel surface and as instructed by Engineer. Adhesion of the paint film to surface depends largely on the degree of cleanliness of the metal surface. Proper surface preparation contributes more to the success of the paint protective system:

- i) Manual or hand tool cleaning
- ii) Mechanical or power tool cleaning
- iii) Blast cleaning

Mill scale, rust, rust scale and foreign matter shall be removed fully to ensure that a clean and dry surface is obtained. The use of aromatic solvent prior to surface cleaning will remove all other contaminants, oil, grease etc.

Blast cleaning shall not be performed where dust can contaminate surfaces undergoing such cleaning or during humid weather conditions having humidity exceeding 85%.

Irrespective of the method of surface preparation, the first coat of primer must be applied on dry surface. This should be done immediately and in any case within 4 hours of cleaning of surface. However, at times of unfavourable weather conditions, the Engineer shall have the liberty to control the time period, at his sole discretion and / or to insist on recleaning, as may be required, before primer application is taken up. In general, during unfavourable weather conditions, blasting and painting shall be avoided as far as practicable.

11.6.2 Procedure of Surface Preparation

Parts shall be cleaned prior to testing at the manufacturer's works. Parts subject to hydraulic test shall be tested before any surface treatment. After test all surfaces shall be thoroughly cleaned and dried out if necessary, by washing with an approved dewatering fluid prior to surface treatment.

Bright parts: Bright parts and bearing surfaces shall be thoroughly polished and protected from corrosion by the application of rust preventive lacquer or high melting-point grease, as approved by the Engineer, before the parts are packed. A sufficient quantity of the correct solvent for removal of the protective compounds shall be supplied and packed with each particular part.

Embedded parts: Embedded parts or those parts of an assembly which will be embedded in concrete shall be thoroughly de-scaled and cleaned to the satisfaction of the Engineer and before being packed shall be protected by a cement wash or other approved method. No cast iron or steel work shall be bitumen or tar coated where it is to be cast into the concrete and provision shall be made for cleaning off any portions so coated.

Grit or shot blasted parts: Grit or shot blasting shall be carried out in accordance with BS 7079 to a standard between 'First Quality' and 'Second Quality' after which the maximum amplitude of the surface shall not exceed 0.1 mm.

Cast Iron and Steel pipework: All ungalvanized steel pipework including pump suspension mains, bearing spiders and tunnel tubes shall be prepared internally and externally by grit or shot blasting as specified above and the surfaces primed as specified within four hours of blasting.

11.6.2.1 Blast Cleaning

Air Blast Cleaning

The surfaces shall be blast cleaned using one of the abrasives such as Al_2O_3 particles, chilled cast iron or malleable iron and steel at pressure of 7kg/cm^2 at appropriate distance and angle depending on nozzle size maintaining constant velocity and pressure. Chilled cast iron,

malleable iron and steel shall be in the form of shot or grit of size not greater than 0.055” maximum in case of steel and malleable iron and 0.04” maximum in case of chilled iron. Compressed air shall be free from moisture and oil. The blasting nozzles should be venturi style with tungsten carbide or boron carbide as the materials for liners. Nozzle orifices may vary from 3/16” to 3 /4”. On completion of blasting operation, the blasted surface shall be clean and free from any scale or rust and must show a grey-white metallic lustre.

Primer or first coat of paint shall be applied within 4 hours of surface preparation. Blast cleaning shall not be done outdoors in bad weather without adequate protection or when there is dew on the metal which is to be cleaned. Surface profile shall be uniform to provide good key to the paint adhesion (i.e. 35 to 50m). If possible, vacuum collector shall be installed for collecting the abrasive and recycling.

Water Blast cleaning

Water Blast cleaning can be applied with or without abrasive and high-pressure water blasting. The water used shall be inhibited with sodium chromate / phosphate. The blast cleaned surface shall be washed thoroughly with detergents and wiped with solvent and dried with compressed Air. For effective cleaning abrasives are used. The most commonly used pressure for high pressure water blast cleaning for maintenance surface preparation is 3000 to 6000 psi at 35-45 litres / minute water volume and pressures up to 10000 psi and water volume of 45 litres / minute provide maximum cleaning.

The water blast cleaned surface shall be comparable to SSPC – SP – 12/NACE No.5.

11.6.2.2 Mechanical or Power tool cleaning

Power tool cleaning shall be done by mechanical striking tools, chipping hammers, grinding wheels or rotating steel wire – brushes. Excessive burnish of surface shall be avoided as it can reduce paint adhesion. On completion of cleaning, the detached rust mill scale etc. shall be removed by clean rags and / or washed by water or steam and thoroughly dried with compressed air jet before application of paint.

11.6.2.3 Manual or hand tool cleaning

Manual or hand tool cleaning is used only where safety problems limit the application of other surface preparation procedure and hence does not appear in the specification of paint systems.

Hand tool cleaning normally consists of the following:

- i) Hand descaling and / or hammering
- ii) Hand scraping
- iii) Hand wire brushing

Rust, mill scale spatters, old coatings and other foreign matter, shall be removed by hammering, scrapping tools, emery paper cleaning, wire brushing or combination of the above methods. On completion of cleaning, loose material shall be removed from the surface by clean rags and the

surface shall be brushed, swept, dedusted and blown off with compressed air / steam to remove all loose matter. Finally, the surface may be washed with water and dried for effective cleaning.

11.7 Primer Application

After surface preparation, the primer should be applied to cover the crevices, corners, sharp edges etc. in the presence of inspector nominated by the Engineer.

The shades of successive coats should be slightly different in colour in order to ensure application of individual coats, the thickness of each coat and complete coverage should be checked as per provision of this specification. This should be approved by the Engineer before application of successive coats.

The Contractor shall provide standard thickness measurement instrument with appropriate range(s) for measuring.

Dry film thickness of each coat, surface profile gauge for checking of surface profile in case of blast cleaning. Holiday detectors and pinhole detector and positector whenever required for checking in cast of immersion conditions.

Prior to application of paints on surfaces, the thickness of the individual coat shall be checked by application of each coat of the same paint on M.S. test panel. The thickness of paint on test panel shall be determined by using gauge such as 'Elkometer', the thickness of each coat shall be checked as per provision of this specification. This shall be approved by the Engineer before application of paints on surface.

At the discretion of the Engineer, the paint manufacturer must provide the expert technical service at site as and when required. This service should be free of cost and without any obligation to the Employer, as it would be in the interest of the manufacturer to ensure that both surface preparation and application are carried out as per their recommendations.

Final inspection shall include measurement of paint dry film thickness, Adhesion, Holiday detection check of finish and workmanship. The thickness should be measured at as many points / locations as decided by the Engineer and shall be within +10% of the dry film thickness, specified in the specifications.

The Contractor shall arrange for spot checking of paint materials for Sp. gr., flow time (ford cup) and spreading rate.

11.7.1 Non-Compatible Shop Coat Primer

The compatibility of finishing coat should be confirmed from the paint manufacturer. In the event of use of primer such as zinc Rich epoxy, inorganic zinc silicate etc. as shop coat, the paint system shall depend on condition of shop coat. If shop coat is in satisfactory condition showing no major defects, the shop coat shall not be removed. The touch up primer and finishing coat (s) shall be identified for application by Engineer.

Shop coated (coated with primer & finishing coat) equipment should not be repainted unless paint is damaged.

Shop primed equipment and surfaces will only be 'spot cleaned' in damaged areas by means of power tool brush cleaning and then spot primed before applying one coat of field primer then shop coated primer should be completely removed before application of selected paint system for particular environment.

11.8 Painting and Finishing

This Clause governs the methods for the protective coatings to be applied to structural steel, metalwork and ironwork as corrosion protection systems. Protective coating specified elsewhere for particular works such as pipes and cladding shall firstly be designed in accordance with particular requirements specified elsewhere and secondly in accordance with any requirements herein which are not overridden elsewhere. This specification makes reference to the following standard: BS 5493 "code of practice for the protective coating of iron and steel against corrosion".

The Contractor shall design each protective coating system and shall submit details of each system to the Engineer for approval. Submissions shall where possible be in the format of which examples are given at the end of this part with such additional information and samples as the Contractor may provide or the Engineer may require to enable the system to be assessed.

Protective coating shall be designed in accordance with BS 5493 to have a long life, generally of at least 10 years prior to first maintenance. Protection systems shall be chosen to be easily maintained in the future and to allow non-specialist on-site re-coating where necessary using single part paints.

For the purposes of system design the general environment shall be as specified in BS 5493 Table 3 Part 2 'Exterior exposed polluted inland'. Bulkhead gates and stoplogs shall be assumed to be exposed to a Table 3 Part 8 'Non-saline water' environment unless otherwise approved by the Engineer.

Interior spaces shall be considered to be dry in administration areas open to continuous access and damp or immersed in other spaces. The protective coating of components or structures which are continuously or infrequently immersed shall be designed for the more onerous of these two conditions relevant to the protection system used.

All exterior exposed items to be coated shall have a final coat of good appearance of a colour and type as approved by the Engineer.

The Contractor shall submit to the Engineer details of his proposals for the corrosion protection of each of the items requiring such protection, which will generally fall into the above categories as follows:

- trash screens, flooring, ladders, access covers and frames, step irons and other components which are inaccessible but subject to abrasion/damage
- structural steelwork (including crane beams, monorails, crane structures and chassis), bulkhead gates, stoplogs, grappling beams, steel tanks and other large items readily

accessible for maintenance

- valves and other corrosion-susceptible items which may be buried and are not covered by the provisions of other specifications
- other components not covered by the above for which the contractor may propose a system which he considers to be more suitable for the duty
- electrical switchgear, transformers, control panels etc.

All painting material shall be applied in strict accordance with the paint manufacturer's instructions.

11.8.1 Coating Procedure and Application

Surface shall not be coated in rain, wind or in environment where injurious air-borne elements exist, when the steel surface temperature is less than 5°F above dew point, when the relative humidity is greater than 8% or when the temperature is below 40°F.

Blast cleaned surface shall be coated with one complete application of primer as soon as practicable but in no case later than 4 hours, the same day.

To the maximum extent practicable, each coat of material shall be applied as a continuous film uniform thickness free of probes. Any spots or areas missed in application shall be recoated and permitted to dry before the next coat is applied. Applied paint should have the desired wet film thickness.

Each coat shall be in proper state of cure or dryness before the application of succeeding coat. Material shall be considered dry for recoating when an additional coat can be applied without the development of any detrimental film irregularities, such as lifting or loss of adhesion of the under coat. Manufacturer instruction shall be followed for inter-coat interval.

When the successive coat of same colour have been specified, alternate coat shall be tinted, when practical, sufficiently to produce enough contrast to indicate complete coverage of the surface. The tinting material shall be compatible with the material and not detrimental to its service life.

11.8.1.1 Air Spray Application

Air spray application shall be in accordance with the following:

- i) The equipment used shall be suitable for the intended purpose, shall be capable of properly atomising the paint to be applied, and shall be equipped with suitable pressure regulators and gauges. The air caps, nozzles, and needles shall be those recommended by the manufacturer of the equipment for the material being sprayed. The equipment shall be kept in satisfactory condition to permit proper paint application.
- ii) Traps or separators shall be provided to remove oil and condensed water from the air. These traps or separators must be of adequate size and must be drained periodically during operations. The air from the spray gun impinging against the surface shall show no condensed water or oil.
- iii) Ingredients shall be kept properly mixed in the spray pots or containers during application by continuous mechanical agitation.

- iv) The pressure on the material in the pot and of the air at the gun shall be adjusted for optimum spraying effectiveness. The pressure on the material in the pot shall be adjusted when necessary for changes in elevation of the gun above the pot. The atomising air pressure at the gun shall be high enough to properly atomize the paint but not so high as to cause excessive fogging of paint, excessive evaporation of solvent, or less by overspray.
- v) Spray equipment shall be kept sufficiently clean so that dirt, dried paint, and other foreign materials are not deposited in the paint film.
- vi) Any solvents left in the equipment shall be completely removed before applying paint to the surface being painted.
- vii) Paint shall be applied in a uniform layer, with overlapping at the edge of the spray pattern. The spray pattern shall be adjusted so that the paint is deposited uniformly. During application, the gun shall be held perpendicular to the surface and at a distance which will ensure that a wet layer of paint is deposited on the surface. The trigger of the gun should be released at the end of each stroke.
- viii) All runs and sags shall be brushed out immediately or the paint shall be removed and the surface repainted.
- ix) Areas inaccessible to the spray gun shall be painted by brush, if not accessible by brush, daubers or sheepskins shall be used.
- x) All nameplates, manufacturer's identification tags, machined surfaces, instrument glass, finished flange faces, control valve items and similar items shall be masked to prohibit coating deposition. If these surfaces are coated, the component shall be cleaned and restored to its original condition.
- xi) Edges of structural shapes and irregular coated surfaces shall be coated first and an extra pass made later.
- xii) If spray gun shows choking, immediately de-choking procedure shall be followed.

Airless spray application shall be in accordance with the following procedure: as per steel structure paint manual Vol.1 & Vol.2 by SSPC, USA. Air less spray relies on hydraulic pressure rather than air atomization to produce the desired spray. An air compressor or electric motor is used to operate a pump to produce pressures of 1,000 to 6,000 psi. Paint is delivered to the spray gun at this pressure through a single hose within the gun, a single paint stream is divided into separate streams, which are forced through a small orifice resulting in atomization of paint without the use of air. This results in more rapid coverage with less overspray. Airless spray usually is faster, cleaner, more economical and easier to use than conventional air spray.

Airless spray equipment is mounted on wheels, and paint is aspirated in a hose that sucks paint from the container, including drums. The unit shall have inbuilt agitator that keep the paint uniformly mixed during the spraying. The unit shall consist of inbuilt strainer. Usually very small quantities of thinning are required before spray. In case of High Build epoxy coatings (two pack). 30:1 pump ratio and 0.020 – 0.023" tip size will provide a good spray pattern. Ideally fluid hoses should not be less than 3/8" ID and not longer than 50 ft. to obtain optimum results.

11.8.1.2 Brush Application

- i) Brush application of paint shall be accordance with the following:
- ii) Brushes shall be of a style and quality that will enable proper application of paint.

- iii) Round or oval brushes are most suitable for rivets, bolts, irregular surfaces, and rough or pitted steel. Wide flat brushes are suitable for large flat areas, but they shall not have width over five inches.
- iv) Paint shall be applied into all corners.
- v) Any runs or sags shall be brushed out.
- vi) There shall be a minimum of brush marks left in the applied paint.
- vii) Surfaces not accessible to brushes shall be painted by spray, daubers, or sheepkin.

11.8.1.3 Manual Application

Manual application by sling (where 6 O'clock position of pipe is not approachable)

A canvas strip (alternatively a tinplate strip) about 450 mm wide and 1.5 m long is held under the pipe by two men. Liquid coating is poured on the sling at each side of the pipe. The men holding this sling move it up and down and walk slowly forward while fresh coating is poured on the pipe and they manipulate the sling so that an even coating is obtained all-round the bottom. This work shall be done very carefully and by experienced personnel. There shall not be any formation of "Whiskers" and holes in the coating. The coating film shall be inspected by mirror.

For each coat the painter should know the WFT corresponding to the specified DFT and standardise the paint application technique to achieve the desired WFT. This has to be ensured in the qualification trial.

11.8.1.4 Drying of Coated Surfaces

No coat shall be applied until the preceding coat has dried. The material shall be considered dry for re-coating when another coat can be applied without the development of any film irregularities such as lifting or loss of adhesion of undercoats. Drying time of the applied coat should not exceed maximum specified for it as a first coat; if it exceeds the paint material has possibly deteriorated or mixing is faulty.

No paint shall be force dried under conditions which will cause checking, wrinkling, blistering formation of pores, or detrimentally affect the condition of the paint.

No drier shall be added to a paint on the job unless specifically called for in the manufacturer's specification for the paint.

Paint shall be protected from rain, condensation, contamination, snow and freezing until dry to the fullest extent practicable.

11.8.1.5 Repair of Damaged Paint Surface

Where paint has been damaged in handling and in transportation, the repair of damaged coating of pre-erection / fabrication shall be as given below:

Repair of damaged inorganic zinc silicate primer after erection / welding:

Quickly remove the primer from damaged area by mechanical scraping and emery paper to expose the white metal. Blast-clean the surface if possible. Feather the primer over the intact adjacent surface surrounding the damaged area by emery paper.

Repair of damaged pre-erection and shop priming in the design temperature of -90°C to 500°C .

- Surface preparation shall be done as per procedure given above.
- One coat of inorganic zinc silicate coating (F-9) shall be applied wherever damaged was observed on pre-erection / pre-fabrication / shop primer of F-9. F-9 shall not be applied if damaged area is not more than 5 x 5 cm.

Shop priming / pre-erection priming with F9 or F12 shall be done only on blasted surface and with airless spray. For large flat surface field painting shall be done by airless spray otherwise brush can be used.

11.8.2 Plant Supplied to Site with Final Coating Applied

Cubicles, Cabinets etc.

Before any steel work is painted the steel must be thoroughly cleaned and an approved anti-rusting priming coat applied so that the possibility of rusting or corrosion taking place is negligible. All surfaces should have not less than two undercoats and two top coats or air-drying paint. The undercoats shall be easily distinguishable in shade or colour from the priming and finishing coats. The two final coats shall be in a colour and finish to be advised by the Engineer. The inside surfaces of any cubicles, cabinets, etc. where condensation is liable to occur, shall be coated with an approved anti-condensation composition. The Contractor shall ensure that all component sections of a switch board wherever manufactured shall have a finish of uniform texture and an exact colour match.

Chromium Plated Parts

Where chromium plating is specified or offered by the manufacturer it shall comply with the requirements of BS 1224 including the following provisions. No blistering of any surfaces will be tolerated. The finished appearance shall be bright. Where the base metal is steel, plating shall be applied in accordance with Table 2 of the above code. Other base metals shall be plated in accordance with Tables 3, 4, 5 as appropriate. For all base metals the service condition number 2 (of the above code) shall be used. Small bore pipes, valves and fittings etc., which are sited in architecturally finished areas of the station and selected by the Engineer shall be chromium plated. Damage to chromium plating shall be made good before taking over.

Galvanised Parts

All materials to be galvanised shall be of the full dimensions shown on the approved drawings or specified and all punching, cutting, drilling, screw tapping and the removal of burrs shall be completed before the galvanising process begins. Parts to be galvanised shall be shot blasted as specified above. Such parts shall be galvanised not more than four hours after commencement of shot blasting.

All galvanising shall be done by the hot dip-process. No alternative process may be used without the approval of the Engineer. No components shall be galvanised which are likely to come into subsequent contact with oil.

The zinc coating shall be uniform, clean smooth and as free from spangle as possible. In the case of component parts the zinc coating shall weigh not less than 610 g/sq. m of area covered and shall not be less than 0.090 mm in thickness.

Bolts and nuts shall be standardised. The Engineer may select for test as many components to be weighed after pickling, and before and after galvanizing as he may think fit.

All galvanised parts shall be protected from injury to the zinc coating due to differential serration and abrasion during the periods of transit, storage and erection. Damaged areas of the coating shall be touched up with an approved zinc-dust paint or other approved flake metallic compound.

Cast Iron and Steel Pipework (Internal Surfaces)

The internal surfaces shall have an approved coating. Where a bitumen-based coating is used, it shall be in accordance with Type 2 of BS 4147.

Prior to lining, the pipe shall be grit blasted and primed with an approved primer. The lining shall be in accordance with BS 534. After installation, the internal lining shall be made good and satisfactorily tested with a Holiday detector to 8 kV.

The coating shall be suitable for use in contact with drinking water. The type of coating shall be entered in Schedule L provided and the Engineer reserves the right to call for test plates of the paint. The manufacturer shall at the time of ordering carry out the 'Taste and smell test' (Appendix E of BS 4147) and 'Effects on water test' (Appendix C of BS 3416) and forward 3 copies of the test results to the Engineer for approval.

Where pipe are to be welded after the protective coatings have been applied the pipe surfaces shall be primed and all other coating stopped 250 mm short of the weld preparation. Collars and fillings shall be primed but no other coating applied.

The manufacturer shall supply a sufficient quantity of suitable materials to repair damage occurring during delivery to site and to provide a flush finished internal lining at welded joints. He shall supply sufficient coating to fill in the recesses at internal welds over the previously primed areas. The costs of these materials shall be included in the unit rates for the supply of the pipes and specials. The coating shall be applied in accordance with the manufacturer's instructions and with Appendices J and K of BS 3416.

Cast Iron and Steel Parts (External Surfaces)

All ungalvanized metal parts which will be immersed in water shall be cleaned by grit blasting and within four hours of blasting given an approved coating. Ungalvanized metal parts exposed

in manholes or areas of high humidity shall be cleaned by grit blasting and given two coats of a black bituminous solution.

11.8.3 Plant Forwarded to Site for Final Finishing

Cast Iron and Steel Parts (External Surfaces) Outside Buildings

All ungalvanized metal parts which will be exposed to the outside atmosphere shall be cleaned by grit blasting and provided with two coats of an approved primer.

Cast Iron and Steel Parts Inside Buildings

All exposed metal surfaces which will not be immersed in water or exposed in areas described above shall be rubbed down, cleaned by grit blasting and within four hours of blasting given one coat of an approved primer before packing.

11.9 Painting at Site

Immediately on arrival at the site, all items of plant shall be examined for damage to the paint coat applied at the manufacturer's works, and any damaged portions shall be cleaned down to the bare metal, all rust removed, and the paint coat made good with similar paint.

Steel and cast-iron parts received at site shall be provided with adequate number of further coats of coal tar epoxy polyamine coating or Polyurethane coating as specified & approved, to a total dry film thickness of minimum 275 microns including the primer coats unless specified somewhere else. All sharp edges, nuts, bolts and other items difficult to be painted shall receive a brush coat of specified paint before application of each coat of epoxy-based coal tar paint giving a total dry film thickness of at least 275 microns. In the case of fabricated steelwork this work shall be done after assembly.

Before painting is commenced the Contractor shall submit for the approval of the Engineer, full details of the paints he proposes to use together with colour charts for the gloss finishes.

After erection, such items which are not finish painted shall be finish painted, items finish painted at the Manufacturer's works shall be touched up for any damaged paint work.

The painting work shall conform to the following requirements:

- (a) The surface preparation shall be carried out generally in accordance with IS: 1477 Part I and IS: 6005.
- (b) After surface preparation, two coats of primer-red oxide zinc chromate with modified phenolic alkyd base conforming to IS: 2074 shall be applied. Dry film thickness of each coat shall be 25 microns.
- (c) For finish painting, after application of primer as in (b) above, two coats of synthetic enamel conforming to IS: 2932 shall be applied. Dry film thickness of each coat shall be 25 microns.

- (d) Colours shall be selected as per IS: 5

No painting shall be carried out unless the item has been inspected and accepted by Engineer at the Manufacturer's works.

The dry paint film thickness shall be measured by Electrometer or other instruments approved by the Employer. In order to obtain the dry film thickness DFT specified, the Contractor shall ensure that the coverage rate given by the paint manufacturer will enable this thickness to be obtained. Strength of adhesion shall be measured with an adhesion tester and this value shall not be less than 10 kg/cm². Painted fabricated steel Work which is to be stored prior to erection shall be kept clear of the ground and shall be laid out or stacked in an orderly manner that will ensure that no pools of water or dirt can accumulate on the surface. Suitable packings shall be laid between the stacked materials. Where cover is provided, it shall be ventilated.

The painting procedure shall be submitted in the following format for approval:

- (a) Surface Preparation
- (b) Reference Standard
- (c) Conditions of Work
- (d) Type of Materials
- (e) Tests and inspection methods and sequence, thickness (DFT)
- (f) Colour in final coat
- (g) Total thickness of coats (DFT)
- (h) Other necessary data and information

The following items in the plant are required to be painted:

- (a) Outer surfaces of pumps, valves, pipes, fittings, motors etc., not exposed to treated water
- (b) Steelwork exposed to weather, such as outer surface of surge vessel, valves, pipes etc.
- (c) Internal Plant and pipework, cranes, exhaust fans, fire extinguishers and miscellaneous steelwork not exposed to weather
- (d) Steelwork exposed to weather, such as platforms, ladders, hand railing, etc.
- (e) Steelwork exposed to humid weather and requiring hard maintenance and repairs
- (f) Buried steelwork
- (g) Buried pipes and fittings prior to application of wrapping
- (h) Other equipment, as per requirement of employer.

All buried steel pipes and fittings shall be coated and unwrapped with hot or cold applied, self-adhesive, polyethylene in accordance with AWWA C214 or equivalent Standard.

Cast iron or mild steel parts to be built into concrete shall remain unpainted. Immediately before it is cast in-situ, it shall be made perfectly free from dirt, scale, loose rust, paint, oil limewash or any other coating.

No blast cleaning or painting shall be applied to corrosion resistant Materials such as stainless steels. Ni-resist cast iron, bronze and other metals used for seals, bearings, lighting fitting etc.

Machined surfaces such as gear teeth shall be coated with a thick layer of grease. Other mechanical surfaces such as shaft ends or other bright parts shall be coated with two coats of an anti-rust solution which can be removed easily when required. Permanently bolted mechanical interfaces such as flanges shall be coated with a thin coat of anti-rust compound before assembly.

All primers, under coats and finishes shall be applied by brush or airless spray, except where otherwise specified.

Consecutive coats shall be in distinct but appropriate shades. All paints shall be supplied from the store to the painters, ready for application, and addition of thinners or any other Material shall be prohibited. Any instruction given by the paint manufacturer shall be strictly followed.

All painting shall be carried out by the painters under supervision. Paint shall be applied to the dry surface which has been prepared in compliance with the approved procedure.

Paint shall not be applied when the ambient temperature falls below 4°C or relative humidity rises above 90%.

The plant and equipment shall be inspected and reviewed at the various stages of the coating application both at the manufacturer's works and at the site of the Works. Samples may be taken from the paints as delivered and submitted to such tests as are deemed necessary. The completed paint systems shall be tested by instruments to ensure that the protection is of adequate thickness and is free from pinholes and the direct measurement of adhesion shall be checked by the removal of a small section of the coating. The Contractor shall supply all instruments and apparatus required for carrying out such tests required by the Employer.

11.10 Waterworks Finish

A high standard of finish, defined as "Waterworks finish" is required for all Plant as detailed below.

11.10.1 Welding and Flame Cutting

A smooth neat finish, by careful grinding if necessary is required on all exterior welding and flame cutting. All plates and bars used in fabrication shall have smooth surfaces with no pitting or deep slag inclusions.

11.10.2 Castings

Casting surfaces shall be smooth and free from surface blowholes. Stock castings shall be selected with this in mind. All castings shall be shot blasted before machining.

11.10.3 Covers

All covers shall be firmly fixed. Weld mesh shall sit square in its frame. Where panels are placed next to each other the patterns shall line up.

11.10.4 Flanges and Beadings

All bolt holes shall be spot faced parallel with the mating face for good seating of nuts and bolt heads. Surplus jointing shall be removed from mating faces and peripheries.

11.10.5 Items to be Chromium Plated

Name plates, instruction plates, rotation arrows, indicators and pointers, small bore pipework, tundish oil level gauges and fittings, small valves (including air valves), plugs and grease nipples, which are sited in architecturally finished areas of the station and as selected by the Engineer, shall be chromium plated. Damage to chromium plating shall be made good.

All pipes and fittings, etc. shall be fitted in a straight, neat symmetrical manner so as to present a pleasing appearance.

11.10.6 External Screws, Bolt-heads, Nuts and Washers

These shall be chromium plated, sherardised or made in stainless steel.

11.10.7 Gauges

All indicating gauges fitted to any machine assembly shall be of similar appearance and grouped together to present a pleasing aspect. They shall all have chromium-plated cases, bezels, cocks and fittings.

11.11 Guarantee

The Contractor shall guarantee that the chemical and physical properties of paint materials used are in accordance with the specifications contained herein / to be provided during execution of work.

The Contractor shall produce test reports from manufacturer regarding the quality of the particular batch of paint supplied. The Engineer shall have the right to test wet samples of paint at random, for quality of same. Batch test reports of the manufacturer's test for each batch of paints supplied shall be made available by the Contractor.

11.12 Painting sub Contractor

Painting sub contractor who is awarded any job for under this standard must have necessary equipment, machinery, tools and tackles for surface preparation, paint application and inspection. The contractor must have qualified, trained and experienced surface preparator, paint applicator, inspector and supervisors. The Contractor supervisor, inspector, surface preparator and paint applicator must be conversant with the standards referred to this specification.

11.13 Procedure for Approval of New Coating Materials and Manufacturers

Following procedure is recommended to be followed for approval of new coating material and manufacturers.

The manufacturer should arrange testing of the inorganic zinc silicate coating materials as per the list of tests given below from one of the reputed Government laboratories.

Samples of coating materials should be submitted to the Govt. laboratory in sealed containers with batch no. and test certificate on regular format of manufacturer's testing laboratory. The sampling shall be certified and sealed by a certifying agency.

All test panels should be prepared by Govt. testing agency coloured photographs of test panels should be taken before and after the test and should be enclosed along with test report.

Sample batch no. and manufacturer's test certificate should be enclosed along with the report. Test report must contain details of observation and rusting if any, as per the testing code. Suggested Government laboratories are:

RRL, Hyderabad
HBTI, Kanpur
DMSRDE, Kanpur
IIT, Mumbai/ Madras
BIS Laboratories
UDCT, Mumbai
RITES, Calcutta
PDIL

Employer's decision in this regard shall be final and binding on the manufacturer.

CHAPTER - 12

12. TRAINING AND ADVISORY REQUIREMENTS

12.1 Training Requirements

12.1.1 General

The Contractor shall provide comprehensive training for the different categories of the Employer's operation and maintenance staff. Training shall fall into two main types which are 'off the job' and 'on the job'. Off the job training shall take place in the classroom, on the job training shall be carried out at the operating treatment plant.

12.1.2 Off -the Job Training

The Contractor shall prepare formal training documentation for distribution to the trainees. Visual aids shall be used to illustrate the points being made and make the training programme as interesting and enjoyable as possible for the participants. The off the job training shall comprise the following, but not limited to:

12.1.2.1 Off the Job Training Programme for all Trainees

- a) simple chemistry and process principles involved in the operation of the Works
- b) details of the processes involved including comparison with other processes
- c) plant operational procedures and trouble shooting
- d) health and safety
- e) use of the local and central HMI's

12.1.2.2 Off the Job Process Training Programme for Operators

- a) operation of individual items of plant and sections of the Works including automatic operation and manual operation in the event of say automatic control failure
- b) day to day operation of the Works and procedures
- c) comprehensive list of 'what if' scenarios dealing with the actions to be taken in the event of potential process problems, alarms, plant failures, overflows, power failures. etc.
- d) first-line mechanical maintenance
- e) safe methods of work general
- f) safety procedures to be followed in operating, maintaining and cleaning the plant
- g) special precautions to be followed in the event of a chlorine leak

12.1.2.3 Off the Job Training Programme for Electrical Maintenance Staff

- a) configuration, construction and operation of the electrical plant
- b) electrical maintenance requirements of the Works

- c) switching and safety procedures to be followed
- d) safe methods of working
- e) fault finding and repair procedures

12.1.2.4 Off the Job Training Programme for Control and Instrumentation Maintenance Staff

- a) configuration, construction and operation of the plant
- b) control and instrumentation maintenance requirements of the Works
- c) fault finding and repair procedures
- d) safe methods of working
- e) special training on the use of the PLC/SCADA/DCS and associated programming software for fault finding on control systems
- f) special training on the use and performance of the central HMI SCADA/DCS hardware and software and other specialist hardware and software systems used on the plant

12.1.2.5 Off the Job Training Programme for Mechanical Maintenance Staff

- a) routine mechanical maintenance requirements of the Works
- b) lubrication requirements of the Works
- c) fault finding, repair and overhaul procedures
- d) safe methods of working

12.1.2.6 Off the Job Training Programme for Desalination Management Staff

- a) desalination process management techniques
- b) desalination plant cost management
- c) desalination plant laboratory management
- d) safe methods of work general
- e) safety procedures to be followed in operating, maintaining and cleaning the plant

12.1.3 On the Job Training

The Contractor shall utilise the Operation and Maintenance manuals as the primary training aid in carrying out the on-the-job training. Short-comings, omissions and errors identified in the Operation and Maintenance manuals during the training shall be rectified prior to final acceptance of the Operation and Maintenance manuals. This shall include but not limited to the following,

12.1.3.1 On the Job Training Programme for all Trainees proposed by the employer

- a) plant familiarisation tour

- b) description of plant process units
- c) understanding of PFD and the PIDs
- d) discuss on the O&M Manual and its use
- e) Understanding of all the critical control points (CCPs)
- f) alarm management protocols
- g) use of the local and central HMIs
- h) plant safety procedures
- i) identify areas where special safety precautions are necessary,
- j) asset management and work-order policies and principles

12.1.3.2 On the Job Process Training Programme for Operators.

- a) operational conditions on the operation of individual items of plant and sections of the Works including automatic operation and manual operation in the event of say automatic control failure,
- b) illustrate by example the day-to-day operation of the Works and procedures,
- c) illustrate by example the actions to be taken in the event of potential process problems, alarms, plant failures overflows, power failures etc. (as identified in the 'what if' scenario off the job training)
- d) illustrate by example the first line mechanical maintenance,
- e) illustrate by example safety procedures to be followed in operation, maintenance and cleaning of the Works,
- f) Training on each process unit using a duplicated simulation tool of exact process controls. Operational staff to be tested using this simulator program module to identify any weakness for continuous improvements and reach a minimum pass standards.

12.1.3.3 On the Job Training Programme for Electrical Maintenance Staff

- a) carry out a detailed tour of the electrical plant
- b) illustrate by example the operation of the electrical plant
- c) illustrate by example the electrical isolation and maintenance procedures
- d) illustrate by example fault finding and repair procedures
- e) illustrate by example switching and safety procedures to be followed
- f) illustrate by example safe systems of work

12.1.3.4 On the Job Training Programme for Control and Instrumentation Maintenance Staff

- a) illustrate by example the operation of the Works
- b) illustrate by example the calibration of the instruments and equipment
- c) illustrate by example the control and instrumentation maintenance requirements of the Works
- d) illustrate by example fault finding and repair procedures
- e) illustrate by example fault finding on DCS based control systems, the central HMI SCADA/DCS hardware and software and other specialist hardware and software systems used on the plant
- f) illustrate by example safe systems of the Works.

12.1.3.5 On the Job Training Programme for Mechanical Maintenance Staff

- a) illustrate by example the routine mechanical maintenance requirements of the Works
- b) illustrate by example lubrication procedures
- c) illustrate by example fault finding, repair and overhaul procedures
- d) illustrate by example safe systems of work

12.1.4 Training Programme

Off the job training shall be carried out prior to the commissioning of the Works or any section of the Works. With the permission of the Engineer and the Employer on the job training shall be carried out prior to the start of the operation and maintenance. On the job training shall be completed as a condition for acceptance of the Works following completion of the Tests After Completion.

The Contractor shall provide a training plan for each category of staff. The training plan shall detail the content and duration of each course. The training plan shall be submitted for the approval of the Engineer at least 120 days prior to the commencement of the training program. The duration of training offered for each category of staff shall not be less than that detailed in the Table below.

Table 12-1: Minimum Duration of Training Courses

Category of Staff	Off the Job (minimum days duration for each course)	On the Job (minimum weeks duration for each course)
All staff	1	1
Operator	5	8
Electrical	3	8

Category of Staff	Off the Job (minimum days duration for each course)	On the Job (minimum weeks duration for each course)
technician/electrician		
Control/instrument technician	5	10
Mechanical technician/fitter	3	5
Desalination plant management	3	

The training day shall be assumed to be not less than six hours split into two sessions. The Contractor shall provide facilities for training which shall include inter alia tables and chairs, projectors, white/black boards, training aids, etc. Where trainees of a given category can all be released from their operational duties simultaneously, they may be trained together. Where this is not possible the Contractor shall repeat the complete course for those who could not attend.

12.1.5 Training Personnel

The Contractor shall provide suitably qualified trainers to carry out the off the job and on the job training. The trainers are to be experienced in desalination plant management, operation and maintenance in their relevant discipline and the training of skilled and unskilled staff. The Contractor shall submit the curriculum vitae of the nominee for the position of training expert to the Engineer for approval 120 days before training is scheduled to commence. The training expert shall be fluent in English, Tamil and Hindi, or the Contractor shall provide the services of an interpreter(s) during the training periods.

12.2 Advisory Requirements

12.2.1 General

The Contractor shall provide personnel to handhold the employer in the operation of the Works for a period after Hand Over. The personnel provided shall have proven experience in their intended roles. Those persons provided shall comprise:

- Advisor to the treatment works manager duration 24 months
- Advisor - mechanical maintenance duration 6 months plus 2 months
- Advisor - electrical/control maintenance duration 6 months plus 2 months
- Advisor - process duration 6 months plus 2 months

The electrical/control, mechanical and process specialist visits are split. During the first visit, procedures shall be established and implemented. During the second visit, the procedures shall be monitored and refined. The role of the Contractor's advisory personnel shall be to:

- advise on day-to-day management of the desalination plant
- advise on the development procedures for the ordering and reordering of consumables
- propose and develop systems to monitor the consumption of consumables and power and to advise actions to reduce their usage to a minimum,
- establish analytical procedures within the laboratory and carry out periodic checks to ensure that they are adhered to,
- establish routines for the analysis of water quality in all areas of the plant and to establish procedures for corrective action in the event of quality falling below that expected,
- establish systems for the recording of water quality appropriate to a plant of this type,
- ensure procedures for operation and planned maintenance of the Works as detailed in the Operation and Maintenance manuals are carried out.
- advise on the optimisation of process settings, dosage rates, operating regimes etc.
- provide continuing informal on the job training to the Employers staff (this is in addition to formal training requirements detailed elsewhere)
- update the Operation and Maintenance manuals in line with experience gained during the year's operation.

The Contractor shall be responsible for all costs associated with the deployment of his advisory personnel.

12.2.2 Advisory Personnel

The Contractor shall provide suitable personnel to provide advisory services. The advisors shall be experienced in desalination plant management, or operation and maintenance in their relevant discipline. The Contractor shall submit the curriculum vitae of the advisory nominees to the Engineer for approval 120 days before the scheduled assignment. Prior to mobilisation, the advisors shall be fluent in Tamil, Hindi and English or the Contractor shall provide the services of an interpreter(s) during the advisory period as necessary.

12.2.3 Operation and Maintenance Manual

This Operation and Maintenance manual shall be provided by the Contractor to establish guidelines for plant operators to understand the new desalination plant to operate this system efficiently and successfully. The guidelines will be provided to the training personnel, on how to operate the plant so that they shall be able to manage to treat the water to best quality; with low consumption of energy; with low cost of maintenance; providing a long life of equipment; protection against accident, safe working methods and protecting systems from damages.

The system operation and unit operation of each component will be needed to be adjusted and modify depending on the raw water quality, and the required data are collected during the training program as well as the operation and maintenance period. The Contractor shall train the CMWSSB personnel about Plant operation knowledge, abilities and skill as follows:

12.2.3.1 Capacity Building

Knowledge:

- System flow and unit operation, maintenance, pumps, blowers, other plant equipment and machinery
- Basic Desalination Process
- Basic sludge handling principle and its characteristics
- Basic maintenance period and work sheet
- Basic laboratory techniques to make standardized tests
- Avoiding any chance of an accident
- Basic safety and health

Abilities:

- Make adjustments to the desalination system according to Raw water characteristics and its flow fluctuation, and control
- Make adjustments to control the chemical dosing system
- Adjust the chlorination process, and to lift sacks of chemicals and to read and follow written and oral instructions
- Adjust the dosing system of chemicals. Perform standardized laboratory tests
- Make repairs and/or adjustments to water treatment equipment and to keep records and prepare reports
- Make repairs and/or adjustments to each equipment and to keep records and prepare reports
- Handling safety valves and its pipeline
- Read and interpret gauges and recording devices used in the desalination plant
- Usage of safety equipment in case of Emergency

12.2.3.2 Tasks of Operation and Maintenance Works

- a) Operate water treatment plant under normal conditions such as equipment, machinery and pipe line, including valves, gate, stop-logs, pumps, thickeners, chlorine feeder, chemical tanks, dewatering equipment, chemical preparation and dosing system, reading flow meter; regulate the flow of water, disposing the sludge, etc.
- b) Select the desalination facility or equipment to meet the actual inflow pattern,
- c) Take samples and make standardized laboratory test if required, including tests for temperature, residual chlorine, pH, turbidity and other required items,
- d) Set the system/equipment to adjust timer or operation period to meet the required specified amounts of feeding chlorine solution, chemical solution, air volume, sludge withdrawal, recycling waste wash water
- e) Make minor repairs and adjustments to machinery, equipment, pipes and other

- materials pertinent to the operation of the plant,
- f) Work on troubleshooting including bulk flow control,
 - g) Maintain maintenance and operational records,,
 - h) Cleaning of machinery, equipment and civil tanks, building, loading and unloading of materials and storage of chemicals properly
 - i) Does general maintenance of the plant, including, but not limited to, painting, general custodial work, maintenance of equipment, etc.
 - j) Assist in repairing flow meters and pipeline including valves in inactive time and/or operation time,
 - k) Assist in the inspection of all necessary equipment, of water & wastewater sampling & of pipeline.

12.2.3.3 Information to be covered in the Operation and Maintenance Manual

The Operation and Maintenance Manual shall be prepared in accordance with the information provided in Part-2 A3 works requirements. The manual should include but not necessarily be limited to the following:

- a) Background of project
- b) Plan and design condition
- c) System operation indices and unit operation indices
- d) Water Quality & Quantity (Inlet/outlet):
 - Actual
 - Standard
- e) Outline of system operation (Civil, Mechanical & Electrical):
 - Summary
 - Flow diagrams, plan view, hydraulic profile, Piping isometrics
 - Operation flow diagram
 - Table of facilities
 - (Tag number, Type, Number, Nominal bore, capacity, motor rating, weight)
- f) Outline of component and its aim (Civil & Mechanical):
 - Normal operation
 - Emergency operation
 - Selection of facility
 - Selection of Auto/Manual mode
 - Notice of danger/peril/hazard
- g) Verification items of system operation mode (Civil & Mechanical):
 - Before the start of system operation
 - Start of system operation
 - During regular operation
 - Set value of level sensors and safety pressure on safety devices

- Position of plant/equipment on the selected mode
- Remove potential danger/peril/hazard
- h) Details of the facility/equipment component (Civil & Mechanical):
 - Summary
 - Specification
 - Outside dimension
 - Weight, quality of material
 - Outside drawing
 - Graph, charts, performance curve, table
 - Photo after installation
 - Notice of danger/peril/hazard
- i) Verification items of component operation (Civil & Mechanical):
 - Preparation before the operation
 - Starting operation flow
 - Normal operation
 - Set value of level sensors and safety valves
 - Emergency maintenance
 - Notice of danger, peril, hazard
- j) Outline of component and its aim (Electrical):
 - Verify incoming power Hz, kWh
 - Verify output from cogeneration Hz, kWh
 - Ordinary line or emergency line operation
 - Detail and full operation procedure
 - Select standby generator
 - Emergency operation
 - Selection of facility
 - Notice of danger/peril/hazard
- k) Verification items of system operation mode (Electrical):
 - Before the start of system operation
 - Start of system operation
 - Set value of level sensors and protection
 - Select Auto/Manual mode on the central control panel
 - Remove potential danger/peril/hazard
- l) Detail of facility component (Electrical):
 - Summary
 - Specification
 - Single line diagram
 - Panel dimension
 - Weight, quality of material
 - Outside drawing
 - Graph, charts, performance curve, table
 - Photo after installation

- Notice of danger/peril/hazard
- m) Facility verification items (Electrical):
 - Preparation before the operation
 - Select Normal operation or Emergency operation
 - Select equipment operation mode/switch by Auto /manual
 - Before the start of system operation
 - Start of system operation
 - Set value of level sensors and protection
 - Remove potential danger/peril/hazard
 - Notice of danger/peril/hazard
- n) Standard:
 - Water quality at inlet and outlet
 - Critical control points
 - Compliance with contractual water quality parameters
 - Risk assessment and control procedures
 - Documentations and Hazard analysis and critical control points (HACCP) audits
 - Emission control
 - Noise and vibration
- o) Fire/explosion protection
- p) Dewatered cake sludge handling/disposal
- q) Frequency of sampling, analysis and evaluation:
 - Inflow and outflow quality /flow rate
 - Regulated pollutants
 - Operation index
 - Amount of sludge and its density
 - Water/sludge temperature
- r) Maintenance schedule (Mechanical & Electrical):
 - Routine work
 - Regular work
 - Manufacturer recommendation
- s) Maintenance schedule(Civil):
 - Routine work
 - Regular work
 - Manufacturer recommendation
- t) Calculation sheets:
 - Calculation of dosing amount (Alum/Chlorine/Poly/etc.)
 - Calculation of sludge amount
- u) Troubleshooting guide (Phenomenon/action/comments):
 - Discharge quality and bulking
 - Process and system control
 - Mechanical equipment

- Electrical equipment
- Case study or/and previous experiences (Normal troubleshooting)
- v) Operation/test data:
 - Operation index
 - Asset management software to meet ISO 55000
 - Mechanical site inspection data
 - Electrical site inspection data
 - Water quality and quantity(inlet/outlet)
 - Regulated pollutants
 - Amount of sludge and its density
 - Amount of cake and its density
 - Noise and vibration
 - Water/sludge temperature
 - Power /chemical consumption
 - Operation cost during the training period
 - Performance test of pressure control valves, pressure reducing valves
 - Consumables, spare parts and its list
 - Photo of inspection (evidence)
- w) List:
 - Equipment control
 - Operation record formats
 - Maintenance record formats
 - Material control
 - Inventory
 - Spare parts
 - Safety and Health

CHAPTER - 13

13. OPERATION AND MAINTENANCE

13.1 General

This section applies to the specifications of materials used for operation and maintenance, the workmanship, period for operation and maintenance, specifications for the acceptable quality of product water, maintenance of records, and responsibilities during Operation and Maintenance period. The Contractor shall operate and maintain the desalination plant and sludge treatment systems at Perur, Chennai, the instrumentation system, the communication system, 230kV/110kV/11kV/415 V GIS substations, SCADA/DCS systems, all ancillary buildings and campus area for a period of 20 years. The Operation and Maintenance period shall only commence only after issue of Commissioning Certificate.

13.1.1 Duties and Responsibilities

- The Employer will provide only power required for the plant during the 20 years of operation and maintenance period. Any cost for extra power consumption at the plant above the functional guaranteed value will be borne by the Contractor. Apart from power, all the remaining responsibilities for operation and maintenance of the plant during O&M period shall lie with the Contractor.
- The obligation of Contractor is to provide product water meeting all the quantity and quality in line with specification requirements.
- The Contractor shall manage plant operations so as to limit power consumption and chemical usage within the specified functional guarantees.
- The Contractor shall ensure satisfactory operation and maintenance of the Works so that the plant operation provides reliable, consistent performance and is economical at all times.
- The Contractor shall use the Computerized Maintenance Management system throughout the O&M period.
- The contractor shall maintain daily record of the water quality and quantity and all operating parameters throughout the O&M period and create a database for the same.
- The product water quality shall be sampled and tested by the Third Party once in every month for the vital parameters to ensure the water quality meeting the contract requirements. The third party shall be NAL accredited laboratory in Chennai. All costs for the sampling and analysing of the product water by the third party lab agency shall be borne by the Contractor.

13.2 Definition of Maintenance

Maintenance of the Works covers all the techniques and systems which, by means of regular monitoring of equipment and scheduled maintenance procedures, prevent failures and, in the event of problems, carry out repairs with minimal disruption of the process. Maintenance is

therefore a combination of technical, administrative, and management activities. Maintenance consists of preventive and corrective procedures.

13.2.1 Preventive Maintenance

Preventive maintenance consists of all the regular works carried out in order to sustain the conditions necessary for smooth operation of the plant and to keep the performance of the equipment as close as possible to its original and guaranteed performance level. Its purpose is to reduce the probabilities of failure or deterioration of equipment of the plant. In simple terms, preventive maintenance involves the elementary operations such as lubrication, mechanical servicing, and electrical and instrumentation servicing.

13.2.2 Corrective or Remedial Maintenance

Corrective or remedial maintenance of the Works consists of all works needed to re-establish the conditions necessary for an apparatus or set of equipment to operate properly subsequent to failure or deterioration of the results produced by the equipment.

The work may be scheduled for the short or medium term in accordance with the checks carried out as part of the preventive maintenance procedure, the number of hours an apparatus has been operating, or an alarm factor (abnormal noise, repeated cut-out, weakening of the insulation, etc.) or may be dictated by an unexpected breakdown.

13.2.2.1 Maintenance work

The maintenance work consists of inspection work and maintenance work as mentioned below:

- Inspection work, that includes physical appearance, inspection, measurement and testing equipment to verify and survey that the plant performance whether operation is normal or not.
- The inspection work shall be executed daily by each technical specialist as a routine and/or regular inspection and shall be recorded each time. The evaluation on the collected data shall be immediately reviewed by the plant manager to instruct the staff member for operation on the same day and/or make a plan of detail inspection and/or make repair schedule to ensure continuous plant operation without any problem.
- Maintenance work, for which main task-work shall include activities, such as lubrication, overhaul and replacement of parts.

13.2.2.2 Operation work

The operation work is the execution of the plant operation based on the processes and procedures to meet design criteria including set up or adjustment of the operational index or data according to the water quality or demand.

Monitoring work is to confirm the operation data, and readout its measurement value on panels, and check-up the working performance of plant appropriately, as well as maintaining records of the output.

13.2.3 Computerized Maintenance Management System (CMMS)

A computerized maintenance management system (CMMS) is a type of management software that performs functions in support of management and tracking of O&M activities.

CMMS systems automate most of the logistical functions performed by maintenance staff and management.

The typical CMMS functions shall include the following, but not limited to:

- Work order generation, prioritization, and tracking by equipment/component.
- Historical tracking of all work orders generated which shall be sortable by equipment, date, person responding, etc.
- Tracking of scheduled and unscheduled maintenance activities.
- Storing of maintenance procedures as well as all warranty information by component.
- Storing of all technical documentation or procedures by component.
- Real-time reports of ongoing work activity
- Calendar- or run-time-based preventive maintenance work order generation.
- Capital and labor cost tracking by component as well as shortest, median, and longest times to close a work order by component.
- Complete parts and materials inventory control with automated reorder capability. • PDA interface to streamline input and work order generation.
- Outside service call/dispatch capabilities.

13.3 Specification

The specification of materials used for repairs shall be the same as have been used in the original work. Specifications for any materials which were not used during construction shall be approved by the Engineer prior to commencement of the operation and maintenance period and must be incorporated in the Operation and Maintenance manual. Without being limited by this clause, during Operation and Maintenance period the Contractor shall use appropriate material for repairs even if material required for such repairs has not been approved earlier, and no delay in making such repairs shall be subjected to such limitation. However, subsequent to use of such material the Contractor shall submit proposals for the approval of specifications of such material. The approved material will subsequently form a part of the Operation and Maintenance manual. The comprehensive information as detailed in Table below shall be submitted to the Engineer.

Table 13-1: List of Execution Schedule

Items	Description
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Maintenance of plant/facilities	List of unit process, capacity of equipment, method/frequency of maintenance and type of maintenance (On-line or Off-line)
Operation of plant/facilities	List of plant/equipment, items to be monitoring/operation, preparation of chemical, handling sludge, method of system control, data input into computer, operation of backup, period of power failure and generator operation, communication method etc.
Monitoring of product water quality	Scope of monitoring, method of sampling and analysis, place of laboratory and name of authorized personnel.
Countermeasure against accident and risk management	Damage prediction, simulation of public relations, method of recovery, contact address, rescue activity and emergency team
Renewal	Replacement of pipe, replacement of equipment and facilities
Subcontracting	Method of contract out, scope of works, limit of responsibility.
Evaluation and report	Method of data analysis, evaluation of collected data, improvement program, reporting
Organization and administration	Executive organization chart, segregation of duties, list of staff members, experience, health certificate of staff member, type of insurance, criminal record, personnel name of taking record and make soft data, method of data control, operation and maintenance cost.

13.4 Activities during Operation and Maintenance Period

13.4.1 General

Within the framework of the Contractor's responsibilities given above, the Contractor shall carry out the following activities. However, these shall not limit the requirement for other activities which otherwise are required as per term and conditions of Contract or to fulfil the Contractor's responsibilities or are essential as per good practices. The Contractor shall be responsible for, but not limited to, the following:

- a) Providing product water with quality as specified and at the production rates as directed by the Contract
- b) Providing the required staff, but not less than the minimum specified numbers/level, during operation and maintenance period and additional staff as per requirement during periodic maintenance and in emergencies.
- c) Providing all consumables required for functioning of plant and equipment except for power charges up to the guaranteed limit. In case the power consumption is above the guaranteed value, the Contractor shall pay for the excess in accordance with the Contract Data. The Contractor shall arrange for the chemicals and use at the plant. The Contractor will charge the cost of the chemicals to the Employer based on the actual chemical consumption up to the guaranteed quantities. Any excess chemical cost above the guaranteed value shall be borne by the Contractor. The Contractor shall provide the chemical dose rates and other consumption evidence in support of the actual consumption values.
- d) Maintenance of substations, etc., pumping stations, pre-treatment units, RO desalination plant, chemical houses, post treatment units etc. in neat and clean condition.
- e) Entering into AMC contracts with system/equipment suppliers, as necessary. It is mandatory to enter into an agreement for a 20 years maintenance contract with the PLC and DCS/CMMS system suppliers, whosoever has executed the work for this project and on call attendance should at site within 24 hours.
- f) Maintenance of the lighting fixtures and the lighting system of all areas and replacement of all non-functional lighting fixtures within 24 hours.
- g) Maintaining the following:
 - Repair history of all mechanical, electrical and instrumentation control equipment in pumping stations, desalination plant, and communication instruments
 - Logbooks through DCS /CMMS system
 - Daily log of operations of all the important equipment
 - Raw and clear water quality test results on turbidity, residual chlorine levels and other process parameters and sludge quality test results (Refer Part 11, Table 11.2)
 - Daily list of critical alarms (1st Priority) with time tag
 - Logbook format and the data to be included in the logbook shall be decided during commissioning in consultation with the Employer
 - CMMS monthly work order and its completion status
 - Last periodic maintenance done for all equipment/buildings of the system
 - In addition to maintenance of above logbooks, the Contractor is required to maintain one inspection /complaint logbook register and a copy from the CMMS. The complaints entered in the complaint register should be keyed in the CMMS and the complaint must be investigated and remedial measures must be taken immediately.
- h) Providing required spares, special tools and test equipment and maintaining adequate inventory of required accessories or equipment itself for repair of system so that the electrical, mechanical, instrumentation and control system, pipe and the communication

system can work efficiently as per the guarantees given or minimum required efficiencies asked for in the Contract, without any additional cost to the Employer. The Contractor may use spares and tools and tackles supplied with the Contract as required by him. However, at the end of the Contract the Contractor shall hand over the spares, tools and tackles available at the plant for maintenance and also any available complimentary spares supplied by the manufacturers along with the equipment and units. If the complimentary spares are used during O&M period, the Contractor shall replenish those with the new spares. The Contractor shall also provide a list of the spare parts required for continuous two years of operation and will help the Employer to procure the items before end of the O&M contract.

- i) Providing manpower for the required repairs of all plant facilities along with the manpower and materials for repair of the roads, buildings and campus area utilities.
- j) Maintaining the drinking water supply facilities at the desalination plant campus and all its units.
- k) Maintaining stores for the electrical, mechanical and instrumentation and control equipment as well as that for the chemicals and laboratory consumables at the desalination plant. The maintenance of stores shall include but not be limited to:
 - Loading/unloading of materials received and issued for works
 - Proper arrangement of material in stores to ensure safety and easy availability
 - Maintaining store areas in a neat and tidy condition
 - Keeping inventory records and accounting for the incoming materials
 - Keeping records and accounting for the consumed materials
 - Updating the inventory data in the CMMS system.

The Contractor shall be solely responsible for the safety and security of the goods in the store and shall be responsible for any loss or damages in stores for any reason. He shall provide insurance cover against the value of the goods to be stored without any additional cost to the Employer.

- l) Periodic routine maintenance of structures/buildings of campus area of the treatment plant and others built in the Contract. Such maintenance must ensure adequate cleanliness, ventilation, illumination and structural safety. In addition to this, the general hygienic standards must be maintained and adequate plantation, horticultural activities must be taken up to maintain the total environment of the campus/buildings pleasant.
- m) Periodic updating and submission of the operation and maintenance manual as defined in this specification for Operation and Maintenance works. The Contractor shall take up all periodic maintenance works provided in the approved Operation and Maintenance manual.
- n) Submission of monthly report – not only limited to the data specified in Section 13.4.15:
 - Co-ordination with other contractors and/or agencies responsible for the execution, operation and maintenance of the product water pumping station.
 - The Engineer shall be entitled to audit any aspect of the system and the Contractor shall ensure remedial action as directed.

- Safety reporting: Brief reports of all accidents and hazardous incidents including descriptions of cause, extent of injuries, action taken, and precautions instituted to prevent repetition of such events.
- o) Insurance: The Contractor shall, without limiting his or the Employer's obligations and responsibilities, ensure:
- The work together with material and plant for incorporation therein, to the full replacement cost (term "cost" in this context shall include profit).
 - The Contractor's equipment and other things brought onto site by the Contractor, for a sum sufficient to provide for their replacement at the site.
 - The insurance shall be in the joint names of the Contractor and the Employer at the Contractor's cost and shall cover the Employer and the Contractor against all losses or damages from whatsoever cause arising from the start of the Operation and Maintenance until the date of completion of Operation and Maintenance in respect of the facility or any section or part thereof as the case may be.
 - Any amount not insured or not recovered from the insurer shall be borne by the Contractor.
- p) The typical main inspection items and some signs of deterioration of plant are presented in Table 13-2, which may be observed during routine inspection or monitoring work. The maintenance works shall be planned together and analyse information to solve the problem.

Information about raw water quality and product water is necessary to make a decision how to operate plant operation properly, and to check the operational performance whether the water quality meets water quality standards or not. Typical parameters to be sampled and its quality analysis shown in Table 13-3. The other tables are:

- Table 13-4: Typical Operation & Maintenance items in Electrical and Instrumentation Systems
- Table 13-5 Operation & Maintenance for Mechanical Systems

Table 13-2: Typical Indication of Sign of Plant Deterioration

Parameters	Concrete and Structure	Pipe Line	Mechanical & Electrical	Chemical	Instrumentation
Deterioration of material quality	<ul style="list-style-type: none"> • Appear crack on concrete structure • Water leakage • Scouring • Wear/abrasion • Corrosion (steel, rebar) • Irregular subsidence • Change of shape • Reducing service life 	<ul style="list-style-type: none"> • Appear corrosion (reducing wall thickness/size/bolts) • Electrical corrosion • Water leakage • Damage • Wear/abrasion • Cavitation erosion • Discoloration • Reducing service life 	<ul style="list-style-type: none"> • Stop operation • Heating • Fumes • Oil/water leakage • Voltage reduction • Lower performance • Electricity failure • Malfunction • Wear/abrasion • Noise/vibration • Electric leakage • Decline acid proof/water proof • Mechanical down • Burnout/damage • Corrosion/rust • High pressure gradient across membranes 	<ul style="list-style-type: none"> • Chemical/water/air/CO₂ gas/ Chlorine solution leakage • Insulation deterioration • Corrosion/rust • Wear/abrasion • Zero-point disparity • Increasing in measurement error • Difficult to adjust accuracy • Performance defect • Equipment malfunction • Mechanical down • Dosing malfunction • Reducing service life • Discolour 	<ul style="list-style-type: none"> • Insulation deterioration • Corrosion/rust • Wear/abrasion • Zero/point disparity • Increasing in measurement error • Frozen System / Frozen reading • Difficult to adjust accuracy • Failure of total accuracy • Performance defect • System malfunction • Mechanical down • Heating • Fumes • Burn up relays • Reducing service life • Remove puddle/keep dry

Parameters	Concrete and Structure	Pipe Line	Mechanical & Electrical	Chemical	Instrumentation
			<ul style="list-style-type: none"> Reducing service life Operation rigidity 		<ul style="list-style-type: none"> Operation rigidity
Deterioration of water quality	<ul style="list-style-type: none"> Contamination of water by inflow hazardous/waste material, small animal, higher turbidity and pH Settlement of floating substance Deterioration/peel-off of internal coating Spoil the facility Algae growing on tank inside wall Low residual chlorine cause of rising water temperature or stagnant water 	<ul style="list-style-type: none"> Water contamination Red/black water Abnormal water color & smell by algae Low residual chlorine by water quality or stagnant water Deterioration of internal coating or pipe/peel-off Observation of metal color in water (Fe, Mn, Cu, Pd) 	<ul style="list-style-type: none"> Quality analysis Observation of small flocks Accumulate sludge on tank bottom Increasing flocks carry-over Clogging surface of filter Crack on surface of filter media Poor product water quality Fall of residual chlorine Reduction of treatment capacity High permeate TDS 	<ul style="list-style-type: none"> Failure of agglutination process due to raw water quality Failure of disinfection dosing rate or process control (lower or higher residual chlorine) Feeding rate Volume, color, small at feeding points A number of equipment as operation Deterioration of stocked chemical Generation of THM 	<ul style="list-style-type: none"> Spoil, consummation, damage, dirty on sensor of measuring devices Inappropriate installation of measuring devices Malfunction of measuring devices Calibration Errors Calibration elapsing System malfunction Chut-down plant or stop equipment On-off emergency alert Defect of operation mode Failure of indication & accuracy

Parameters	Concrete and Structure	Pipe Line	Mechanical & Electrical	Chemical	Instrumentation
			<ul style="list-style-type: none"> Abnormal water color Stop & adjust number of operation facility 		<ul style="list-style-type: none"> Remove puddle/keep dry
Reduction of water quantity and pressure	<ul style="list-style-type: none"> Lack of water tank storage capacity Water leakage Lack of water tank elevation Accumulation of bottom Settlement Clogging filter media/under-drain/strainer Blockage inlet/outlet opening by obstacle 	<ul style="list-style-type: none"> Reduction of pipe diameter due to corrosion Scale growing Increasing head loss Declining water velocity Declining water quantity Accumulation of silt, Air accumulation Lack of supplying water quantity Discoloration Water hammer 	<ul style="list-style-type: none"> Amount of receiving raw seawater Water contamination Declining production quantity More filter's back wash or shorter filtration life Uneven backwash or high initial filter loss head Increasing pump head loss 	<ul style="list-style-type: none"> Defect of pumping, mixing, making solution. Declining chemical dosing rate at points Lack of storage capacity Failure of agglutination process Failure of disinfection Control plant operation 	<ul style="list-style-type: none"> System malfunction Malfunction of measuring devices Control plant operation On-off pump operation Water hammer

Parameters	Concrete and Structure	Pipe Line	Mechanical & Electrical	Chemical	Instrumentation
			<ul style="list-style-type: none"> • Readout o water meters or water level • Number of pumps on duty or On-off operation • Failure of equipment • Service life of facility • Control supply water • Water hammer 		
Decline in plant/system performance	<ul style="list-style-type: none"> • Decline in retention time • Increasing dangerous unit operation • Difficult to repair • Declining facility efficiency • Increasing operation cost 	<ul style="list-style-type: none"> • Required longer repair work • Defect value/gates operation • Impossible of water flow control 	<ul style="list-style-type: none"> • Increasing frequency of out of order • Increase in frequency of CIP • Longer repair time • Increasing electricity failure 	<ul style="list-style-type: none"> • Increasing frequency of out of order • Longer repair time • Declining operational performance • Poor ventilation & odor • Poor mixing • Increasing third person fault (create ripple 	<ul style="list-style-type: none"> • Unstable system • Increasing frequency of out of order • Longer repair time • Declining operational performance • Missing/lack of operational/maintenance data & record remove puddle/keep dry

Parameters	Concrete and Structure	Pipe Line	Mechanical & Electrical	Chemical	Instrumentation
			<ul style="list-style-type: none"> Declining operational performance Poor flash mixing & flocculation Accumulation of sludge cake in site Increasing third person fault (create ripple accident by electricity failure) 	accident by chemical leakage)	<ul style="list-style-type: none"> Frequent Alarms Slow Response Controllers Loading issues Controller Freeze

Table 13-3: Typical Parameters for Water Analysis

Parameters	Location and Sampling/Analysis Points for Water Quality						
	Raw Water	Lamella Effluent	DAF Effluent	GDMF Effluent	RO Feed	RO permeate	Product Water
Turbidity	Online	Online	Online	Online	Online	Online	Online
pH	Online	Online	Online	Online	Online	Online	Online
TOC	Weekly	Weekly	Weekly	Weekly	Weekly	-	-
COD	Weekly	Weekly	Weekly	Weekly	Weekly	-	Weekly
BOD	Weekly	Weekly	Weekly	Weekly	Weekly	-	Weekly
Alkalinity	Daily	Weekly	Weekly	Weekly	Daily	Online	Daily
Total Hardness	Daily	Weekly	Weekly	Weekly	Daily	Online	Online
Total Dissolved Solids	Daily	Weekly	Weekly	Weekly	Daily	-	Daily
Elec. Conductivity	Online	Weekly	Weekly	Weekly	Online	Online	Online
Iron	Daily	Daily	Daily	Daily	Online	-	Daily
Total Coliforms	Daily	Weekly	Weekly	Weekly	Daily	Daily	Daily
Water Temperature	Online	-	-	Online	Online	Online	Online
Total suspended solids	Daily	Daily	Daily	Daily	Daily	-	Daily
Residual Chlorine	Online	Online	Online	Online	Online	-	Online
SDI	Daily	-	-	Online	Online	-	-
ORP	-	-	-	-	Online	-	
Boron	Daily	-	-	Online	-	Daily	Daily
Oil & grease	Online	Daily	Weekly	Weekly	Weekly	-	-
Odour	Daily	Weekly	Weekly	Weekly	Weekly	-	Daily
Taste	Daily	Weekly	Weekly	Weekly	Weekly	-	Daily
Colour	Daily	Daily	Daily	Daily	Daily	-	Daily
Ammonium nitrogen	Weekly	Weekly	Weekly	Weekly	Weekly	-	Daily
Algae	Daily	Weekly	Weekly	Weekly	Weekly	-	-
Nitrate	Weekly	Weekly	Weekly	Weekly	Weekly	-	-

Table 13-4 : Typical Items in Electrical and Instrumentation Systems

Daily		Periodic	
Frequency	Description	Frequency	Description
Transformer	Verification of kVA, V, Am, current protection, oil temperature	Every 6 Months	Verification of oil, abnormal sound, performance
Incoming Panels	Verification of kVA, V, Am, lamp test /replacement, moisture cut heater, current protection, burned smell, remove water	Every 6 Months	Verification of switch On/Off, Fuse, abnormal sound, condenser, relays, protection devices, earthing, wiring and connection
Control Panels	Verification of V, Am, lamp test & replacement, moisture cut heater, overload protection, operation mode, burned smell, remove water	Every 6 Months	Verification of switch On/Off, Fuse, abnormal sound, condenser, relays, protection devices, earthing, wiring and connection
Lighting Panels	Verification of Am, light test & replacement, moisture cut heaters, overload protection, remove water	Every 6 Months	Verification of switch On/Off, Fuse, abnormal sound, condenser, relays, protection devices, earthing, wiring and connection
Meters reading	Verification of V, Am, overload protection	Every 6 Months	Verification of over load protection indication, switch On/Off, accuracy, damage
Motors	Verification of burned smell, heating, vibration	Every 6 Months	Verification of switch On/Off, earthing, insulation resistance, rpm, damage, temperature
System	Verification of system sequence ON/OFF	Every 6 Months	Verification of All system, insulation resistance

Cable line	Verification of short circuit, cable colour, damage	Every 6 Months	Verification of wire droop, degradation, insulation resistance
Instrumentation	Verification on operations of the instrumentation	Every day	Online

Table 13-5 : Typical Items in Mechanical System

Activity	Frequency
Monitoring of Cartridge Filter differential pressure	Online
Monitoring of RO membrane differential pressure	Online
Maintenance on ERI unit	Within 6 hours
Removal of clogged materials from screens	Daily
Cleaning of level sensors	Weekly
Checking vibration and noise level of pump/blower sets	Weekly
Fully closing and opening of sluice gates and valves	Monthly
Replacement of bearings	Within a day of breakdown
Replacement of bulbs, lamps etc	Within a day of breakdown
Tightening of gland	When leakage increases beyond acceptable limit
Greasing, oiling	As per manufacturers recommendation
Preparation of list of spares for satisfactory operation	Semi-annually
Transformer oil sample checking	Semi-annually
Checking of relays/ alarm (trough secondary injection)	Yearly
Condition of gasket and replacement (if required)	Yearly
Operation of crane for all motions	Weekly
Submission of report on maintenance to Employer	Monthly

13.4.2 Experience & Qualification of Staff

For all operation and maintenance works, the Contractor shall provide skilled staff, who have adequate qualifications and sufficient experience in O&M of minimum 100 MLD Desalination plant. CV of Plant Manager, Shift-in-charge, Senior Operations Manager, shall have to be approved by the Employer. The following Table 13-6 describes the minimum levels of staffing,

and their minimum qualifications and experience in similar works, that the Contractor shall be required to deploy for carrying out the Operation and Maintenance functions:

Table 13-6: Minimum Requirements for Staff and Qualifications

Sr. No	Designation	Qualification	Experience	Shift-1	Shift-2	Shift-3	Reliever	Total Nos.
1.	Plant Manager	Graduate Engineer (Civil/Env/Chemical)	>15 years	General shift 1				1
2.	Sr. Operation Manager	Graduate Engineer (Elec/Mech/Chem)	>10 years	1				1
3.	Operation Manager/ Shift-in-charge	Graduate Engineer (Elec/Mech/Chem)	> 10 years	2	2	2		6
4.	Maintenance Incharge	Diploma (Elec/Mech/Instr)	5 years	2	2	2		6
5.	Maintenance Personnel	Diploma (Elec/Mech/Instr)	5 years	2	2	2		6
6.	SCADA Operator	Diploma (Engg)/ Science Grad	5 years	2	2	2		6
7.	Field Operator	Diploma (Elec/Mech)/ Science Grad	5 years	8	8	8		24
8.	Admin Staff	Graduate	5 years	2				2
9.	Chemist	B. Sc-Chemistry	5 years	1				1
10.	Lab Assistant	Diploma in Lab Tech.	2 years	3	3	3	1	10
11.	Helpers	10th pass	-	16	10	10	1	37
12.	Safety Officer	Skilled		1			1	2
13.	Security Guards	10th pass	2 years	6	2	2	1	11
14.	Drivers	Skilled	2 years	2	1	1	1	5
15.	Gardener/Cafeteria cleaning	8th pass	2 years	8	4	4	2	18
	Total			56	36	36	7	136

Notes:

1. The above requirement is minimum and indicative. The Contractor shall arrange extra work force, as and when required, so as to smoothly run the operation and maintenance including preventive maintenance, repairs etc. and general cleanliness of the installations.
2. The above staff strength is exclusive of leave reserve required for different category of staff. The Contractor shall ensure availability of the personnel given in the above table for all seven days in a week.
3. The Contractor shall make appropriate arrangements for maintenance of items like road work, buildings, arboriculture, patrolling and maintenance of civil structures, vehicle operations and other activities defined to fulfil its obligations under Operation and Maintenance Contract.

13.4.3 Safety and Health

a) Chemicals

- All personal who are assigned to work on chemical storage and injection system shall first be trained to understand and follow all aspects of handling and safety procedures.
- Chemical handlers shall be instructed to report any condition that may affect their personal health to their superiors.

b) Electricity

- All the electrical equipment shall be handled and operated by a trained and authorized person only. All the equipment shall be checked for its proper earthing and loose connections prior to start equipment. Naked wire, loose connections and faulty connections shall be repaired immediately prior to start for operation.
- Electrical sockets and switch shall not be touched by bare or wet hands. If there is any live wire found naked or on wet ground, main switch shall be turned off first then the wire shall be repaired or moved.
- For any electrical works proper insulated tools shall be used. Do not try to use tools made for other purpose; it may be hazardous.

c) Fall Protection

- Only authorized person shall work at high place, people working at high level shall be very careful and protect himself from fall and injuries. Protective gears such as gloves, safety belts shall be worn and safety belts shall be tied to proper location prior to start the work. If anybody feels dizzy and drowsy he should not work at high and should come down immediately.
- Whenever possible a ladder shall be used. Ladder shall be in stable condition and proper slope of the ladder is 4 vertical and 1 horizontal and it shall be secured at the base.

- All the openings shall be secured properly by a barrier of a hand rail to avoid unauthorized person getting in. Whenever covers are provided for opening those covers shall be kept closed all the time, except for maintenance type.

d) Entering Tank

- If worker should enter inside of deeper manholes or tanks precautions shall be taken.
- Manholes covers shall be open and wait for fresh air to circulate.
- Prior to enter-oxygen level inside the tank shall be checked otherwise it may be hazardous. If oxygen is not enough a ventilating fan should use to supply fresh air inside.
- Only permitted person shall work inside, while a person is working inside there must be another person watching outside; unless he appoints next person he should not leave from duty. While men working inside manholes must keep open and manholes shall be protected from outsiders to go inside.
- If person inside feels drowsy, dizzy or unusual feeling he should come out immediately. He should take rest and take a fresh air.
- If the worker is collapsing inside, do not immediately enter inside for rescue him as as you may be next victim of accident. Prior to rescue make sure that oxygen is enough inside, report immediately to person in charge. Try to rescue the person from outside.

e) Health Checkup

Water can be scrapped and become a carrier of water borne disease if it is handled by an ill person. That is why personal health is an important factor to keep the water potable. Any person not feeling well shall report to their superior and shall be go through proper health checkups. All workers should go through medical checkup every year, and the result of check up shall be reported to the Engineer.

f) General Hygiene

Persons working for seawater treatment and desalination shall maintain a high level of personal hygiene. This includes clean work clothes, skin, fingernails and hair. They should wash their hands properly by using soap and clean water prior to handle the water treatment works.

g) Uniform

All workers at site work shall wear helmet, safety shoes, regular uniform to avoid any accident by rotating equipment.

13.4.4 Job Description

Plant Manager

The Plant Manager shall be in charge of all aspects linked to the performance of the operations contract. He shall have authority to carry out or have carried out all tasks involved in the smooth operation of the installation he manages. The Plant Manager will:

- Recruit staff
- Organize work
- Order chemicals and local supplies, including negotiation of supply contracts
- Assume full responsibility for ensuring compliance with safety regulations
- Handle the relations with the customer and inspection bodies
- Implement the resources required for compliance with treatment guarantees.

Operation Manager

The Operation Manager shall be directly under the orders of the Sr. Operation Manager. He shall be accountable for the treatment performance of the unit for which he is responsible; and will:

- Coordinate the process teams, who monitor and control the installations,
- Define the operating instruction allot tasks
- Supervise the laboratory, define the program of analysis, and interpret the results
- Draw up plant operation reports
- Inform the maintenance manager, define the modalities for work by maintenance crews.

Operating Staff

- Monitoring, reading and analysing all the operating parameters
- Applying the standardized procedures defined by Management
- Supervising and running the various units in accordance with the operating instructions, in compliance with the treatment objective
- Keeping a log of events in the installation
- Locking units out for servicing operations
- Informing operations Manager any problem in operation of equipment.

13.4.5 Desalination Plant

- a) Operation and maintenance of all the desalination process facilities from Intake system to clear water reservoir and sludge treatment to wastewater discharge to sea through outfall diffusers.
- b) The plant shall be operated continuously at minimum 97% availability. However, the net product water shall be produced at 400 MLD everyday of a month.
- c) Providing required manpower for routine operation of water and sludge treatment units, clear water reservoir and distribution pumps, EHV/LV switchgear room, PLC control, all motors, valves and piping in the system, and laboratory.
- d) Maintaining the PLC, including the hardware, software and all instruments, in good working condition. The downtime of entire control system shall not exceed 2 hours. During the downtime, the Contractor shall continue to operate the desalination plant in manual mode using the local panel controls and the readings from local instruments.
- e) Routine and periodic maintenance of the entire control system and instruments as per the manufacturer's recommendations.

- f) Replacement of damaged controls, communication cables and power supply cables.
- g) Repair or replacement, as required, of all instruments such as flow meters, pressure transmitters, pressure gauges, level sensors/transmitters, float type level switches, on-line pH meters, on-line turbidity meters, on-line residual chlorine meters and laboratory instruments along with all other equipment. The downtime of any individual instrument as referred above shall not exceed 24 hours.
- h) Periodic site calibration of all measuring/metering equipment or as recommended by the manufacturer. The calibration at manufacturer's works shall be done only in case of major failure/ repairs of the instruments.
- i) Preparation and submission of daily and monthly customized reports produced by the local SCADA/DCS system.
- j) Provision and maintenance of all consumables for printing without any additional costs to the Employer.
- k) Weekly lubrication of all gears of reduction motors, motorized valves, gates and other parts of the system.
- l) Periodic operating and checking all valves and gates for their manual and electric operation. Operation of valves must be checked from local control console, switchgear and through PLC system. Any defect observed must be made good.
- m) Ensuring environmentally friendly disposal of sludge at approved site(s), within a radius of 20 kilometers from the plant site. Contractor shall provide the rate for disposal at 20 kms and also beyond 20 km from the plant site.
- n) Operation and maintenance of all circuits and buildings associated with the treatment works.
- o) Breakdown maintenance of all electrical, mechanical and instrumentation equipment.
- p) Routine monitoring of substation equipment and take preventive measures (as required)
- q) Routine maintenance works of lighting and earthing system.
- r) Re-painting of the exposed mild steel components of pipeline, ladders, railings etc. in the desalination plant in every 3rd year of Operation and Maintenance to keep them in good shape.
- s) Maintaining the surrounding areas of the filter plant free from shrubs, weeds, grass and other unwanted vegetation.
- t) Annual cleaning and disinfection of the clear water reservoirs. The raw water shall be used for watering plant and washing.
- u) Providing safety accessories, (e. g. gloves, shoes, first aid box, etc.)
- v) Ensuring fire and safety equipment.
- w) The Contractor shall provide all necessary chemicals such as sodium hypochlorite, sulfuric acid, ferric chloride, polyelectrolytes, RO operational and cleaning chemicals, post treatment chemicals etc. The Contractor shall take three quotations from reputed

suppliers of required consumables and procure the material from the lowest quoted rate supplier. The Contractor will charge the cost of actual chemical consumption within the guaranteed limit. Minimum 30 days chemical stock shall have to be maintained to ensure that operation is not affected, and quality of water does not suffer. The Contractor shall use chemicals to ensure their most economic consumption and minimize wastage.

- x) The power consumption shall also not be more than the projected consumption provided by the Contractor in the Tender. In case the power consumption is above the guaranteed value, the Contractor shall pay for the excess in accordance with the Contract Data.

13.4.6 Lubrication

The Contractor shall furnish a complete schedule of recommended oils and other lubricants in the Operation and Maintenance manual. The number of types of lubricants shall be kept to a minimum. In case of grease lubricated bearings for electric motors, lithium base grease is preferred.

The Contractor shall indicate the brand name of indigenously available equivalent lubricants, with their complete duty specifications, in the Operation and Maintenance manual. The Contractor shall also furnish the schedule of quantities for each fill, frequency of filling and annual requirement in Operation and Maintenance manual.

Where lubrication is affected by means of grease, preference shall be given to a pressure system which does not require frequent adjustment or recharging. Frequent, for this purpose, means more than once in a month. Where more than one type of special grease is required, a grease gun for each special type shall be used. All lubricant systems shall be designed so as not to cause a fire or pollution hazard.

The Contractor shall supply flushing oil for such lubrication system when an item of plant is ready for preliminary running.

13.4.7 Spare Parts

All spare parts required for the maintenance of the plant must be from the manufacturer of the equipment or, if the equipment itself has been made with parts from other manufacturers, the parts must be of the same make as used in the equipment supplied and installed.

All spare parts shall be packed for long storage under the climatic conditions prevailing at the Site. Each spare part shall be labelled on the outside of its packing with its description, number and purpose. If more than one spare is packed in a single case, a general description of the case contents shall be shown on the outside and a packing list enclosed.

13.4.8 Desalination and Ancillary Works

- a) Providing guards in the campus areas round the clock, gardeners and other manpower to maintain the campus area green, neat and tidy.

- b) Maintenance of gardens and plantations in campus area, which will generally involve the following activities:
1. Watering of plants at required intervals
 2. Re-plantation without any additional cost in place of dead plants or damaged plants
 3. Hoeing and weeding, etc.
 4. Pruning, trimming and cutting of old big trees
 5. Removing shrubs, weeds, grass and unwanted vegetation after each rainy season from the desalination plant area
- c) Maintenance of roads and lighting fixtures and lighting circuits in the desalination plant campus.
- d) Maintenance of lighting fixtures and lighting circuits, water supply facilities in the desalination plant campus, offices and other residential buildings.
- e) The Contractor shall carry out ordinary repairs to buildings during the Operation and Maintenance period. The repairs may include but not limited to the following items:
- Easing of doors and windows, monsoon repairs to roofs, attention to drains, rain water spouts, attention to plinth protection.
 - External white or colour wash, external or internal painting, internal distempering, renewal of approach roads within the campus.
 - The frequency of repairs must not be less than as specified in Table below:

Table 13-7: Repair Frequency of Buildings

S. No.	Nature of Repair	Frequency of repair for Residential Buildings	Frequency of repair for other Buildings
1	External finishing (colour washing) after attending minor repairs such as damage to plaster etc.	In 3 rd year of Operation and Maintenance	Every three years
2	Internal finishing (distemper / painting) after attending minor repairs such as damage to plaster etc	In 3 rd year of Operation and Maintenance	In 3 rd year of Operation and Maintenance

- f) Repairs to buildings must be carried out during May to June except for white and colour washing work, which should be done in September and October after monsoon in residential buildings.
- g) Following repairs prior to onset of monsoon are essential:

- Any faults in the electric installation, leakages, earthing, exposed wire ends and any hazards on this account to the users/inmates of the buildings, should be taken care of suitably, wiring, which is damaged or outlived, should be replaced.
- Damaged sanitary lines should be replaced and choked lines cleared.
- Proper drainage of the area around the building should be ensured to avoid stagnation of rainwater/house effluent, in order to prevent malarial conditions. Where courtyards exist in the buildings, their drainage into the outer drains should be ensured. Any choked drains should be cleared properly.
- Leaking roofs should be attended to immediately with suitable repairs/treatment, as the case may be. The rain waterspouts should also be cleared of blockages, etc. The roof should be swept clean of leaves, debris, etc. , if any.
- The plaster on outer walls of the building, which is exposed to weather, should be repaired before rains in order to prevent dampness inside. Where plinth protection has been provided, it should be checked and the damaged portions, if any, should be repaired before rains.
- Damaged flooring should be repaired/ replaced as per requirement, in order to prevent dampness inside the rooms, etc. during rains.
- Periodic repairs of damaged floors, door/window fittings, water taps, water coolers, furniture, desert coolers, electric circuits, must be taken up on complaints using the material of same quality as used during construction.

13.4.9 Restoration of Rain Cuts

Earthwork for restoration of rain cuts in embankment and shoulders shall be made using suitable material and compacting the same. The material used for restoration of rain cuts shall be approved by the Engineer.

The area affected by rain cuts shall be cleared of all loose soil and benched. The width of the benches shall be at least 300 mm and they shall extend continuously for a sufficient length. The height of the benches shall be in the range of 150-300 mm.

Fresh material shall be deposited in layers not exceeding 250 mm loose thickness and compacted so as to match with the benching at moisture content close to the optimum. Compaction shall be carried out using suitable equipment such as plate compactors and rammers or by suitable implements handled manually. The finished work shall conform to alignment, levels and slopes.

13.4.10 Maintenance of Earthen Shoulder

The work of maintenance of earthen shoulder shall include making up the irregularities/loss of material on shoulder to the design level by adding fresh approved soil and compacting it with appropriate equipment, or stripping excess soil from the shoulder surface, as required.

The material to be added to the shoulder, if required, shall be the selected soil as specified for shoulder works. Wherever extra earth is required to be added, the earthen shoulder shall be stripped and loosened to receive fresh soil. The deficiency of thickness shall be made up in

layers of loose thickness not exceeding 250 mm. Water shall be added, if required, to attain the optimum moisture content and the layer compacted by 80 to 200 kN smooth wheel roller, vibratory roller, hand roller, plate vibrator or hand rammer to obtain at least 90% maximum dry density in accordance with IS: 2720 (Part 8). The finished surface shall have the specified cross slope and line in accordance with the drawing. The side shall be trimmed to the required slope with the help of grader or manual methods using hand tools.

Wherever the earth is required to be excavated from the shoulder, this shall be done either using equipment like grader or by manual means using hand tools. The resulting surface shall be uniform and have a field density of at least 90% maximum dry density obtained in accordance with IS:2720 (Part 8). If the surface is not uniformly compacted, it shall be excavated to a depth of 150 mm and the soil mixed with water if required and compacted at moisture content close to the optimum to achieve 90% of maximum density as stated above.

13.4.11 Wireless Communication System

- a) Maintaining of a wireless communication system to ensure reliable and easy communication within to and from desalination plant at Perur, Chennai.
- b) Replacement of batteries, faulty sets and all other non-functional equipment to ensure trouble free communication.

13.4.12 Operations and Maintenance Manual

The Operation and Maintenance manual shall establish guidelines for successful desalination plant systems operation by the plant operator. The guidelines shall also provide basic idea on how to operate the desalination plant and its pipe line so as to manage to steady water supply and the best water quality; less consumption of energy; less cost of maintenance expenses; a long life of equipment; protection against accidents and damage of system. The operators have to be well conversant with the manual and the guidelines stipulated therein.

In practice, the system operation and unit operation of each component needs to be continuously adjusted and modified depending on water demand and raw water quality.

The comprehensive manual shall be submitted before the commencement of operation and maintenance period, as specified for review and approval by the Engineer. It shall be periodically updated to incorporate the “best practices” experience gained while carrying out the Operation and Maintenance activities, broadly on the principles listed in Table below.

Table 13-8: Operation and Maintenance Manual

Items	Description
1. General	<ol style="list-style-type: none"> 1) plan and design condition 2) quality & quantity of raw water 3) quality & quantity of product water

Items	Description
	<ul style="list-style-type: none"> 4) planned desalination capacity 5) design pressure(pipe line) 6) component of the system (item, specification, quantity, remark) 7) detail of facilities (name of facility, units, no. structure, capacity, remarks) 8) detail of mechanical & electrical (name, specification, s. no./tag no., quantity, remarks) 9) detail of pipe line route (flow diagram including valves/gates s. no. /tag no. , specification, quantity, remarks)
2. System operation (Mech./Elec./ Inst)	<ul style="list-style-type: none"> 1) system drawings (plan view of desalination plant, hydraulic profile, flow diagram, single line diagram, electrical operation/control flow diagram, location /depth of water level sensor, flow control sensor system, others) 2) outline of main facility 3) concept of operation 4) concept of selection of facility 5) operation procedure (photograph with explanation) including operation of RO system. 6) preparation before start operation 7) starting of system operation 8) during regular operation 9) emergency operation 10) Intake pipe pigging for cleaning 11) CIP and flushing of RO skids 12) back washing of sand filter system (when back wash timing schedule, back wash condition, restoring, stopping of filter for long time) 13) sludge handling system (sludge withdrawing, dewatering, chemical feeding, cleaning)
3. Component detail & full operation (Mech./Elec./Inst)	<ul style="list-style-type: none"> 1) outline of all components 2) concept of selection of component 3) concept of auto-manual operation 4) preparation before start of operation 5) starting of operation 6) during regular operation

Items	Description
	7) emergency operation
4. Equipment details (Mech./Elec.)	1) outline of all equipment 2) specification, dimensional drawings, performance curve, dimension of water level sensor 3) concept of selection of facility 4) preparation before start of operation 5) starting of system operation 6) during regular system operation 7) emergency system operation
5. Quality of water	1) water quality standards with the authorized certificates of water analysis
6. Maintenance work summary	1) inspection (system, facility, unit operation, others) 2) maintenance (system, facility, unit operation, others) 3) replace/repair(system, facility, unit operation, others) 4) modification(system, facility, unit operation, others) 5) troubleshooting(photograph with explanation)
7. List of data sheet/chart(for daily &/or periodic report)	1) operational schedule (including sludge control valves, filter backwash, slope plates cleaning, jar test, water analysis, sludge disposal, staffing/shift etc.) 2) operational chart (description/number of workers/ allocation) 3) calculation method of dosing of coagulant/chlorination dosage 4) instruction manual for equipment 5) record of pump operation (pressure, q, time, rotation, noise) 6) record of water quality 7) record of water quantity control 8) record of facility control (including filter backwash, sludge control valves) 9) record of equipment control (including generators, sludge collectors) 10) record of chemical inventory(coagulant/hypochlorite) 11) record of sludge control (including dewatering, sludge handling, hopper) 12) record of material control

Items	Description
	13) list of analytical instrumentation & reagent 14) list of accessory/spare parts 15) list of manufacture/supplier 16) list of contractor/subcontractors 17) emergency control (accident/water contamination etc.) 18) list of key control
8. Safety & Health	1) acidification 2) coagulant 3) chlorination 4) electricity 5) fall protection 6) entering inside tank (lack of oxygen/being filled with gas poisoning) 7) health checkup (staff member/workers) 8) general personnel's cleaning 9) uniform 10) site cleaning 11) security control

- a) Updating any changes in the procedures set out in the Operation and Maintenance manual, as deemed necessary based on any limitations observed during the maintenance period, including incorporating additional procedures for maintenance of other repairs/break downs not incorporated in the maintenance manual but faced during Operation and Maintenance period.
- b) Procedures for repair of leaks/burst in different types of pipes must be provided, with supporting drawings. The Operation and Maintenance manual must be updated if any difference is observed during Operation and Maintenance period.
- c) Frequency of spares used in maintenance of valves (air-valve, sluice valves and butterfly valves), expansion joints, equipment installed for surge protection and protection against corrosion must be recorded for updating the contents of the manual.
- d) Records of troubleshooting points and details of events causing trouble (breakdowns) during maintenance of mixing and distribution chamber, flocculators, clarifiers, filters, RO system, limestone filters, CO₂ storage and dosing system, product water tanks, clear water reservoir and distribution pumps, sludge thickener and pump houses for thickened sludge feed, thickened sludge transfer and belt filter press wash water unit and any other parts of the plant must be maintained and used for updating the contents of the manual.
- e) Records of troubleshooting points and details of events causing troubles (break downs) during maintenance of pumps/motors/measuring equipment(s)/electric panel and

accessories there in must be maintained and used for updating the contents of the manual.

- f) Records of trouble shooting points and details of events causing trouble (breakdowns) during maintenance of sub-station, must be maintained and used for updating the contents of manual.
- g) Records of Inventory used must be maintained and the relevant portion of Operation and Maintenance manual must be updated to list out the inventory requirements for maintaining the system for 240 months.
- h) Records of the raw water quality, as monitored during very day of the Operation and Maintenance period, must be maintained and handed over after the expiry of Contract period. The chemical requirement in the worst conditions of operation must be identified and incorporated in the manual. Record keeping must be sufficient so as to assist in forming a relationship between the chemical dosages required for treatment with respect to the raw water input quality.
- i) The provisions in the manual must incorporate every aspect of good industrial practices even if not elaborated here or in other parts of the bid document. The provisions in the approved operation and maintenance document shall be valid and binding for both the parties during operation and maintenance along with the additions and deletions made.
- j) The manual so prepared must be updated after the end of every year of operation and maintenance, giving effect to the experience gained and the observations made by the Employer during the maintenance period.
- k) At the time of handing over after completion of Operation and Maintenance period, all the equipment, including standby equipment, must be in good working order.

13.4.13Quality of Product Water

Water will be provided within the permissible chemical and bacteriological parameters and, in general, there should be no lapse in it. The product water will be checked for important parameters at the critical points as mentioned in the Part-2, Chapter-3 and Chapter 10 instrumentation and control documents. The product water must meet the quality and quantity as specified in bid documents Part-2 Chapter 1 Project requirements (Table 1-1&1-2). In case the permissible parameters are not achieved, the liquidated damage shall be applied as per the particular conditions of the contract Part-3.

13.4.14Facilities to Contractor

The Contractor will be permitted to use the premises developed under the Contract for use by his staff during the operation and maintenance period to the extent agreed and approved by the Engineer.

13.4.15Format

The Contractor has to prepare a Report (Daily/ Monthly) regarding the Works performance, operations and maintenance. The report should include data pertaining to performance

compliance with Applicable Permit requirements, Performance Standards, Potable water and Raw Seawater, and any other information stipulated in this O&M section. The Monthly Report shall also include a description of operating parameters, maintenance activities, trouble shootings and emergency services performed. Apart from these, the report shall include minimum the following:

- a) Monthly average Potable water quantity delivered to each of the points of delivery of potable water and potable water (MLD).
- b) Monthly Average Source water quantity (MLD)
- c) Compilations of the daily flow records with respect to quantities of source water treated and Potable water delivered to the distribution system.
- d) A summary of all tests performed, and reports prepared during the month with respect to source seawater quality characteristics and parameters specified in this Schedule.
- e) A summary of all tests performed, and reports prepared during the month with respect to Potable water quality characteristics and parameters as specified in Attachment 3.
- f) A projection of the Potable water capacity for both process water and for source seawater of the Works for the current month.
- g) A description of recommended Works or unit shutdowns for maintenance and repairs during the current month and anticipated during the following month.
- h) Description of unscheduled repairs.
- i) A list of significant preventive maintenance activities performed on major pieces of equipment and Works during this month and similar activities anticipated for the following month.
- j) Any anticipated adverse condition that may affect the ability of the Works to receive and treat source water and deliver Potable water to the points of connection to the water distribution system.
- k) The results of any inspections conducted by governmental regulatory authorities during the current month, including recommended follow-up actions by the Bidder.
- l) The quantities (units) of electricity used during such month.
- m) Information on any utility (power, water or other) outages that have occurred during the current month that have an impact on the ability of the Bidder to perform its obligations under this agreement.
- n) A description of all incidents wherein the Potable water quality standards and / or quantity standards were not met, including the follow-up actions recommended by the Bidder to taken to eliminate or reduce the likelihood of re-occurrence.

- o) A description of any incidents (hazardous materials emergencies, security breaches, etc.) that adversely impacted Works operations and Bidder ability to fulfil its obligations under this agreement.
- p) Summary of Bidder worker claims filed, third party claims filed, and updates on the status of existing claims.
- q) Semi-annually, an update of the spare parts inventory.
- r) CMMS report on Scheduled / completed maintenance report
- s) Any other data or information as mutually agreed by the Parties.

Suggested formats to be followed for proper recording of pumping and plant operations are given below. The format can be finalized during execution stage with the consent of the Engineer. The format is an example for format only as it does not include complete parameters.

Format 1**Daily Report on Operation and Maintenance**

Prepared by: [Name of Contractor] Report For: [Date]

A. Consumption Records							
Sr. No.	Item Consumed	Meter Reading or other records		Daily Quantity	Average per m ³ of raw water	Remarks	
		At 6:00 hrs of reporting day	At 6:00 hrs of previous day				
A.1	Raw seawater quantity received at plant inlet (comm Reading - ML)						
A.2	Coagulant						
A.3	Liquid Polymer						
A.4	Sodium Hypochlorite						
A.5	Electrical Power						
A.6	Product Water quantity produced at plant outlet (comm Reading - ML)						
B. Quality Records							
Raw Water							
		6:00 hrs	12:00 hrs	18:00 hrs	24:00 hrs	Average	Remarks
B.1	Turbidity						
B.2	Temperature						
B.3	pH						
B.4	Residual Chlorine						
B.5	Conductivity						
		Daily Once at 12. 00 hrs					
B.6	Colour						
B.7	TSS						
B.8	Alkalinity						
		Weekly Once at 12. 00 hrs					
B.9	BOD						
B.10	COD						
B.11	TOC						

B.12	Ammonia						
B.13	NO ₃						
Seawater after RO Feed Tank							
		6:00 hrs	12:00 hrs	18:00 hrs	24:00 hrs	Average	Remarks
B.14	Turbidity						
B.15	Temperature						
B.16	pH						
B.17	Residual Chlorine						
B.18	ORP						
		Daily Once at 12. 00 hrs					
B.19	SDI						
B.20	TOC						
Product Water							
		6:00 hrs	12:00 hrs	18:00 hrs	24:00 hrs	Ave.	
B.21	Res. Chlorine						
B.22	Turbidity						
B.23	pH						
B.24	Conductivity						
		Daily Once at 12. 00 hrs					
B.25	Colour						
B.26	TSS						
B.27	Boron						
		Weekly Once at 12. 00 hrs					
B.28	BOD						
B.29	NO ₃						
B.30	Ammonia						
B.31	Hardness						
C. Operational Downtime							
Sr. No.	Unit	From hrs.	To hrs.	Total time	Remarks		
C.1	Unit (identify)						

Signed by: _____

Designation: _____

On behalf of Contractor: _____

Format 2**Monthly Report on Operation and Maintenance**

Prepared by: [Name of Contractor] Report For: [Month]

Sr. No.	Item Consumed	Reading on last date of month	Maximum Reading of month	Average Quantity per day	Remarks
A.1	Raw seawater quantity received at plant inlet				
A.2	Liquid Polymer –1				
A.3	Liquid Polymer –2				
A.4	Hypochlorite				
A.5	Electrical Power				
A.6	Product Water quantity produced at plant outlet (comm Reading – ML)				
B. Quality Records					
Particulars		Average during month	Maximum during month	Minimum during month	Remarks
Raw Water					
B.1	Turbidity				
B.2	Temperature				
B.3	pH				
B.4	Residual Chlorine				
B.5	Conductivity				
B.6	Colour				
B.7	TSS				
B.8	Alkalinity				
B.9	BOD				
B.10	COD				
B.11	TOC				
B.12	Ammonia				

B.13	NO3				
B.14	SDI				
	Product Water				
B.15	Res. Chlorine				
B.16	Turbidity				
B.17	pH				
B.18	Conductivity				
B.19	Colour				
B.20	TSS				
B.21	Boron				
B.22	BOD				
B.23	NO3				
B.24	Ammonia				
B.25+ ++++	Hardness				

C. Quantity of Sludge (by storage measurement)				
	Total during month	Average daily	Average per MLD of product water	Remark
Thickener				
Thickened Sludge (%)				
Belt Filter Press Solids (%)				
D. Operational Downtime				
Sr. No.	Unit	Total time during month	Average daily	Remark
D.1				

Signed by: _____

Designation: _____

On behalf of Contractor: _____

13.5 Operation and Maintenance Practices for Instrumentation Control and Automation

13.5.1 General

A comprehensive maintenance program is critical to attaining long-term reliable performance of SCADA/DCS/ICA systems. The aid of Computerized Maintenance Management System (CMMS) shall be envisaged for the O&M. Periodic device calibration, preventive maintenance, and testing allow potential problems to be identified before they can cause failure. Prompt corrective maintenance assures reliability by minimizing downtime of redundant components. The EPC or Turnkey contractor has to enter into AMC contracts with system/equipment suppliers, as necessary. It is mandatory to enter into an agreement for minimum 5 years maintenance contract with the instrumentation, PLC and SCADA/DCS system supplier or the authorized system integrator, whosoever has executed the work for this project.

13.5.2 Preventive Maintenance

The SCADA/DCS system shall be included in the preventive maintenance (PM) program for the facility. The table below provides a list of recommended maintenance activities and frequencies for SCADA systems and their components. Preventive maintenance schedules for SCADA components and subsystems should be coordinated with those for the mechanical/electrical systems they serve to minimize overall scheduled down time.

Table 13-9: List of Recommended Maintenance for SCADA System

Activity	Frequency
Pneumatic Systems/Components/Instruments	
Check Regulators and Filters	Monthly
Inspect Tubing and Piping	Monthly
Actuate Pressure Switches	3 months
Calibrate Switches and Sensors	Yearly
Calibrate Pressure Gauges	Yearly
Calibrate Level Transmitters	Yearly
Calibrate Flow Transmitters	Yearly
Calibrate Pressure Transmitters	Yearly
Calibrate Thermometers/Temperature transmitters	Yearly
Calibrate Analytical Instruments/Online Instruments (pH, Turbidity Residual chlorine, etc.)	6 Months
Change Sampling solution of Analytical Instruments	As required
Electronic Systems	

Activity	Frequency
Lamp Test/Verify Indicators	Monthly
Inspect Enclosures for Dirt, Water, Heat	Monthly
Run PLC Diagnostics	3 Months
Calibrate Sensors and Transmitters	Yearly
Calibrate Meters	Yearly
PLC Communication Modules	Monthly
PLC Batteries	Yearly
Test Automatic control Sequences	Monthly
Verify Alarms	Weekly
Software Maintenance and Patching	3months
Anti-virus Definition Updates	Monthly
Inspect Wire, Cable and Connections	Monthly
Inter site Communication Network	Weekly
Dead Bus Relays	3 Months
UPS setting with SCADA	Weekly
PLC Redundant Power back up	Monthly
SCADA Redundancy	Monthly
Network Redundancy	Weekly
PLC Hot-Standby	Monthly
Historian Package(Capacity)	Monthly
Data Archiving	Monthly
System Upgrade	When available

Many components of DCS/SCADA systems, such as dead-bus relays, are not required to function under normal system operating modes. For this reason, the system should be tested periodically under actual or simulated contingency conditions. These tests should approach as closely as possible the actual off- normal conditions in which the system must operate. For example, DCS/SCADA for Dual Redundant system should be tested by interrupting the utility source as far upstream of the normal service as possible.

Periodic system testing procedures can duplicate or be derived from the functional performance testing procedures.

The DCS/SCADA software maintenance should include timely updates of any new versions from the supplier and testing to verify proper installation on the DCS/SCADA computer. In addition, software antivirus updates should be maintained. This should be performed any time after the computer is connected to the Internet or the antivirus patch should be downloaded as and when the updates are available. Normal operation requires that the DCS/SCADA computer not be connected to the Internet.

Faulty Instruments, sensors, transmitters, communication modules, computer hardware should be replaced with new components. Repair of the failure items would not be accepted. Instruments, modules would have to replace with a new instruments and components.

13.5.3 Concurrent Maintenance

Concurrent maintenance is defined as testing, troubleshooting, repair or replacement of a component or subsystem while redundant component(s) or subsystem(s) are serving the load. The ability to perform concurrent maintenance is critical to attaining the specified reliability/availability criteria for facilities and must be designed into the DCS/SCADA system. Where DCS/SCADA components are associated with equipment that has redundancy and therefore are not themselves redundant, their maintenance should be scheduled to occur during maintenance of the associated equipment. DCS/SCADA components and controllers that are redundant must be capable of being taken out of service, repaired or replaced and tested without interfering with the operation of the redundant component.

13.5.4 Reliability Centred Maintenance

Reliability-Centred Maintenance (RCM) is an approach for developing an effective and efficient maintenance program based on the reliability characteristics of the constituent parts and subsystems, economics, and safety. RCM provides a logical, structured framework for determining the optimum mix of applicable and effective maintenance activities needed to sustain the operational reliability of systems and equipment while ensuring their safe and economical operation and support. This shall be aided by the use of the Computerized Maintenance Management System.

A significant byproduct of the application of DCS/SCADA systems to the control of facilities is the large amount of operational data made available through the trending and data storage features of the DCS/SCADA. This operational data can be used for automated performance monitoring of mechanical and electrical systems that can support an RCM approach.

13.5.5 Operation and Maintenance Documentation

The contractor should perform an Operation and Maintenance analysis to determine the Operation and Maintenance data required to support maintenance of the ICA/DCS/SCADA system. This analysis should be coordinated with CMWSSB to determine maintenance parameters and Operation and Maintenance data that are available. Typical Operation and Maintenance data requirements include the following items:

- System documentation as defined in FDS, FAT & SAT documents

- Minimum spare parts list.
- Recommended spare parts list.
- Recommended onsite test equipment.
- Recommended Operation and Maintenance training.
- Recommended Operation and Maintenance to be performed by the Contractor.

13.5.6 Spare Parts Stocking

An adequate on-site stock of spare parts is essential to obtaining high availability of ICA/DCS/SCADA systems. All spare parts used for the equipment in the maintenance of the system must be from the manufacturer of the equipment or, if the equipment itself has been made with parts from other manufacturers, the parts must be of the same make as used in the equipment supplied and installed.

All spare parts shall be packed for long storage under the climatic conditions prevailing at the Site. Each spare part shall be labelled on the outside of its packing with its description, number and purpose and, if more than one spare is packed in a single case, a general description of the case contents shall be shown on the outside and a packing list enclosed.

- a) Minimum recommended stocking levels include the following. These quantities may need to be increased for components which are used in large numbers in the facility:
 - Manufacturer's recommended spare parts list.
 - One each of all line replaceable boards or modules.
 - Six each power and control fuses used in the system.
 - Tools required to terminate coaxial or fibre optic cables.
- b) Automation:
 - Laptop computer loaded with software required to access controllers. Licenses for all software installed on the system.
 - Permission to modify program code.
 - Spare cables for connecting computer to controllers.
 - PLC CPU, Power supply module. 1 DI, DO, AI, AO modules, Communication module, protocol converter, etc. .
 - PLC batteries, fuses, etc.

13.5.7 Utilities & Consumables

The Contractor shall provide consumables for printers e.g: Ink cartridges (colour & B/W), A4, A3, A1 size of paper, dot-matrix print paper for the complete operation and maintenance period. Downtime of the above system should not exceed more than 2 hours.

13.5.8 Technical Support

The Contractor should specify functional areas of the operating system and/or equipment where a Technical representative will be furnished by the manufacturer for training, test, checkout, validation, or pre-operational exercises.

Ongoing operation and maintenance of DCS/SCADA system software may require technical support from the system vendor or from agency technical personnel not located at the facility. Commercial DCS/SCADA software typically has provisions for remote modem access that permit this type of support from the vendor's location or an agency central engineering group.

Such remote access provisions represent a vulnerability to "hacking" and must be used with great caution. They should be monitored when in use and physically disconnected when not in use. Password protection policies for all DCS/SCADA systems, including PLC's, shall be in compliance with Established policies and to be agreed with the Employer's representative.

These policies require that the default password that came from the control supplier be changed when placed into operation at the facility.

CHAPTER - 14

14. HAND OVER

14.1 General

This section applies to procedures for transferring the 400 MLD desalination plant at Perur, Chennai after 20 years of operation and maintenance by the Contractor to the Employer. The specifications of the Plant is the complete plant including seawater pre-treatment, RO desalination and post-treatment processes with sludge treatment facilities, the instrumentation and control system, the communication system, 230kV/110kV/11kV/433V substations, DCS systems, all ancillary buildings and campus area. The procedure for Hand Over shall be processed only after the final examination by the Engineer. A Contract Completion Certificate shall be issued after the submission of all the approved completion documents before the Contract deadline and the successful final examination.

14.2 Duties and Responsibilities

All costs for the examination/test/training, and preparation of any documents shall be the Contractor's responsibility.

14.2.1 Official Certificate

All units and equipment shall be tested and verified for their satisfactory performance and test certificates shall be issued by the testing team/agency. A number of units/equipment as essential shall be tested by an outside authorised agency. All test certificates will be issued by the authorized organization by the qualified personnel with his signature.

14.2.2 Conduct First Training

The Contractor shall provide first the training program to Perur plant staff member for six months before conducting joint inspection. The typical training program is as follows:

- Basic process engineering
- Study of Operation and Maintenance manual
- Operation skill/technology (mechanical and electrical) including normal and emergency operation
- Maintenance and repair skill/technology (mechanical and electrical)
- Water analysis
- Record keeping and maintenance of records
- SCADA/DCS systems
- Safety & Health
- Visits to existing water treatment plants
- Evaluation of the program (examination)
- Others requested by the Engineer.

14.2.3 Joint Inspection

To verify the plant condition and its performance before the completion of 20 years of operation and maintenance, joint inspection will be carried out using updated Operation and Maintenance manual. Not less than two years prior to the expiry date of the O&M period, a joint inspection of the Works shall be conducted. Within 28 days of the completion of the joint inspection, the Contractor shall submit a report on the condition of the Works identifying maintenance works, replacements and other works required to be carried out to satisfy the requirements of the O&M plan before the Contract Completion Date. This section shall be read in conjunction with the Clause 11.8 Part 3 of the Contract.

The Contractor shall submit a programme for carrying out such works over the remainder of the O&M period.

The typical inspection items are shown in the table below.

Table 14-1: Typical Items to be examined at the end of the Operation Service Period

Item	Description
1. Appearance test /Visual examination (Damage/crack, differential settlement, soil settlement, peel off paint, missing/lost, leakage of water/solution/gas, corrosion, decolonization, condition of maintenance, others)	<ul style="list-style-type: none"> • All civil structures, building including interior/exterior, fence/gate, stairs, others • All mechanical & electrical equipment/accessories, others • All pipe line valves and gates, others • All instrumentation and control equipment, others • All water quality analysers, others
2. Performance examination (Selection of operation mode, selection of facilities, flow/water level, overflow, leakage of water/solution/gas, heating, vibration/noise level, speed of rotation, smoothness, gap/spaces, accuracy, setting value, condition of maintenance, others)	<ul style="list-style-type: none"> • Check the sequence, or manual operation including water level sensors/protections, others • Check the specification of all processes facilities, others • Check the specification of all mechanical equipment including pressure gauges, pressure relief valves, others • Check the specification of all electrical equipment, others • Check the specification of all pipe line including valves, gates, others • Check the specification of all accrual condition after troubleshooting, others • Check performance (flow, pressure, noise, vibration, other conditions etc.) of all equipment

Item	Description
	and units.
3. Verification of rectified works (System, leakage, crack, damage, soil settlement, corrosion, others)	<ul style="list-style-type: none"> • Checklist of all defect items, history, tendency, repeating, others • Checklist of all miss operation and maintenance items, others • Check all factors of defect/miss operation, others • Verification of action on the take measures, others • Verification of all rectified works with the reports and photo, others • Check emergency works and its factor, action plan, others • Check actual condition after rectified works, others
4. Operation skill (Staff member, others)	<ul style="list-style-type: none"> • Review of daily report and a summary report on Operation and Maintenance activities • Check time and motion of staff member, others • Interview operator regarding troubleshooting, others • Paper test (basic knowledge, calculation of chemical dosing, safety, others) • Field test (using/put on the safety gear, drill of chlorine leakage accident, others)
5. Water analysis (Sampling and analysis, others)	<ul style="list-style-type: none"> • Location of sampling and time, and date • Raw water and treated water • Process wise • Authorized certificate
6. Spare parts and others	<ul style="list-style-type: none"> • Check inventory list (parts, chemical, reagent, others) • Check the quantity of inventory, others • Check maintenance tools and equipment, vehicles, others

14.2.4 Tests Prior to Contract Completion

Upon satisfactory completion of the items identified above, the Contractor shall submit the program and procedures for the tests prior or the contract completion. After the review of the submission and revision of the program as needed, the Employer's representative shall instruct

the Contractor to commence the Tests Prior to Contract Completion.

14.2.5 Submission of Completion Documents

The Contractor shall submit the completion documents after passing the final examination before the Contract deadline. The typical report consists of relevant documents for the request for issue the Contract Completion Certificate of 20 years Operation and Maintenance period. Typical completion documents are shown in the table below. These data shall be provided in soft and hard copies in proper professional format as approved by the Employer's Representative.

Table 14-2: Typical Completion Documents to be Handed Over at the End of the Operation and Maintenance Period

Contents	Description
1. Outline	Outline <ul style="list-style-type: none"> Summary of the project, scope of work, location of the project, main component with the specification, others
2. Completion Photographs (At acceptance complete inspection, completion inspection and final inspection)	Photographs with a short description <ul style="list-style-type: none"> Civil (structural, buildings, others) Mechanical and Electrical (equipment, facility, others) Piping works
3. Inspection summary (At acceptance complete inspection, completion inspection and final inspection)	Appearance test/visual/performance examination <ul style="list-style-type: none"> Table of summary of daily and monthly test activities List of type of test, date, inspector, evaluation, comments Civil (name of the structure, drawing No., drawings, design dimension, previous dimension, actual dimension, photograph with short description others) Mechanical (name of facility and equipment, Tag. No., quantity, others) Electrical and ICA (name of facility and equipment, Tag. No., quantity, others)
4. Main inspection data during construction	Summary of data with graphic /chart <ul style="list-style-type: none"> Civil (plate load bearing test, compressive strength test, water retaining test, compaction field test, road restoration works, road construction works, hydrostatic test, others) Mechanical (disinfection test, control of filter and filter media quality others)

Contents	Description
	<ul style="list-style-type: none"> Electrical (earthing resistance test, others)
5. Inspection record (At acceptance complete inspection, completion inspection and final inspection)	<ul style="list-style-type: none"> Appearance test /visual/ performance examination Performance examination Verification of rectified works (refer to Table 15.1) Civil Mechanical Electrical and ICA
6. Training and commissioning record (At first and second training program)	<ul style="list-style-type: none"> Summary (schedule of training and commissioning, attendance rate, impression on training program) Training attendance list (participants, trainings date, others) Commissioning daily record (water flow rate of designed and actual, tested water flow, name of the operated facility, list of measurement and its time and reading value, raw and treated water quality, value of V/Am/kW of each equipment, others) Photographs with a short description
7. Water quality certification data (At acceptance complete inspection, completion inspection and a final inspection)	<ul style="list-style-type: none"> Location of sampling and time, and date Raw water and treated water Each process (Refer to Section 14.5, Table 14.3) Issued from Authorized certificate
8. Operation/maintenance manual (Civil, mechanical, electrical, ICA)	<p>Update</p> <ul style="list-style-type: none"> Refer to Section 14.5.12
9. Spare parts list	<ul style="list-style-type: none"> Mechanical (name of parts, Tag. No., quantity, location of stock, others) Electrical (name of parts, Tag. No., quantity, location of stock others) Pipe & fittings (name of parts, Tag. No., quantity, location of stock others) Valve & gates (name of parts, Tag. No., quantity, location of stock others) Others (name of parts, Tag. No., quantity, location of stock others)

Contents	Description
10. Key list with boxes	<ul style="list-style-type: none"> Name of key, location, Tag. No., quantity
11. Manufacture produced catalogue (Civil, mechanical, electrical, ICA)	<ul style="list-style-type: none"> Civil (all related material: sand filter media, bar, round bar, cement, cement paste, asphalt, chemical admixture, water reducing agent, pozzolan, vibrator, water-tightness sheet, construction equipment, manhole, fence-gate, pipe, water-resistant coating, paint, coating agent, windows, door, lock & key, others) Mechanical (all related equipment; pumps, fine screens, manual screen, mixer, blower, control valve, sludge collectors, dewatering, conveyor, hopper, tanks, chorine dosing equipment, coagulant dosing equipment, safety equipment, pipe, valve, gate , pressure gauge, safety valves, flow meter, coating painting, others) Electrical (all related equipment: electric wire, electric conduit, manhole , motor, control panel, relay, transformer, heater, generator and silencer, timer, breaker, light/lamp, switch, street light, earthing, measurement equipment, air condition, communication equipment, electric pole, coating painting, ventilation fan, air duct, others) ICA (All instruments, DCS etc.) Safety equipment Others
12. Instruction manual (Civil, mechanical, electrical & ICA)	See above
13. Factory inspection record or quality assurance (Civil, mechanical, electrical & ICA)	<ul style="list-style-type: none"> Civil (all related material: sand filter media, bar, round bar, cement, aggregate, sand, gravel, asphalt, crushed stone, chemical admixture, water reducing agent, pozzolan, water-tightness sheet, construction equipment, manhole, pipe, water-resistant coating, paint, windows, door, others) Mechanical (all related equipment; pumps, fine screens, manual screen, mixer, blower, control valve, sludge collectors, dewatering, conveyor, hopper, tanks, chorine dosing, safety equipment, pipe, valve, gate, pressure gauge, safety valves, flow meter, coating

Contents	Description
	<p>painting, others)</p> <ul style="list-style-type: none"> Electrical (all related equipment: electric wire, electric conduit, manhole, motor, control panel, relay, transformer, heater, generator and silencer, timer, breaker, light/lamp, switch, street light, earthing, measurement equipment, air condition, communication equipment, electric pole, coating painting, ventilation fan, air duct, others) ICA (All instruments, DCS etc.) Safety equipment Others
<p>14. Photograph (during Construction, at joint completion inspection, at defect liability) (Civil, mechanical, electrical & ICA)</p>	<p>History of construction Replacement of defect liability</p> <ul style="list-style-type: none"> Civil: construction site before starting construction, earthwork, the arrangement of the bar, rust, cleaning before placing, formwork, concrete mixing work, placing, vibrator, curing, remove of formwork, backfill, compaction, all field inspection and lab test, others Mechanical: inspection at factory, receiving inspection, completion inspection, all field inspection and lab test, others Electrical: inspection at factory, receiving inspection, completion inspection, all field inspection and lab test, others ICA (All instruments, DCS etc)
<p>15. Production samples (Civil, mechanical, electrical & ICA)</p>	<p>All samples for technical approve</p> <ul style="list-style-type: none"> Attach Tag. No., and its name, approved sign of the Engineer.
<p>16. Report</p>	<ul style="list-style-type: none"> Monthly and annual report Others

14.3 Specifications

The specification of materials used for repairs shall be the same as that have been used in the original DB Works. The Engineer should approve specifications for any materials that were not employed during construction before repair work prior to the Hand Over. In spite of being restricted by this clause, in an emergency the Contractor may use an appropriate material for repairs even if the Engineer has not approved material required for such repairs. However, subsequent to the use of such material, the Contractor shall submit proposals for the approval

of specifications of such materials at the earliest within two-week time duration.

14.4 Check List of Contractor's Responsibility

14.4.1 General

Within the framework of the Contractor's responsibilities, the Contractor shall carry out the following activities. However, these shall not limit the requirement for other activities that otherwise are required as per terms and conditions of the Contract or to fulfil the Contractor's responsibilities or are essential as per the good industry practices. The Contractor shall hand over the components of Works in good working condition for, but not limited to the following items:

- a) All process units in good working condition with replaced wear and tear parts to the satisfaction of the Engineer. All MS equipment and structures shall be buffed, cleaned and painted with the appropriate paint and specified specifications.
- b) All civil works intact without any evidence of crack, peeling of plaster or surface finish. All civil building shall be painted with the appropriate paint and of the specified specifications.
- c) All electrical equipment such as 230kV/110kV/11kV/415V transformers, GIS, LT switchgear/MCCs, control stations, cables, earthing, AMF Panel, battery, etc. at the water treatment plant, etc. (all works constructed under this Contract) in neat and clean condition.
- d) All consumables required for the functioning of the plant with the inventory of materials.
- e) AMC contracts with system/equipment suppliers, as necessary for PLC and SCADA system supplier or the authorized system integrator as executed the work for this project.
- f) Lighting fixtures and the lighting system of all areas and replacement of all non-functional lighting fixtures.
- g) Records for:
 - Repair history of all mechanical, electrical and instrumentation control equipment in the water treatment plant, and communication instruments
 - Logbooks through the DCS system
 - Daily log of operations of all the important equipment such as mixing and distribution chamber, chemical feed system, flocculators, clarifiers, filters, chlorination systems, electrically actuated valves, etc., with a time tag
 - Hourly readings water production
 - Raw seawater and product water quality test results on turbidity, residual chlorine levels, etc.
 - Daily list of alarms with a time tag
 - Logbook format and the data to be included in the logbook
 - Last periodic maintenance done for all equipment/buildings of the system
- h) All available spares, special tools and test equipment and adequate inventory of required

accessories or equipment for repair of electrical, mechanical, instrumentation and control system, pipe and the communication system. At the end of the Contract, the Contractor shall hand over the full spares, machines, equipment, tools and tackles (as detailed in Part-2 for workshop, Spare Parts, Accessories and Tools”) as supplied with the Contract by replacing the used/dilapidated items with fresh supplies of the same specifications.

- i) Repair of the roads, buildings and campus area utilities
- j) Drinking water supply facilities at desalination plant campus and all its units
- k) Record of stores for the electrical, mechanical and instrumentation and control equipment as well as that for the chemicals, membranes, and laboratory consumables at the plant. The records shall include but shall not be limited to:
 - Loading/unloading of materials received and issued for works;
 - Proper arrangement of material in stores to ensure its safety and easy availability;
 - Maintaining store areas in a neat and tidy condition;
 - Keeping records and accounting for the incoming materials;
 - Keeping records and accounting for the consumed materials.
- l) Structures/buildings of campus areas of the treatment plant and others built in the Contract must ensure adequate cleanliness, ventilation, illumination and structural safety. In addition to this, the general hygienic standards must be in acceptable condition and adequate plantation, horticultural activities must be well maintained to give the pleasant environment of the campus/buildings.
- m) Updated Operation and Maintenance manual as defined in specifications for operation and maintenance works.

14.4.2 Plant in Good Working Condition

The Contractor shall hand over all components of the Works in good working condition for the following, but not limited to:

- a) All the process unit facilities from intake works to clear water tank and sludge/sewage treatment facilities including mechanical, civil, electrical works and ancillary equipment and instruments such as laboratory equipment, analysers, computer system, etc. as built.
- b) DSC including all the hardware, software and all instruments, in good working condition.
- c) Entire control system and instruments as recommended by the manufacturer.
- d) Replacement of damaged controls, communication cables and power supply cables.
- e) Repair or replacement, as required, of all instruments such as flow meters, pressure transmitters, pressure gauges, level sensors/transmitters, float type level switches, on-line pH meters, on-line turbidity meters, on-line residual chlorine meters and laboratory instruments along with all other equipment.
- f) Calibration of all measuring/metering equipment or as recommended by the manufacturer. The calibration at the manufacturer's workplace shall be done only in

case of major failure/ repairs of the instruments.

- g) Submission of daily and monthly customized reports produced by the local SCADA/DCS system in hard copy and soft copy.
- h) Provision of all required consumables for printing.
- i) Repair of damaged moving parts, steel structures, and the reinforced concrete structures. Repairs, cleaning and disinfection shall be done.
- j) Repair or replacement of all leaking or malfunctioning ERDs and associated items.
- k) Lubrication of all gears of reduction motors, motorized valves, gates and other parts of the system.
- l) Check all valves and gates for their manual and electric operation. Operation of valves must be checked from the local control console, switchgear and through the PLC system. Any defect observed must be made good.
- m) Ensuring environmentally friendly disposal of sludge at the approved site(s), within a radius of 20 kilometers from the Desalination plant.
- n) Make good all circuits and buildings all electrical, mechanical and instrumentation equipment, substation equipment, lighting, DG Set and earthing system associated with the treatment works including replacement, if any (as required).
- o) Painting of the exposed mild steel components of pipeline, ladders, railings etc. in the filter must be in good shape.
- p) Make good surrounding areas of the filter plant free from shrubs, weeds, grass and other unwanted vegetation.
- q) Ensure availability of safety accessories, (e.g. gloves, shoes, first aid box, etc.)
- r) Ensure availability of fire and safety equipment.
- s) The Contractor shall provide necessary chemicals such as ferric chloride, acid polyelectrolyte etc. for a stock of at least one month period.

14.4.3 Lubrication

In the Operation and Maintenance manuals, the Contractor shall furnish a complete schedule of recommended oils and other lubricants. The number of types of lubricants shall be kept to a minimum. In case of grease-lubricated bearings for electric motors, lithium-base grease is preferred.

The Contractor shall indicate the brand name of indigenously available equivalent lubricants, with their complete duty specifications, in the Operation and Maintenance manual. The Contractor shall also furnish the schedule of quantities for each fill, frequency of filling and annual requirement in the Operation and Maintenance manual. Where lubrication is affected by means of grease, preference shall be given to a pressure system which does not require frequent adjustment or recharging. Frequent, for this purpose, means more than once in a month. Where more than one type of special grease is required, a grease gun for each special type shall be used.

All lubricant systems shall be designed so as not to cause a fire or pollution hazard. The

Contractor shall supply flushing oil for such a lubrication system when an item of plant is ready for preliminary running.

14.4.4 Spare Parts

All spare parts used for equipment in the maintenance of the system must be from the manufacturer of the equipment or, if the equipment itself has been made with parts from other manufacturers, the parts must be of the same make as used in the equipment supplied and installed.

Any balance available spare parts may be handed over to CMWSSB.

All spare parts shall be packed for long storage under the climatic conditions prevailing at the Site. Each spare part shall be labelled on the outside of its packing with its description, number and purpose and, if more than one spare is packed in a single case, a general description of the case contents shall be shown on the outside and a packing list enclosed.

14.4.5 Electrical System

The Contractor shall hand over the following at the end of the Operation and Maintenance period:

- a) Revised As built drawings based on all modifications during the Operation and Maintenance period. All electrical drawings like Single Line Diagrams, Control Circuits Equipment Layout, Cable Layout, and Cable Schedules, Earthing Layouts shall be maintained and shall be handed over.
- b) Details of protective relay settings and time relay settings, including any changes done during the Operation and Maintenance period, details of oil changes/filtration of transformers, records of any changes made in the system during the Operation and Maintenance period, etc. shall be maintained.
- c) Equipment wise maintenance record during Operation and Maintenance period, as per daily checking out/inspection and regular (every 6 months or 12 months).
- d) Motor wise power consumption details and over-all power consumption detail of plant. Details of IR test of all equipment like HT/LT panels, HT/LT motors, generators, transformers.
- e) Switchgears and cables, etc., shall be maintained.
- f) Logbook showing details electrical faults that have occurred in the plant and record of corrective actions taken during Operation and Maintenance period.
- g) Equipment wise technical data given by equipment supplier, documents showing Bill of Materials and Operation & Maintenance Manual (hard copy and soft copy).
- h) List of mandatory spares that are to be maintained at stores and their actual availability in the plant, if it is below, the same shall be replenished.
- i) Details of measurement of earth resistance, earth pit wise and overall values during the Operation and Maintenance period.
- j) Details of illumination levels during the Operation and Maintenance period along with

details of changes, if any, effected during the Operation and Maintenance period.

14.4.6 Electrical Checks to be Done During Hand Over

- a) Contractor to provide a test schedule & format to be approved by Engineer before commencing any test.
- b) Checking of all electrical equipment, items etc., as per bill of materials. visual checking and tracing out the circuit based on revised as-built drawings.
- c) Visual operational checks of all equipment & protections have to be done.
- d) If transformer oil samples are not tested in the last 6 months, the same shall be done during Hand Over.
- e) Earth resistance of individual, combined pits for substations shall be checked during Hand Over.

14.4.7 Instrumentation, Control and Automation System

The Contractor shall hand over the following documents/drawings/manuals/programs at the end of the Operation and Maintenance period:

- a) Revised As built drawings approved by the Employer's Representative based on all modifications during the Operation and Maintenance period. All ICA Drawings like P&ID, system configuration diagram (PLC & DCS architecture), instrument installation drawings, instrument cable schedule, and cable layouts shall be maintained and shall be handed over.
- b) Handing over document/manuals shall include a minimum five sets of soft copies and five sets of hard copies. The hard copies shall be spiral bounded clearly indicating the version/revision submitted. All the contents shall be indexed. The contents of handing over document/manual shall be clearly legible and shall include the original manufacturer's literature on a minimum, and in-corporate any changes as per site conditions. Suitable Asset Management software tool may be adopted by the contractor for the purpose.
- c) Detailed drawing and manual of the DCS installed. Manual shall include the PLC series installed along with complete details on I/O modules, Ethernet switch, relay modules, and converters (if any).
- d) A complete manual shall be provided which shall include operating instructions and troubleshooting techniques of the DCS and accessories installed illustrated with examples. This shall be provided along with the standard manufacturer's literature.
- e) A complete manual shall be provided, which shall include operating instructions and troubleshooting techniques of the DCS and accessories installed, illustrated with examples. This shall be provided along with the standard manufacturer's literature.
- f) A complete manual shall be provided, which shall include operating instructions and troubleshooting techniques of the ODMS installed illustrated with examples. This shall be provided along with the standard manufacturer's literature.
- g) A complete manual shall be provided, which shall include operating instructions and

troubleshooting techniques of the interface control panel, where applicable. This shall be provided along with the standard manufacturer's literature.

- h) Interoperability testing tool/software shall be provided along with relevant manuals and operating instruction with examples.
- i) Latest PLC program back-up, DCS software back-up with license, DCS database backup, reports and alarm back-up, Historical archived data containing reports and alarms, and ODMS data and configuration set-up shall be provided.
- j) All software's used under ICA shall be handed over along with their original licenses.
- k) Complete list of database/addresses shall be provided clearly indicating the spare tags for DCS/SCADA and ODMS software's.
- l) List of mandatory spares that are to be maintained at stores for complete ICA package and their actual availability in the plant shall be provided.
- m) Any password's set to access the internal PLC program; an interface control panel shall be provided and demonstrated.
- n) All passwords (PLC, Interface control panel & DCS and other software/hardware) shall be provided in a sealed envelope and addressed to the Engineer.
- o) DCS, PLC, and ODMS package shall be updated with the latest software version/patch before handing over. The same shall be demonstrated to the Engineer.
- p) Latest licensed version of Windows operating system along with MS Office or equivalent software which is prevailing at that point in time shall be installed on SCADA machines and other machines installed and integrated with the SCADA and ODMS package. The same shall be demonstrated to the Engineer.
- q) The Contractor shall conduct a training session for the Employer's personnel which shall include PLC/DSC configuration, troubleshooting techniques, SCADA configuration and troubleshooting techniques, ODMS configuration and troubleshooting techniques, diagnostic techniques and troubleshooting techniques for wireless technology employed for communication.
- r) The training session shall be conducted for the duration indicated elsewhere in the specification documents.
- s) Manufacturer's literature/manuals for flow meters, level transmitters, switches, pressure transmitters etc and analytical instruments installed.
- t) Instrument wise, DSC and ODMS maintenance record during the complete Operation and Maintenance period shall be provided.
- u) A complete and updated list of all manufacturers/system integrators/contractors of ICA with contact numbers shall be provided. The same shall also be made available on site for ready reference.
- v) The latest versions of all drawings of ICA, which shall include cable termination details, I/O mapping, database details etc., shall be provided in PDF format and editable format and loaded in the operator machine available on site. The same shall be demonstrated to the Engineer.

14.4.8 ICA Checks to be Done during Hand Over

- a) Contractor to provide a test schedule and format to be approved by the Engineer before commencing any of the tests.
- b) Functional checking of all laboratory instruments/equipment and ICA equipment, including online analyzers, flow meters, pressure and level instruments, vibration monitoring instruments, and wireless equipment being used for communication.
- c) Loop checks will be conducted.
- d) All instrument cabling shall be inspected for continuity. If found faulty, the same shall be replaced and demonstrated.
- e) All instrumentation cable conduits shall be checked for damage. If found faulty, they shall be rectified or replaced and sealed to the satisfaction of the Engineer
- f) Visual operational checks of PLC panel, DCS system and interface control panel.
- g) Licensing feature of PLC, DCS software and hardware, ODMS software and other hardware shall be demonstrated.
- h) Functional check of set points changes at HMI and it's downloading to PLC's concerned.
- i) Hot-standby feature of PLC and hot swappable feature of I/O modules shall be demonstrated. If found to be faulty/non-operational, shall be rectified and, if required replaced to normal working condition and demonstrated to the Employer.
- j) Dual-redundant server feature of DCS shall be demonstrated. If found to be faulty/non-operational, shall be rectified and if required replaced to normal working condition and demonstrated to the Employer.
- k) Functional check of ODMS software in conjunction with DCS shall be conducted.
- l) Functional check of data received/transmitted from remote stations shall be conducted in conjunction with DCS.
- m) Historical archiving of all data shall be demonstrated.
- n) Availability of memory for the smooth operation of DCS and ODMS machines shall be demonstrated. If found to be inadequate, the same shall be rectified/archived and demonstrated.
- o) If any instruments and automation equipment are found to be faulty during the above tests, the same shall be rectified or replaced as necessary.

14.4.9 Plant Ancillary Works

- a) Make gardens and plantation in the campus area green, neat and tidy with the removal of shrubs, weeds, grass and unwanted vegetation and make pruning, trimming and cutting of old big trees from the Plant Area along with.
- b) Reinstate the roads and lighting fixtures and lighting circuits in the water treatment plant campus to its original state.
- c) Make good and working conditions for lighting fixtures and lighting circuits, water supply facilities in water treatment plant campus, offices and other residential buildings.

- d) The Contractor shall carry out ordinary repairs to buildings. The repairs shall include but not limited to the following items:
- Easing of doors and windows, monsoon repairs to roofs, attention to drains, rainwater-spouts, attention to plinth protection.
 - External white or colour wash, external or internal painting, internal distempering, renewal of approach roads within the campus.
 - Repairs to administrative and other buildings must be carried out during fair season after monsoon. The building shall be fully renovated as needed at the Hand-Over.

Following repairs before the onset of the preceding monsoon are essential:

- a) Any faults in the electric installation, leakages, earthing, exposed wire ends and any hazards on this account to the users/inmates of the buildings, shall be taken care of suitably, wiring, which is damaged or outlived, shall be replaced.
- b) Damaged sanitary lines shall be replaced and choked lines cleared.
- c) Proper drainage of the area around the building shall be ensured to avoid stagnation of rainwater/house effluent in order to prevent malarial conditions. Where courtyards exist in the buildings, their drainage into the outer drains shall be ensured. Any choked drains shall be cleared properly.
- d) Leaking roofs shall be attended to immediately with suitable repairs/treatment, as the case may be. The rain waterspouts shall also be cleared of blockages, etc. The roof shall be swept clean of leaves, debris, etc., if any.
- e) The plaster on the outer walls of the building, which is exposed to weather, shall be repaired before rains in order to prevent dampness inside. Where plinth protection has been provided, it shall be checked and the damaged portions, if any, shall be repaired before rains.
- f) Damaged flooring shall be repaired/replaced as per requirement, in order to prevent dampness inside the rooms, etc., during rains.
- g) Repairs of damaged floors, door/window fittings, water taps, water coolers, furniture, desert coolers, electric circuits, must be taken up on complaints using the material of the same quality as used during construction.

14.4.10 Restoration of Rain Cuts

Earthwork for the restoration of rain cuts in embankment and the shoulders shall be made using suitable material and compacting the same. The material used for the restoration of rain cuts shall be approved by Engineer and in general shall be as specified for earth work in specifications elsewhere.

14.4.11 Maintenance of Earthen Shoulder

The work of maintenance of earthen shoulder shall include making up the irregularities/loss of material on shoulder to the design level by adding fresh approved soil and compacting it with the appropriate equipment, or stripping excess soil from the shoulder surface, as required.

14.4.12 Wireless Communication System

Make good a wireless communication system to ensure reliable and easy communication to and from Desalination Plant at Perur, to CMWSSB, Chennai. Replacement of batteries, faulty sets and all other non-functional equipment to ensure trouble-free communication, if required.

14.4.13 Operation and Maintenance Manual

The comprehensive Operation and Maintenance manual (seven sets) shall be submitted at the end of the Operation and Maintenance period as specified. It shall be updated based on the Engineer's comments. These manuals shall be made available during training sessions conducted by the Contractor. A soft copy of the same shall also be submitted.

14.4.14 Quality of Product Water

Water shall be provided within the permissible chemical and bacteriological parameters. The product water quality shall be as per BIS 10500 standards.

14.4.15 Payments

The Contractor, at the time of tendering, shall ensure the completeness and adequacy of his Tender Price to fulfil the entire responsibilities as described in specifications. His Tender Price for operation and maintenance, shall include all costs for Hand Over.

14.4.16 Format

For proper recording of desalination plant operations, the formats are provided in Operation and Maintenance Specifications in Volume 2, Part 13. All the operation and maintenance records shall be submitted in hard and soft editable form.

14.5 Completion Certificate

Notwithstanding the foregoing, other services to be performed by the Contractor must be completed before the Contractor will be entitled to receive the Contract Completion Certificate. Pre-conditions that must be fulfilled by the Contractor before the Contract Completion Certificate is specified in GC 8.6 Part 3 of the contract document. In addition, the following are to be fulfilled.

- (a) Inspection and tests of all the Works
- (b) Remedying defects found during tests and inspection;
- (c) All activities in accordance with the above Clause 14.4;
- (d) Updating Operation and Maintenance manuals providing performance records and data;
and

A joint inspection shall be arranged by the Contractor to assess the condition of civil structure, mechanical and electrical equipment and instrumentation. Based on this inspection, a list of remedial repair and replacement for the components will be prepared by the Engineer. The Contractor shall carryout such remedial works at his own cost. Again, the joint inspection shall

be arranged by the Contractor for certification of completion of remedial work as well as condition of all civil work to its original appearance. The Contractor shall submit the entire required document to the Engineer / Employer's Representative for review and comments. The Contractor shall resubmit the document incorporating any comments.

The Employer shall issue a Contract Completion Certificate to the Contractor on his request within 30 days after the take-over of the plant subject to the above documents and obligation are met by the Contractor before 90 days prior to Hand Over.

CHAPTER - 15

ENVIRONMENTAL AND SOCIAL MANAGEMENT PLAN

The Bidder shall provide his Environmental and Social Management Plan (ESMP) in detail so as to demonstrate the procedures that will be used to ensure that the environmental and social concerns are addressed.

After award of contract and before the start of work, Contractor shall review the available Environmental and Social Management Plan (ESMP) prepared for the project which is 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 in line with JICA Environmental and Social guidelines. The ESMP shall incorporate the requirements stipulated in the Project's EIA Report and conditions of approval from State/ Centre Regulatory agencies. The ESMP shall also clearly define roles, responsibilities, reporting requirement and budgetary allocations for implementation of mitigation measures. The revised ESMP shall be submitted by the Contractor to CMWSSB for necessary approval before initiating any groundwork.

The ESMP shall identify the potential environmental and social impacts from the various construction and operations and maintenance activities to be undertaken in the Contract and set out in detail the approach he will adopt in mitigating these impacts to ensure that the residual impacts are minor and confined to a short period.

While preparing the proposed ESMP, the Bidder shall consider but not be limited to the following:

- The Bidder shall pay attention to the methods of materials delivery, storage, usage and disposal; equipment usage; and site activities to ensure they have minimal impact on the environment, workforce and community,
- The Bidder shall propose only environmentally safe products and practices in performing his works, and
- The Bidder shall comply with all the statutes regarding environmental and social impacts.

The Bidder shall provide separate descriptions of its proposals for minimizing any adverse environmental and social impacts/ effects during the construction phase and the subsequent operations and maintenance phase. It is the responsibility of the successful bidder to implement ESMP addressing all the safeguards and measures for the project.

15. ENVIRONMENTAL MANAGEMENT PLAN

15.1 Project-related activities, issues, and mitigation measures

15.1.1 Pre-Construction Stage

S No.	Project-related Issues	Mitigation Measures to be taken	Responsibilities	
			Planning and Execution	Supervision/ Monitoring
A.	Pre-Construction Stage			
A.1	Assure compliance with relevant construction field legislation	All clearances required and Environmental and social aspects from other departments shall be ensured and made available before the start of work. Acquire construction permit and Provide Water management guidelines. The project requires Consent to Establish (CtE) under the Water and Air Act from the Tamil Nadu State Pollution Control Board.	CMWSSB/ Contractor	CMWSSB
A.2	Utility Relocation	<ul style="list-style-type: none">Identify the common utilities that would be affected, such as telephone cables, electric cables, electric poles, water pipelines etc.,Affected utilities shall be relocated with prior approval of the concerned agencies before construction starts.Alternate temporary arrangement for crossing over shall be provided.	Contractor	CMWSSB
A.3	Supply of Material and resources	Procurement of construction material only from permitted sites and licensed/ authorized quarries. Identify locally available resources/ materials and eco-friendly materials.	Contractor	CMWSSB
A.4	Water	The Contractor will be responsible for arranging an adequate supply of water of the required quantity for the entire construction period. Groundwater extraction not permitted in the area. The contractor will minimize the wastage of water during construction.	Contractor	CMWSSB

S No.	Project-related Issues	Mitigation Measures to be taken	Responsibilities	
			Planning and Execution	Supervision/ Monitoring
A.5	Appointment of Environment Health & Safety Officer	The contractor will appoint qualified and experienced HSE Officers who will dedicatedly work and ensure implementation of EMP, including Occupational health and safety issues at the camp, construction work sites.	Contractor	CMWSSB
A.6	Other Construction Vehicles, Equipment and Machinery	<p>All vehicles, equipment and machinery to be procured for construction/ protection work will conform to the relevant Bureau of Indian Standard (BIS) norms/ CPCB standards. The discharge standards promulgated under the Environment Protection Act, 1986 and Motor Vehicles Act, 1988 will be strictly adhered to.</p> <p>Soundproof DG set as per regulations will be used at the project site.</p> <p>The contractor will maintain records of Pollution Under Control (PUC) certificates for all vehicles used during the contract period, which will be produced to the Project Implementation Unit for verification whenever required.</p>	Contractor	CMWSSB
A.7	Risk Assessment and preparation of management plans ²	<p>Risk and hazards associated with different construction activities shall be identified by the contractor, and accordingly, management plans shall be prepared for implementation on-site such as</p> <ul style="list-style-type: none"> • Construction Labour Management Plan; • Traffic Management Plan; • Health and Safety Management Plan; • Construction material Management Plan; • Air pollution control Plan; 	Contractor	CMWSSB

S No.	Project-related Issues	Mitigation Measures to be taken	Responsibilities	
			Planning and Execution	Supervision/ Monitoring
		<ul style="list-style-type: none"> • Construction Waste Management Plan; • Spillage Management Plan; • Marine environment Management Plan; • Tree plantation Programme; • Environmental Monitoring Plan including marine water and sediment quality monitoring; • Emergency Response Plan; and Construction Demobilization Plan. 		
A.8	Disaster Management Plan	<p>The Contractor shall identify the key risks associated with each component/ activities for entire project life cycle (construction, operations, & decommissioning) and shall prepare Disaster Management Plan (DMP) for the proposed plant.</p> <ul style="list-style-type: none"> • Further, the DMP for the plant should be synchronized with the district Disaster Management Plan (DMP) for off-site emergencies. • Contractor shall ensure the availability of required resources for the implementation of DMP at the site and incapacitate local communities in handling disaster and emergency response 	Contractor	CMWSSB

S No.	Project-related Issues	Mitigation Measures to be taken	Responsibilities	
			Planning and Execution	Supervision/ Monitoring
A.9	Land Acquisition/ Resettlement & Rehabilitation (R&R)	<p>R&R issue is not involved in the proposed land. However, the site has Casuarina tree plantation, which needs to be cleared.</p> <p>These trees to be cleared in accordance with the provisions given under Government order (G.O.157) dated 29.4.2016</p> <p>The plan is to be prepared for clearing the trees, i.e. cutting Schedules, coordination with the Forest Department and/ or, TN-Newsprint and Papers, Total value of the trees, Budget allocations, compensation to the landowner, auction systems and management of tree cutting for pulps, waste management, construction vehicle and equipment managements etc., for Perur DSP site.</p>	CMWSSB/ Prospective Tree cutting contractor	CMWSSB

15.1.2 Construction Stage

Sr. No.	Project Activity	Relevant Environmental components likely to be impacted	Nature of Impact	Likely Impacts and their significance in the absence of Mitigation Measures	Proposed Mitigation Measures	Responsibilities		
						Planning	Execution	Monitoring
B	Construction Phase							
B.1	Trenching for Intake and outfall pipelines	Marine water quality	Short Term, Localised, Reversible	<ul style="list-style-type: none">– Increase in turbidity affecting the Photosynthetic process affecting the aquatic productivity.– Suspended Particles will affect the filter feeders, and adult fish will migrate from the site of impact– Change in marine water	<p>Check turbidity levels with baseline levels as a reference during the entire monitoring programme</p> <p>Use of good engineering tools like cutter suction dredger for trenching to be used</p> <p>Controlled method of dredging with the latest technology which will limit the plume generation</p> <p>Discharge of waste into the sea will be prohibited</p> <p>Oil Spill control measures will be adopted</p> <p>Ensure slop tanks will be provided to barges/ workboats</p>	Contractor	Contractor	CMWSSB

Sr. No.	Project Activity	Relevant Environmental components likely to be impacted	Nature of Impact	Likely Impacts and their significance in the absence of Mitigation Measures	Proposed Mitigation Measures	Responsibilities		
						Planning	Execution	Monitoring
				quality due to aqueous discharges (oily waste, sanitary wastes) from dredgers, barges and workboats	for collection of liquid/ solid waste. Marine environmental monitoring program Silt fences (Pollution Control Equipment) are utilized for controlling turbid water during the construction of trenches for the pipelines			
		Marine ecology	Short Term Localised Reversible	<ul style="list-style-type: none"> Trenching will disturb the sea bed resulting in loss of seagrass beds and associated benthic communities Boat movement and fishing activity 	<p>To complete the trenching works in the shortest duration.</p> <p>Environmental education on the marine ecosystem as well as the habitat of sea turtles to workers, labourers, and surrounding villagers.</p> <p>Preparation of reports of Sea turtle sightings in and around the seashore in Perur to relevant official entities and NGOs.</p>			

Sr. No.	Project Activity	Relevant Environmental components likely to be impacted	Nature of Impact	Likely Impacts and their significance in the absence of Mitigation Measures	Proposed Mitigation Measures	Responsibilities		
						Planning	Execution	Monitoring
				<p>will be restricted</p> <ul style="list-style-type: none"> – The decrease in DO levels – Increase in noise levels – Removal of benthic communities – Increase in species diversity and density in areas adjoining dredging site – Smothering or blanketing of sub-tidal communities. 	<p>Avoidance of installations of intake/ outfall pipelines during the sea turtles egg-laying seasons.</p> <p>Actions to be taken in cases where sea turtles are observed in and around the seashore in Perur such as to contact to relevant NGOs and official entities handling sea turtle conservations and monitoring for getting necessary instructions.</p> <p>Temporary suspension of the construction works if necessary with prior intimation.</p> <p>Announcement of the existence of sea turtles to the contractor(s), construction workers/labourers and surrounding communities.</p>			

Sr. No.	Project Activity	Relevant Environmental components likely to be impacted	Nature of Impact	Likely Impacts and their significance in the absence of Mitigation Measures	Proposed Mitigation Measures	Responsibilities		
						Planning	Execution	Monitoring
		Mangrove area	Long Term Localised Non-Reversible	– Impact on nearby mangrove	No mangroves were observed at the proposed project site The impact is not envisaged	Contractor	Contractor	CMWSSB
B.2	Seawater Intake head	Entrapment of fishes and other organisms	Continuous	– Impact on Fish and Fish larvae	– Deep Water Intake having velocity cap and screen is proposed. – The intake velocity is limited to 0.12 m/s – The bar screen of 0.1 m width is to be installed Above are the design consideration included in the project	Contractor	Contractor	CMWSSB
		Entrainment of smaller organisms such as fish larvae.						
B.3	Fishing	Fishermen and fishing travellers	Short Term Localised Reversible	– Impact on fishing due to Construction works – During the trenching for	The following measures are suggested: Signboards will be placed at the construction site to make fishermen aware of ongoing activities	Contractor	Contractor	CMWSSB

Sr. No.	Project Activity	Relevant Environmental components likely to be impacted	Nature of Impact	Likely Impacts and their significance in the absence of Mitigation Measures	Proposed Mitigation Measures	Responsibilities		
						Planning	Execution	Monitoring
				laying the submarine pipeline, the fisherman will not be allowed to cross over the areas where trenching is being done. This is a short term impact and completely reversible as there will not be any prohibition of fisherman crossing the areas above the path where the submarine pipeline is laid	<p>Necessary marker buoys will be installed</p> <p>Interactions will be initiated with a fishing community prior to commencement of construction</p> <p>Construction shall be limited to as per development plan.</p> <p>Proper Planning execution of offshore construction activities to ensure the completion of construction as per schedule</p> <p>Ensure slop tanks will be provided to barges/ workboats for collection of liquid/ solid waste</p> <p>Trenching will be done only in small stretches, and so fishing activities can continue as normal in all other areas except where the active trenching/ laying of the pipeline is being done. There</p>			

Sr. No.	Project Activity	Relevant Environmental components likely to be impacted	Nature of Impact	Likely Impacts and their significance in the absence of Mitigation Measures	Proposed Mitigation Measures	Responsibilities		
						Planning	Execution	Monitoring
					will not be any prohibition of fisherman crossing the areas above the submarine pipeline are laid below the seabed.			
B.4	Outfall diffuser	Marine water quality	Temporary	– Increased suspended solids	Monitoring of marine water quality for timely action to prevent adverse effect on marine life. Suitable measures to ensure the same shall be implemented.	Contractor	Contractor	CMWSSB
		Chlorine concentration		– Chlorine concentration to be maintained below 0.2 ppm at the outfall.	Chlorine dosing rate to intake seawater is designed for the elimination of marine growth at intake and inside the pipeline. Residual Cl ₂ concentration will be approximately 0.2 ppm at the outlet of the pre-treatment system by consuming Cl ₂ in the intake and pre-treatment processes. To protect the RO membrane from chlorine attack, Sodium			

Sr. No.	Project Activity	Relevant Environmental components likely to be impacted	Nature of Impact	Likely Impacts and their significance in the absence of Mitigation Measures	Proposed Mitigation Measures	Responsibilities		
						Planning	Execution	Monitoring
					<p>Bisulphite (SBS) is injected for removing Cl₂ at the inlet of the RO membrane. Accordingly, the brine has no chlorine as calculated in the above equation.</p> <p>RO reject contains an excess SMBS which can reduce the Cl₂ concentration in the discharge. During regular operation, the Cl₂ concentration of the discharge from DSP can be maintained less than 0.2 ppm.</p>			
B.5	Vehicle movement	Air quality	Short Term Localised Reversible	– Negative Impact of Air quality	<p>Periodic inspection of exhaust gases of dump trucks, other trucks and heavy equipment to be used;</p> <p>Water spraying for heavy vehicles, equipment and trucks operation on-site in the dry season to avoid dust uplift and air pollution;</p>	Contractor	Contractor	CMWSSB

Sr. No.	Project Activity	Relevant Environmental components likely to be impacted	Nature of Impact	Likely Impacts and their significance in the absence of Mitigation Measures	Proposed Mitigation Measures	Responsibilities		
						Planning	Execution	Monitoring
					<p>Trucks carrying construction material/ demolition debris to be adequately covered to avoid dust pollution and to avoid the material spillage;</p> <p>The contractor shall ensure that the batching plant has closed belt conveyor;</p> <p>DG set shall have adequate stack height as per TNPCB requirement;</p> <p>Excavated soil shall be covered to avoid dust emissions.</p>			
B.6	Manpower for Construction works	Water Quality	Short Term Localised Reversible	– Negative Impact of water quality	Construction office will be provided with an adequate number of toilets as per labour laws and connected with a septic	Contractor	Contractor	CMWSSB

Sr. No.	Project Activity	Relevant Environmental components likely to be impacted	Nature of Impact	Likely Impacts and their significance in the absence of Mitigation Measures	Proposed Mitigation Measures	Responsibilities		
						Planning	Execution	Monitoring
					<p>tank or modular STP for treatment of wastewater.</p> <p>Once the construction is over, Septic tank to be removed and closed.</p>			
B.7	Noise and Vibration	Noise Quality	Short Term Localised	– Negative Impact of noise quality	<p>PPEs to be provided to all labours working at the site.</p> <p>Servicing of all vehicles and machinery shall be done regularly as per the manufacturer's guidelines, and during routine servicing operations, the effectiveness of exhaust silencers will be checked and if found defective will be replaced.</p> <p>Batching plant shall be located minimum 1 km away from the nearby settlement, and noise barriers shall be provided around batching plant in case of nearby</p>	Contractor	Contractor	CMWSSB

Sr. No.	Project Activity	Relevant Environmental components likely to be impacted	Nature of Impact	Likely Impacts and their significance in the absence of Mitigation Measures	Proposed Mitigation Measures	Responsibilities		
						Planning	Execution	Monitoring
					<p>settlement is located much closer to the batching plant site;</p> <p>DG set shall have an acoustic enclosure.</p> <p>Maintenance of vehicles, equipment and machinery shall be regular and up to the satisfaction of the Engineer to keep noise levels at the minimum.</p> <p>The contractor should maintain the proper records for all the constructions vehicles and have a valid fitness certificate, NOC, insurance etc.</p> <p>The construction activities shall be carried out in a planned manner restricting high noise-generating construction activities only during daytime;</p>			

Sr. No.	Project Activity	Relevant Environmental components likely to be impacted	Nature of Impact	Likely Impacts and their significance in the absence of Mitigation Measures	Proposed Mitigation Measures	Responsibilities		
						Planning	Execution	Monitoring
					<p>Acoustic measures to be provided to reduce noise propagation to noise-generating machinery during operations.</p> <p>Regular monitoring shall be conducted at site during operations.</p>			
B.8	Solid waste management	Soil Quality	Short Term Localised Reversible	– Impacts due to disposal of solid waste	<p>Periodical de-sludge activities for toilets in construction sites by the use of public services or by the service providers.</p> <p>Waste oil (from hydraulic systems, etc.) collection and treatment by solid waste collection companies. Storage at DSP site to be provided with secondary containment (Dike) for avoiding any spillages.</p> <p>Surplus soil management by back-filling.</p>	Contractor	Contractor	CMWSSB

Sr. No.	Project Activity	Relevant Environmental components likely to be impacted	Nature of Impact	Likely Impacts and their significance in the absence of Mitigation Measures	Proposed Mitigation Measures	Responsibilities		
						Planning	Execution	Monitoring
					Being a greenfield project, Construction waste and debris waste generation is minimal. The minor quantity generated will be utilized within the DSP for various construction works			
B.9	Handling of Hazardous Waste	Human safety and property loss	Short Term Localised	– Fire accidents due to hazardous material handling	<p>Hazardous materials such as lubricants, paints, compressed gases, varnishes etc., will be stored and disposed of as per the Hazardous Wastes (Management, Handling) Rules 2016 India</p> <p>Hazardous wastes will be disposed of through approved TNPCB/ CPCB authorised recycler/ disposal agency. Copy of the agreement should be maintained with inventories.</p>	Contractor	Contractor	CMWSSB

Sr. No.	Project Activity	Relevant Environmental components likely to be impacted	Nature of Impact	Likely Impacts and their significance in the absence of Mitigation Measures	Proposed Mitigation Measures	Responsibilities		
						Planning	Execution	Monitoring
					<p>Regular audit of hazardous waste generated and records and records</p> <p>A suitable site should be identified for the safe storage and handling of chemicals and other hazardous materials with a paved surface and proper display of requirements and marking as a protected area.</p> <p>Secondary containment shall be provided for hazardous chemicals such as diesel, lubricants, paints etc.</p> <p>Material safety data sheets (MSDS) of all the hazardous chemicals shall be properly displayed at storage areas as well as handling areas.</p>			

Sr. No.	Project Activity	Relevant Environmental components likely to be impacted	Nature of Impact	Likely Impacts and their significance in the absence of Mitigation Measures	Proposed Mitigation Measures	Responsibilities		
						Planning	Execution	Monitoring
B.10	Transportation of Construction material and mobilization of construction machinery and vehicular movement within site ⁴			—	<ul style="list-style-type: none"> Contractor shall ensure that traffic management plan for onsite and offsite vehicular movement is in place to the satisfaction of the CMWSSB Engineers; Routes for use by construction traffic within site to be planned with proper signage to minimize encountering of construction workers with vehicles. The routes for the movement of heavy machinery shall be designated to avoid the soil compaction in other areas; All vehicles deployed at the site shall be pollution under control (PUC) certified; Holding area shall be provided within site for vehicles waiting 	Contractor	Contractor	CMWSSB

Sr. No.	Project Activity	Relevant Environmental components likely to be impacted	Nature of Impact	Likely Impacts and their significance in the absence of Mitigation Measures	Proposed Mitigation Measures	Responsibilities		
						Planning	Execution	Monitoring
					to deliver loads at the site so as to avoid queuing outside the site; Proper clearance to be obtained from the concerned authorities and sent to the CMWSSB before the commencement of works; Modern machinery such as JCBs, backhoes etc., shall be used to increase work efficiency and minimize the construction period. Regular maintenance shall be done.			
B.11	Barricading site			—	Contractor shall ensure that the construction area is barricaded properly. The construction site should be barricaded at all time in with adequate marking, flags, reflectors etc. to isolate it from other operating areas.	Contractor	Contractor	CMWSSB

Sr. No.	Project Activity	Relevant Environmental components likely to be impacted	Nature of Impact	Likely Impacts and their significance in the absence of Mitigation Measures	Proposed Mitigation Measures	Responsibilities		
						Planning	Execution	Monitoring
					Barricading the onshore pipeline route prior to construction activities.			
B.12	Site preparation- excavation and levelling			—	<ul style="list-style-type: none"> Disturbance to land surface contours to be kept to a minimum. Contractor shall try to maintain the natural drainage pattern existing onsite; Adequate drains and slopes to be laid across the proposed Project site prior to the start of excavation work to ensure adequate cross drainage. 	Contractor	Contractor	CMWSSB
B.13	Top Soil Protection			—	<ul style="list-style-type: none"> Topsoil removed prior to commencement of construction activities shall be stored separately, protected and reused for landscape development within the project area. Land disturbance shall be restricted to the footprint of the 	Contractor	Contractor	CMWSSB

Sr. No.	Project Activity	Relevant Environmental components likely to be impacted	Nature of Impact	Likely Impacts and their significance in the absence of Mitigation Measures	Proposed Mitigation Measures	Responsibilities		
						Planning	Execution	Monitoring
					Project components, and the remaining area will be kept undisturbed to the extent possible. All excavations should be closed before the start of the rainy season.			
B.14	Storage of construction material			—	Contractor shall identify designated covered area for storage of construction material with proper marking and measures to avoid dust emissions. Construction material stored in open shall be covered in order to avoid wind-blown dust emissions.	Contractor	Contractor	CMWSSB
B.15	Removal of temporary construction structures and			—	Contractor to prepare site restoration plans, the plan is to be implemented by the	Contractor	Contractor	CMWSSB

Sr. No.	Project Activity	Relevant Environmental components likely to be impacted	Nature of Impact	Likely Impacts and their significance in the absence of Mitigation Measures	Proposed Mitigation Measures	Responsibilities		
						Planning	Execution	Monitoring
	demobilization of construction machinery				contractor prior to demobilization. On completion of the works, all temporary structures will be cleared away, all rubbish cleared, excreta or other disposal pits or trenches filled in and effectively sealed off and the site left clean and tidy, at the contractor's expenses, to the entire satisfaction of the engineer			
B.16	Compliance to Permits			—	Contractor shall ensure all compliance conditions given in CRZ clearance, Consent to Establish are compiled, and compliance monitoring reports are submitted to agencies on a regular basis.	Contractor	Contractor	CMWSSB

Sr. No.	Project Activity	Relevant Environmental components likely to be impacted	Nature of Impact	Likely Impacts and their significance in the absence of Mitigation Measures	Proposed Mitigation Measures	Responsibilities		
						Planning	Execution	Monitoring
B.17	Chance found archaeological property			—	<p>All fossils, coins, articles of the value of antiquity, structures and other remains or things of geological or archaeological interest discovered on the site shall be the property of the Government and shall be dealt with as per provisions of the relevant legislation.</p> <p>The contractor will take reasonable precautions to prevent his workmen or any other persons from removing and damaging any such article or thing. He will, immediately upon discovery thereof and before removal, acquaint the Engineer of such discovery and carry out the SC's instructions for dealing with the same, waiting which all work shall be stopped.</p>	Contractor	Contractor	CMWSSB

Sr. No.	Project Activity	Relevant Environmental components likely to be impacted	Nature of Impact	Likely Impacts and their significance in the absence of Mitigation Measures	Proposed Mitigation Measures	Responsibilities		
						Planning	Execution	Monitoring
					The Engineer will seek direction from the Archaeological Survey of India (ASI) before instructing the Contractor to recommence the work at the site			

Note : PMC will be assisting CMWSSB in monitoring during construction phase.

C	Operation Phase							
C.1	Product water production	Water Quality	Localised Reversible	– Impact on offshore water quality	Periodical maintenance of Screens, Lamella, DAF, DMF, Membrane, CIP systems of DSP operation, filter backwashing, Belt filter press washing and Sewage Treatment Plant (STP) based on relevant O&M manuals and instructions of such facilities.	O&M Contractor	O&M Contractor	CMWSSB
		Noise Quality	Localised Reversible	– Due to the operation of Blowers, DG sets	Provision of acoustic enclosures for equipment			

Sr. No.	Project Activity	Relevant Environmental components likely to be impacted	Nature of Impact	Likely Impacts and their significance in the absence of Mitigation Measures	Proposed Mitigation Measures	Responsibilities		
						Planning	Execution	Monitoring
					Personal Protecting Equipment (PPE).			
		Ecosystem	Localised Reversible		<p>Chlorine from DSP shall be maintained less than 0.2 ppm at diffuser of the outfall.</p> <p>Implementation of environmental education on the marine ecosystem as well as the habitat of sea turtles to workers and labourers in DSP, and surrounding villagers.</p> <p>Preparation of reports of Sea turtle sightings in and around the seashore in Perur to relevant official entities and NGO.</p> <p>Collaboration and consultation with other plants in the vicinity for conservation activities as directed by Government authorities time-to-time.</p>			

Sr. No.	Project Activity	Relevant Environmental components likely to be impacted	Nature of Impact	Likely Impacts and their significance in the absence of Mitigation Measures	Proposed Mitigation Measures	Responsibilities		
						Planning	Execution	Monitoring
C.2	Compliance to Permits				Contractor shall ensure all compliance conditions given in CRZ clearance, Consent to Operate is compiled, and compliance monitoring reports are submitted to agencies on a regular basis.	Contractor	Contractor	CMWSSB

The approvals and permits are also needed during operations and decommissioning phase; therefore, CMWSSB needs to ensure the required compliance.

15.2 Environmental Monitoring Plan (EMoP)

The environmental monitoring plan helps in signalling the potential problems resulting from the proposed project activities and will allow for prompt implementation of corrective measures. The environmental monitoring will be required during both construction and operational phases. The following parameters are proposed to be monitored by the Contractor.

- Terrestrial Water Quality (Groundwater and Surface water)
- Air Quality
- Noise Intensity
- Soil Quality
- Marine Water Quality
- Marine Ecological Monitoring
- Marine Sediment Quality

Environmental monitoring during the pre-construction phase is important to set up the baseline data and to predict the deviation from baseline data and adverse impacts during construction and operations phases.

Pre-construction phase baseline monitoring for all the aforesaid monitoring parameters is required to be carried out by the contractor for 3 months duration.

The results of monitoring will be required to be provided to JICA every quarter during the construction phase and biannually during the operation of the desalination plant until the two years after the completion of the project.

15.2.1 Details of Environmental Monitoring Plan

Environmental Item	Monitoring Item	Location	Frequency	Responsible Organization
Construction Phase				
Air Pollution*	Visual inspection of discharge conditions of exhaust gases (such as black smoke) of dump trucks, other trucks and heavy equipment and maintenance of the inspection logbook.	Construction site	Daily	Contractors

Environmental Item	Monitoring Item	Location	Frequency	Responsible Organization
	· Visual inspection on soil dust diffusions in the dry season for water spraying.	Construction site	Daily (Dry Season only)	Contractors
Water Quality	· Visual inspection of sewage water leakage (overflow), bad odour, the emergence of vector flies and de-sludge activities for the on-site toilets	Construction site	Once/ month	Contractors
	· Checking Turbidity levels with baseline levels turbid water in the sea during installations of intake/outfall pipelines	Intake/ outfall installation sea areas	Daily for the installation period	Contractors
Wastes	· Waste composition, quantity, transportation and treatment methods	Construction site	Once/ month	Contractors
Soil Contamination	· Visual inspection of leakage conditions of oil and fuel leakages (from Engine, hydraulic power units and fuel tanks) of dump trucks, other trucks and heavy equipment	Construction site	Daily	Contractors
Noise and Vibration*	· Visual inspection (common sensation) of silencer conditions	Construction site	Daily	Contractors

Environmental Item	Monitoring Item	Location	Frequency	Responsible Organization
	of dump trucks, other trucks and heavy Equipment			
Ecosystem	· Visual inspection on turbid water in the sea during installations of intake/outfall pipelines	Intake/outfall installation sea areas	Daily for the installation period	Contractors
	· Implementation of environmental education on the marine ecosystem and sea turtles.	Construction site and surrounding communities	Twice/ year	Contractors/ CMWSSB
	· Information on Sea turtle sightings in and around the seashore in Perur	Construction site	In the event of Sightings	Contractors/ CMWSSB
	· Actions on sea turtle sighting (construction suspensions periods, records of the announcements and relevant entities contacted) taken by CMWSSB	Construction site and surrounding communities	In the event of Sightings	CMWSSB
Land Acquisition/ /Resettlement	· Implementation of tree cutting action plan (Per-Construction Stage)	Construction site	Once/week	Contractors/ CMWSSB
Living and Livelihood	· Checking Turbidity levels with baseline levels turbid water in the sea during installations of	Intake/ outfall installation sea areas	Daily for the installation period	Contractors

Environmental Item	Monitoring Item	Location	Frequency	Responsible Organization
	intake/ outfall pipelines			
	<ul style="list-style-type: none"> · Pipelines installation schedules · Installation (Construction) Management 			
Social Infrastructure and Services	<ul style="list-style-type: none"> · Implementation of construction vehicle management plans 	Construction site	Daily	Contractors
	<ul style="list-style-type: none"> · Implementation of meetings with communities 	Construction site and surrounding communities	Where necessary	CMWSSB/ Contractors
Risk of infectious diseases such as HIV/ AIDS	<ul style="list-style-type: none"> · Implementation of Health and Sanitation education on STD. 	Construction site and surrounding communities	Once/ year	
Working Conditions/ Work Safety	Visual inspection on the utilization of PPE by workers/labours	Construction site	Daily	CMWSSB/ Contractors
Accidents	Implementation of Traffic safety education	Construction site and surrounding Communities	Once/ year	CMWSSB/ Contractors
General Environment [#]	Site conditions	Construction site and the coast	Every year	CMWSSB
Operational Phase				
Water Quality	Water quality of Raw seawater and Product water in DSP	DSP	Daily	Contractor
	Concentration of Brine diffusion	Seawater at the nearest beach	Daily	Contractor
	<ul style="list-style-type: none"> · Visual inspection of sewage leakage (overflow), bad 	DSP	Once/month	Contractor

Environmental Item	Monitoring Item	Location	Frequency	Responsible Organization
	odour, the emergence of vector flies of Sewage Treatment Plant (STP)			
	· Operational Inspection in accordance with instructions on the STP as suggested by the STP construction sub-contractor including Inlet and outlet quantity and quality monitoring	DSP	Daily	Contractor
Ecosystem	· Implementation of Meetings on environmental education.	DSP and surrounding communities	Once/ year	Contractor/ CMWSSB
	· Information on Sea turtle sightings in and around the seashore of Perur	DSP and surrounding communities	In the event of Sightings	Contractor/ CMWSSB
	Actions (Records of the announcements and relevant entities contacted) taken by CMWSSB	DSP and surrounding communities	In the event of Sightings	CMWSSB

Note # - A close and continuous monitoring during the construction phase through reputed intuitions such as NCSCM, Anna University, Chennai/ NIOT, Chennai/ IIT Madras to review the mitigation measures periodically and to take mitigation measures in the event of any adverse impacts to the coast.

It stipulates the post-clearance monitoring, which is required to be submitted half-yearly compliance reports in respect of the stipulated terms and conditions of the clearance to regulatory authorities, i.e., MoEF & CC and TNPCB. The monitoring activities specified in CRZ clearances are furnished in tables below:

15.2.2 Monitoring Activities requested by CZMAs

CZMA	Monitoring Activity	Frequency
Kancheepuram District (KDCZMA)	Marine quality including water quality and biological characteristics	Continuous
	Marine biodiversity	Twice in a year
	The concentration of toxic trace metals in the reject water	Periodical
	A moored data buoy shall be maintained in the vicinity of the effluent discharge to continuously monitor the changes in the selected physicochemical parameters (salinity, temperature, DO, current, etc.).	Periodical during the construction and operation phases
	The high salinity rejected water may be periodically monitored for the physiochemical and toxic trace metal contents through appropriate standard procedures.	Periodical
Tamil Nadu State (TNSCZMA)	Marine water at the outfall area	Every Quarter
	Periodical report on the site conditions to take mitigation measures on the event of any adverse impacts on the coast	Every Year
	Impact on the corals*, marine organisms, Turtle nesting etc. should be evaluated and monitored through experts (ecologists).	Not specified

15.2.3 Marine Environmental Monitoring proposed in the EIA Report

Marine environmental monitoring activities of Seawater & Sediment Quality, Marine Benthic Fauna, and Intake Seawater outfall have been proposed as shown in Table below

Monitoring	Purpose	Parameter	Frequency
Seawater & Sediment Quality	To monitor impacts on seawater and sediment quality	Measurements of levels of nutrients and heavy metals in water and sediment samples collected from sides at risk of pollution	Each season: April (Fair Weather), July (SW monsoon) and November (NE monsoon)
Marine Benthic Fauna	To determine the composition and distribution of major groups of fauna	Benthic fauna composition in the water outfall region	Each season as indicated above
Intake	To determine the incidence of entrapment	Screens on pump stations and the effectiveness of management	Each season as indicated above

Monitoring	Purpose	Parameter	Frequency
	and mortality of marine fauna	measure	
	To determine the impact of entrainment within and external ponds/storage sump/well to assess the loss of fishery	Record an abundance of fauna within the pond/storage sump/well Video recording near intake heads	Each season as indicated above Bi-annual
Seawater outfall	To determine the effect of increased temp/salinity on the plankton	Monitor abundance and distribution of both phytoplankton and zooplankton near the outfall.	Each season as indicated above
		Monitor abundance and distribution of benthic animal communities near the outfall	Each season as indicated above
		Video recording to elucidate the distribution of planktons may be conducted.	Bi annual

15.3 Environmental Sampling and Analysis Programme

The following Environmental sampling program shall be carried out as a minimum requirement by the Contractor before commencing construction activity. Bidder to submit the Approach and methodology of environmental monitoring to the Employer's representative for review and approval. The Contractor shall submit results of the Sampling program to the Employer's representative for approval. The initial environmental monitoring shall be carried for a duration of three months. Thereafter during the construction period, monthly reports to be submitted to the Employer's representative. The consolidated reports are required to be submitted to JICA and to MoEF & CC and TNPCB as part of regulatory compliance.

15.3.1 Sampling Program – Part A

A1. Ambient Air Quality

Parameters	No. of Locations	Frequency of monitoring per week (days)	Total Samples per week	Total samples per Month	Method
SO ₂ (24 hrly)	5	2	10	40	West and Gaeke
NO _x (24 hrly)	5	2	10	40	Arsenite modified J and H
RSPM 10µm (24 hrly)	5	2	10	40	EHVS
PM 2.5µm (24 hrly)	5	2	10	40	HVS with cyclone

Parameters	No. of Locations	Frequency of monitoring per week (days)	Total Samples per week	Total samples per Month	Method
CO (8 hourly)	5	2	10	40	As per MOEF Guidelines
Volatile organic compounds (VOCs) 24 hourly	5	2	10	40	As per MOEF Guidelines
Hydrocarbon (HC) 24 hourly	5	2	10	40	Gas Chromatographer

A2. Meteorology

Parameter	No. of Location	Frequency	Days	Total samples per Month	Method
<ul style="list-style-type: none"> - Wind speed - Wind direction - Relative humidity - Temperature, - Rainfall 	1	1 hourly continuous	Monthly	1	Automatic weather station and as per IMD specification & MoEF Guidelines

A3. Noise Level

Parameters	No. of locations and Frequency	Minimum no. of sample per month
Equivalent noise level (Leq) for day time and night time (Ld, Ln, and Ldn).	5 locations & hourly intervals at each location	5

A4. Water Quality

Parameters	No. of Location	Frequency	Minimum No. of samples per month
(As per IS 10500) Colour, Odour, Temp, pH, turbidity, Total Hardness (Mg & Ca), TDS, total alkalinity, chloride, sulphate,	2 groundwater + 3 surface water	5	5

Parameters	No. of Location	Frequency	Minimum No. of samples per month
nitrate, fluoride, Na, K, Calcium, Magnesium, phenolic compounds, Mineral oil, Cyanides, Anionic detergents, Residual chlorine, Boron, Cadmium, Arsenic, Copper, Lead, Manganese, Iron, Chromium VI, Selenium, Zinc, Aluminium, Mercury, Pesticides, Total coliform, E-coli			

A5. Soil Quality

Parameters	No. of Location and Frequency	Frequency	Total No. of samples per month
Bulk density, Salinity, Porosity, Texture Class (Percent wise silt, clay & sand), pH, Electrical conductivity, Cation exchange capacity, Sodium, Potassium, Nitrogen, Magnesium, Phosphorous, Sodium Absorption Ratio (SAR), Water holding capacity, Iron, Copper, Zinc, Manganese, Nickel, Permeability, physiochemical analysis and relevant metals.	5	Monthly	5

Note: Soil samples shall be collected from three different depths, i.e., 30 cm, 60 cm and 90 cm and homogenized samples to be used for analysis.

15.3.2 Sampling Program – Part B**B1. Marine Water Quality:**

Sl. No.	Parameters	Number of Locations	Minimum Number of Samples per month
1.	Salinity	1 At intake point offshore	5
2.	Electrical Conductivity		
3.	Temperature		

Sl. No.	Parameters	Number of Locations	Minimum Number of Samples per month
4.	Turbidity		
5.	Suspended Solids		
6.	pH		
7.	Dissolved Oxygen (DO)		
8.	Biological Oxygen Demand (BOD)		
9.	Nitrates as NO ₃ -2		
10.	Ammonical Nitrogen		
11.	Nitrites as NO ₂ -2		
12.	Total Nitrogen		
13.	Inorganic Phosphate		
14.	Total Phosphate		
15.	Silicates		
16.	Phosphates as PO ₄ -2		
17.	Chlorides as Cl-		
18.	Sulphates as SO ₄ -2		
19.	Total Nitrogen		
20.	Heavy Metals		
20.1	• Zinc		
20.2	• Mercury		
20.3	• Cadmium		
20.4	• Lead		
20.5	• Copper		

Sl. No.	Parameters	Number of Locations	Minimum Number of Samples per month
20.6	• Iron		
21.	Oil and Grease		
22.	TOC/DOC		
23.	Petroleum Hydrocarbons		

B2. Sediment Quality:

The sediment samples will be collected using a suitable grab. After collection, the samples shall be sieved and subjected to Physico-chemical analysis. The samples collected will be tested for the following parameters:

Sr. No.	Parameters	Number of Locations	Minimum Number of Samples per month
1.	pH	4 & 1 from dredged material during project construction	5
2.	Texture		
3.	Oil & Grease		
4.	Petroleum Hydrocarbons		
5.	Organic Matter		
6.	Total Volatile Solids		
7.	Chlorides as Cl-		
8.	Phosphates as PO ₄ -2		
9.	Nitrites as NO ₂ -2		
10.	Nitrates as NO ₃ -2		
11.	Sulphates as SO ₄ -2		
12.	Sodium		
13.	Potassium		

Sr. No.	Parameters	Number of Locations	Minimum Number of Samples per month
14.	Magnesium		
15.	Total Kjeldahl Nitrogen		
16.	Heavy Metals		
16.1	Zinc		
16.2	Nickel		
16.3	Cadmium		
16.4	Copper		
16.5	Lead		
16.6	Mercury		
16.7	Iron		

B3. Biological Parameters:

The marine water and sediment samples shall be collected as analyzed for the following biological parameters:

B3.1 List of Biological Parameters for Marine Water Samples

Sr. No.	Parameters	Number of Locations	Minimum Number of Samples per month
1.	Primary Productivity	1	5
2.	Chlorophyll -a		
3.	Phaeophytin		
4.	Total Biomass		
5.	Oxidizable particulate organic carbon		
6.	Phytoplanktons		

Sr. No.	Parameters	Number of Locations	Minimum Number of Samples per month
6.1	Abundance		
6.2	Number and name of groups		
6.3	Total number and name of the species of each group present		
6.4	Density (total numbers of individual species present)		
6.5	Total biomass		
7.	Zooplanktons		
7.1	Abundance		
7.2	Number and name of groups		
7.3	Total number and name of the species of each group present		
7.4	Density (total numbers of individual species present)		
8.	Bacteriological parameters		

B3.2 List of Biological Parameters for Sediment Samples

Sr. No.	Parameters	Number of Locations	Minimum Number of Samples per month
1.	Benthic Organisms	1	5
2.	Meio fauna		
3.	Microfauna		
4.	Macrofauna		
5.	Abundance		

Sr. No.	Parameters	Number of Locations	Minimum Number of Samples per month
6.	Number and name of each group present		
7.	Total number and name of species of each group present		
8.	Density (total numbers of individuals of each species)		

15.4 Proposed Monitoring Forms

The template of Environmental Monitoring Forms which are required to be used during the pre-construction stage, Construction stage and Operation phase of the project are furnished in Tables below.

15.4.1 Pre-Construction Phase (Tree cutting) Monitoring Forms

The latest results of the below-monitoring items shall be submitted to the Employer as part of the Progress Report throughout the pre-construction phase.

15.4.1.1 Air Pollution

- Exhaust Gases

Date	Type of Construction Vehicles/ Equipment	Fleet/ Registration Number	Exhaust Gases Discharge Conditions				Frequency
(Day, Month, Year)			Items	Yes	No	If Yes, Measures Taken	Daily
			Black Smoke				
			White Smoke				
			Others (Specify)				

Logbook: to be prepared and recorded by the contractor(s) which is submitted to CMWSSB monthly.

If any problem arises, such vehicles and equipment to be sustained to use or be replaced by appropriate ones.

- Soil Dust (Dry Season only)

Date	Location	Dust and dried sandy soil stirred up by construction activities	Frequency
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(Day, Month, Year)	Construction Site including access roads	Items	Yes	No	If Yes, Measures Taken (such as water supplying)	Daily
		Dust				
		Dried Sandy Soil				
		Others (Specify)				

Log Book: to be prepared and recorded by the contractor(s) which is submitted to CMWSSB monthly.

15.4.1.2 Land Acquisition/ Resettlement (Progress of the tree cutting)

Items	Implementation (as of)			Frequency
Cutting Schedule	1. As scheduled ()	2. Delayed (months)	3. Postponed ()	Once/ week
Total Value of Trees	1. Decided (Rs)	2. Under evaluation ()	3. No action ()	
Budget Allocation	1. Allocated by ()	2. Under discussion ()	3. No action ()	
Compensation to Landowner	1. Compensated ()	2. Under preparation ()	3. No action ()	
Auction for tree cutting	1. Conducted (when)	2. Under preparation ()	3. No action ()	
Waste Management	1. Properly Managed ()	2. Under preparation ()	3. No action ()	

Progress of the preparation and implementation shall be submitted to CMWSSB monthly

15.4.2 Construction Phase Monitoring Form

The latest results of the below-monitoring items shall be submitted to the lenders as part of the Quarterly Progress Report throughout the construction phase

15.4.2.1 Air Pollution

- Exhaust Gases

Date	Type of Construction	Fleet/ Registration	Exhaust Gases Discharge Conditions	Frequency
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	Vehicles/ Equipment	Number					
(Day, Month, Year)			Items	Yes	No	If Yes, Measures Taken	Daily
			Black Smoke				
			White Smoke				
			Others (Specify)				

Log Book: to be prepared and recorded by the contractor(s) which is submitted to CMWSSB monthly. If any problem arises, such vehicles and equipment to be sustained to use or be replaced by appropriate ones.

- Soil Dust (Dry Season only)

Date	Location	Dust and dried sandy soil stirred up by construction activities				Frequency
(Day, Month, Year)	Construction Site including access roads	Items	Yes	No	If Yes, Measures Taken (such as water supplying)	Daily
		Dust				
		Dried Sandy Soil				
		Others (Specify)				

Log Book: to be prepared and recorded by the contractor(s) which is submitted to CMWSSB monthly.

15.4.2.2 Water Quality

- On-site toilets

Date	On-site Toilet Number/location	Sewerage water Conditions				Frequency
(Day, Month, Year)		Items	Yes	No	If Yes, Measures Taken	Daily
		Black (sewage)water leakage				

Date	On-site Toilet Number/location	Sewerage water Conditions				Frequency
		Bad odour				
		Emergency of Flies				
		Others (Specify)				

Log Book: to be prepared and recorded by the contractor(s) which is submitted to CMWSSB monthly.

- Turbidity (Seawater Turbidity during the installation of intake/outfall pipelines)

Date	Location of installation of Intake/ Outfall (GPS position)	Turbid water Conditions				Frequency
(Day, Month, Year)	Intake () Outfall () GPS Position	Items	Yes	No	If Yes, Measures Taken	Daily
		Silts				
		Sea sands				
		Bottom sediments				
		Others (Specify)				

Log Book: to be prepared and recorded by the contractor(s) which is submitted to CMWSSB monthly.

15.4.2.3 Soil Contamination

- Oil and Fuel leakage (spill)

Date	Type of Construction Vehicles/ Equipment	Fleet/ Registration Number	Oil/Fuel Leakage Conditions				Frequency
(Day, Month, Year)			Items	Yes	No	If Yes, Measures Taken	Daily
			Engine oil				
			Hydric power				

			unit oil				
			Fuel				
			Others (Specify)				

Log Book: to be prepared and recorded by the contractor(s) which is submitted to CMWSSB monthly. If any problem arises, such vehicles and equipment to be sustained to use or be replaced by appropriate ones.

15.4.2.4 Wastes

- Construction Wastes and Debris

Waste Composition	Waste Quantity (ton/month)	Transportation, Disposal/Treatment Methods (Specify: ex. Registered Service Provider, Officially final disposal site, registered treatment facility (or company))				Frequency
		Transport	Disposal	Treatment	Remarks	
Construction Debris						
Surplus Soil						
Toxic and Chemical Waste						
Other (specify)						

15.4.2.5 Noise and Vibration

- Noise from Construction Vehicles and Equipment

Visual Inspection Date	Type of Construction Vehicles/ Equipment	Fleet/ Registration Number	Condition of Silencer equipped with construction vehicles/Equipment				Frequency
(Day, Month, Year)			Items	Yes	No	If Yes, measures are taken (such as water)	Daily

Visual Inspection Date	Type of Construction Vehicles/ Equipment	Fleet/ Registration Number	Condition of Silencer equipped with construction vehicles/Equipment				Frequency
						sprinkling)	
			Properly Equipped				
			Damaged				
			Large noise discharge				
			Others (Specify)				

Log Book: to be prepared and recorded by the contractor(s) which is submitted to CMWSSB monthly. If any problem arises, such vehicles and equipment to be sustained to use or be replaced by appropriate ones.

15.4.2.6 Ecosystem

- Turbidity

Date	Location of installation of Intake/outfall (GPS position)	Turbid water Conditions				Frequency
(Day, Month, Year)	Intake () Outfall () GPS Position	Items	Yes	No	If Yes, measures are taken	Daily
		Silts				
		Sea sands				
		Bottom sediments				
		Others (Specify)				

- Environmental Education on Marine ecosystems and Sea Turtles

Date	Venue	Agenda	Lecturer	Number of Participants	Materials paraded	Frequency
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(Day, Month, Year)				Community ()		Twice/year
				Worker/ Labor ()		
				Others (Specify)		
				Total ()		

Participant list and educational materials shall be attached

- Sea Turtles Sightings

Item	Sighting Report					Frequency
Sea turtles	Time/ Date	Place (In or around Perur DSP construction site)	Sighted by whom (ex, Villager, Worker/labour, rumour and others	Description of the Sighting	Actions were taken to the sightings	In the event of sighting*
					See the Actions on Sea Turtle	

*During the egg-laying season of sea turtles, hearing survey on the sighting shall be done in the surrounding communities twice of the season

- Actions on Sea Turtle Sightings

Item	Sighting Report			Frequency
Actions on Sea turtle sighting	Construction Suspension Periods	Records of the announcements	Relevant entities contacted	In the event of Sighting

15.4.2.7 Living and Livelihood

- Seawater Turbidity during the installation of intake/outfall pipelines

Date	Location of installation of Intake/outfall (GPS position)	Turbid water Conditions				Frequency
(Day, Month, Year)	Intake () Outfall ()GPS	Items	Yes	No	If Yes, Measures Taken	Daily

	Position	Silts				
		Sea sands				
		Bottom sediments				
		Others (Specify)				

- Pipelines installation schedules and Installation (Construction) Management

Date	Location	Management				Compensation budget and status (Specify)	Frequency
		Type Space used (1. Paddy Field, 2. Farmland, 3. Others)	Area (m ²)	Duration of use	Condition of Space		
(Day, Month Year)							Daily during the installation

15.4.2.8 Social Infrastructure and Services

- Road Traffic

Date	Location	Construction Vehicle Management				Frequency
		Traffic Control (Specify the details)				Daily
		Time Restriction	Avoidance of Rush Hour	Avoidance of Rush Hour	Others (Specify)	
(Day, Month, Year)						

Log Book: to be prepared and recorded by the contractor(s) which is submitted to CMWSSB monthly.

- Commercial Activities (for the transmission pipelines installations)

Date	Location	Management				Frequency
		Traffic Control (Specify the details)				Daily during the
		Diversion	Time	No	Others	

		Route	Restriction	Control	(Specify)	installation
(Day, Month, Year)						

- Meetings with surrounding Communities (for the transmission pipelines installations)

Date	Location / Community	Meeting Venue	Number of Participants	Agenda	Opinions Requests	Countermeasures	Frequency
(Day, Month, Year)			Community ()				Where necessary
			Officials ()				
			Others (Specify)				
			Total ()				

Participant list and meeting minutes shall be attached.

15.4.2.9 Risks of Infectious diseases such as HIV/AIDS

- Health and Sanitation Education

Date	Venue	Agenda	Lecturer	Number of Participants	Materials paraded	Frequency
(Day, Month, Year)				Community ()		Once/year
				Worker/Labor ()		
				Others (Specify)		
				Total ()		

Participant list and educational materials shall be attached.

15.4.2.10 Working Conditions/Work safety for the Construction

- Personnel Protective Equipment (PPE)

Date	Monitoring Item	If any problems, measures are taken	Frequency

(Day, Month, Year)	PPE: such as Helmet, Gloves, Masks, shoes) -		Daily
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Log Book: to be prepared and recorded by the contractor(s) which is submitted to CMWSSB monthly.

15.4.2.11 Accidents

- Meetings with surrounding Communities

Date	Venue	Agenda	Lecturer	Number of Participants	Materials paraded	Frequency
(Day, Month, Year)				Community ()		Once/year
				Worker/Labor ()		
				Others (Specify)		
				Total ()		

15.4.3 Operation Phase Monitoring Form

The latest results of the below-monitoring items shall be submitted to the Employer on a biannual basis.

15.4.3.1 Water Quality

- Seawater and Product Water

Sl. No.	Constituents	Seawater	Product Water	Frequency
1	Silt Density Index	✓		Daily
2	pH	✓	✓	Daily
3	Total Dissolved Solids	✓	✓	Daily
4	Temperature	✓	✓	Daily
5	Electrical conductivity	✓	✓	Daily
6	Turbidity	✓	✓	Daily

7	Residual chlorine	✓	✓	Daily
8	Boron content	✓	✓	Daily
9	Langelier index	-	✓	Daily
10	Oxidation-reduction potential	✓	-	Daily
11	Alkalinity	✓	✓	Daily
12	Chloride	✓	✓	Daily
13	Hardness	✓	✓	Daily

Operational Monitoring Report on the Seawater and Product Water monitored at DSP can be attached.

- Brine Concentration

Date	Sampling Location	Brine Concentration (ppt)	Remarks	Frequency
				Daily

- Domestic Wastewater (Sewage Treatment Plant)

Monitoring Item	Method	If any negative results measures – Action to be taken	Frequency
Bad Odor	Visual Inspection (Common sensation)		Once/month
Water Leakage	Visual Inspection		
Generation of flies	Visual Inspection		
Other necessary actions to be monitored as per the instruction and manuals on the operation and maintenance of aerated sewage treatment facilities (STP) is to be installed.			Once/month (or instructions of the Contractor of STP)

15.4.3.2 Ecosystem

- Environmental Education on Marine Ecosystems and Sea Turtles

Date	Venue	Agenda	Lecturer	Number of Participants	Materials paraded	Frequency
(Day, Month, Year)				Community ()		Once/year
				Worker/Labor ()		
				Others (Specify)		
				Total ()		

Participant list and educational materials shall be attached.

- Sea Turtles Sightings

Item	Sighting Report					Frequency
Sea turtles	Time/ Date	Place (In or around Perur DSP site)	Sighted by whom (ex, Villager, Worker/labour, rumour and others	Description of the Sighting	Actions were taken to the sightings	In the event of Sighting*
					See the Actions on Sea Turtle Sightings (specified below)	

*During the egg-laying season of sea turtles, hearing survey on the sighting shall be done in the surrounding communities twice of the season.

- Actions on Sea Turtle Sightings

Item	Sighting Report			Frequency
Actions on Sea turtle sighting	Construction Suspension Periods	Records of the announcements	relevant entities contacted)	In the event of Sighting

15.4.4 Monitoring Format for EIA And CZMAS Recommendations

15.4.4.1 Construction Phase

Environmental Items	Monitoring Items	Parameters	Frequency	Recommended by	Monitoring Results
General Environment	Site conditions	Any adverse impacts on the coast	Every Year	Tamil Nadu State CZMA	

15.4.4.2 Operation Phase

Environmental Items	Monitoring Items	Parameters	Frequency	Recommended by	Monitoring Results
Water Quality	Seawater & Sediment Quality	Nutrients and heavy metals	Each season: April (Fair Weather), July (SW monsoon) and November (NE monsoon)	EIA Report	
Ecosystem	Marine Benthic Fauna	Benthic fauna composition	Each season as indicated above	EIA Report	
Ecosystem	Intake entrapment of marine fauna	Screens on pump stations and Effectiveness of management measure	Each season as indicated above	EIA Report	
Ecosystem	Entrainment of marine fauna	Abundance of fauna within the pond/ storage sump/well	Each season as indicated above	EIA Report	
Ecosystem	Seawater outfall	Abundance and distribution of both phytoplankton and zooplankton	Each season as indicated above	EIA Report	

Environmental Items	Monitoring Items	Parameters	Frequency	Recommended by	Monitoring Results
Ecosystem		Abundance and distribution of benthic animal communities	Each season as indicated above	EIA Report	
Water Quality/ Ecosystem	Post-project marine quality	Marine quality, including water quality and biological characteristic.	Continuous	Kancheepuram District CZMA	
Ecosystem	Marine biodiversity	Not specified	Twice in a year	Kancheepuram District CZMA	
Water Quality	Reject water	Concentration of toxic trace metals	Periodical	Kancheepuram District CZMA	
Water Quality	Changes in the selected physicochemical parameters	Salinity, temperature, DO, current etc.	Periodical during the construction and operation phases	Kancheepuram District CZMA	
Water Quality	The high salinity reject water (maybe monitored through appropriate standard procedures)	Physiochemical and toxic trace metal contents	Periodical	Kancheepuram District CZMA	
Water Quality	Marine water	Parameter is not specified/ to be monitored at the outfall area	Every Quarter	Tamil Nadu State CZMA	
General Environment	Site conditions	Any adverse impacts on the coast	Every Year	Tamil Nadu State CZMA	
Ecosystem	Impact on marine organisms, Turtle nesting etc.	Marine organisms, Turtle nesting etc.	Not specified (to be monitored by experts)	Tamil Nadu State CZMA	

CHAPTER - 16

16. SOCIAL MANAGEMENT PLAN

Social safeguard interventions play a major role in bringing understanding and harmony while addressing the impact of infrastructure development which is meant for the greater interest of the society and the people embedded. Hence, the objective of social safeguard intervention is to adhere to JICA's guideline, ISO and the international standards during construction and operation of the Chennai Perur 400 MLD Desalination Plant.

16.1 Scope of Social Safeguard Intervention

The scope of work shall include but not be limited to the following:

16.1.1 Social Management Strategies, Plan and Execution

- After award of the contract and before the start of work, the Contractor shall review the Social Management Plan (SMP) for the project available with CMWSSB. The contractor shall duly update the SMP to ensure compliance with all applicable legislation and regulations of State / Central Government, JICA's Guidelines and IFC Performance Standards on Social Sustainability. The SMP shall incorporate the requirements stipulated in the Project's SIA (Social Impact Assessment) Report and conditions of approval from State/Centre Regulatory agencies. The SMP shall clearly define roles, responsibilities, reporting requirement and budgetary allocations for the implementation of mitigation measures. In case of any revision to SMP shall be submitted by the Contractor to CMWSSB for necessary approval before initiating any groundwork.
- Separate Social Management Plans for Construction, maintenance and Operations Stages shall be prepared to address the impacts associated with construction, maintenance and operation activities on the workforce engaged and surrounding communities. These plans shall incorporate the requirements stipulated in the Project's SIA Report, applicable legislation and regulations, conditions of approval from State/Centre Regulatory agencies and also considering best practices and good engineering practices, as applicable.

16.1.2 Labour Influx and Worker's Camp Management Plan

The labour influx and worker's camp management plan, including the process for mitigating construction-related impacts on the local community are given below.

16.1.2.1 Labour Camp Management

- i) The contractor preferably will use unskilled/semi-skilled labour from the local area to give the maximum benefit to the local community whenever this is possible.
- ii) The contractor will follow all relevant provisions of the Building and the other Construction Workers (Regulation of Employment and Conditions of Service) Act, 1996 for construction and maintenance of labour camp.

- iii) Pooled transportation facilities as may be required, shall be provided by the contractor. The location, layout and basic facility provision of labour camp will be submitted to Engineer for approval prior to its construction.
- iv) The contractor will provide and maintain well-ventilated living accommodation and ancillary facilities for workers, including adequate working, eating, and sleeping arrangements for field workers functionally, hygienically and safely.
- v) The contractor will construct and maintain all labour accommodation in such a fashion that uncontaminated clean potable water is available for drinking, cooking, bathing and washing.
- vi) Potable water for drinking will be made available for workers by the contractor at the construction site/labour camp/s. The Contractor will also provide product water facilities at the construction site in an accessible place, as per standards set by the Building and other Construction Workers (Regulation of Employment and Conditions of Service) Act, 1996. Provision of mobile drinking water counter/kiosk, with 300-litre capacity, with at least two taps, with a bottom tank, to collect wastewater will be placed at a suitable place near worksites.
- vii) Workers shall not be allowed to defecate in the open. Proper mobile toilets fitted with a septic tank will be provided by the contractor. Separate toilets/bathrooms, wherever required, will be provided for male and female, marked in sign as well as in vernacular in the construction camp.
- viii) Adequate freshwater supply will be ensured in kitchen/mess, bathrooms, toilets and urinals.
- ix) Fuelwood will not be allowed for cooking at labour camps. LPG cylinders as cooking fuel will be provided at labour camp by the contractor.
- x) Regular damp cleaning, sweeping, disinfecting and sanitizing will be ensured at the labour campsite.
- xi) The contractor will ensure that the sewage system for the camp will be designed, built and operated in such a manner that no health hazard occurs and no pollution to the air, groundwater or adjacent watercourses take place and biologically treated, to consistently deliver excellent effluent quality with biweekly test reports.
- xii) The contractor will provide stability to the marine outfall system even during cyclonic conditions, and appropriate anchor shall be provided.
- xiii) The contractor will ensure that the pipelines such as intake pipeline and outfall line and intake arrangement in the sea shall not cause any hindrance to the movement of the local communities including the fishermen and the movement of fishing vessels. Any hindrance impacting the livelihood of fishermen partially/entirely during the construction, in

particular, construction of intake-well pipeline; will attract subsistence grant for the period the livelihood was impacted which will be addressed by the Employer.

- xiv) The contractor will ensure that there is no displacement of people, housing or fishing activity as a result of the project; as nothing of that sort was observed and envisaged prior to drafting the scope.

16.1.2.2 Provision of First Aid/Medical Facilities and Emergency Response Arrangements

- i) The Construction Safety Plan to be prepared by the Contractor will identify necessary actions in the event of an emergency. This plan will be submitted for Engineer's approval along with the Work Program at the mobilization stage itself.
- ii) The Contractor will arrange for:
 - Readily available first-aid box, including an adequate supply of sterilized dressing materials and appliances, as per rules shall be provided in work zones and at the campsite/s.
 - Registered medical practitioner (Doctor) and trained First Aid personnel will be available at the construction site.
 - Emergency numbers will be displayed at camp, plant and construction sites.
 - Availability of suitable transport at all times to take an injured or sick person(s) to the nearest hospital shall be made.
- iii) The contractor will make required arrangements so that in case of any mishap on the construction site, all necessary steps can be taken for prompt first aid treatment.
- iv) First aid facilities and free emergency care shall be provided to all workforce and third party. No cost shall be recovered from them on this account.
- v) All supervisory staff shall be provided with mobile phones for better communication across operational areas, in case of emergency or otherwise.
- vi) The Contractor shall provide information to his workers on methods of avoiding COVID-19 pandemic, sexually transmitted diseases and infection by HIV/AIDS. The information about the location of camps shall be known to the District Societies for Prevention of COVID-19 and HIV/AIDS. The awareness programs launched for the prevention of COVID-19 and HIV/AIDS should be well documented.

16.1.3 Stakeholder Engagement Strategies, Plan and Implementation

- i) SMP explains interaction with the community, including project information disclosure and emergency response planning relevant for the community. This sub-plan should cover means and methods to inform the affected population about the construction schedule and expected impacts such as access limitation to properties, if any, and also spell out the grievance redressal mechanism available to the communities to ensure any concerns brought to the CMWSSB are resolved appropriately and on time.

- ii) The Contractor shall implement all requirements of the SMP approved by CMWSSB during the entire period of the contract, i.e. during Construction Stage and Operation Stage of the Desalination Plant and associated facilities.
- iii) Operation and Maintenance of aforesaid the Desalination Plant and associated facilities are to be carried out strictly as per the approved SMP and as directed by the CMWSSB and State Norms.

16.1.4 Social Monitoring Plan (SMoP)

- i) SMoP shall be prepared to ensure that the envisaged purpose of the SMoP is achieved across all stages of the project. Performance indicators will be developed for critical social conditions. For each of the indicators, the monitoring plan will specify parameters to be monitored, the location of monitoring sites along with frequency and duration of monitoring. The monitoring plan will also specify applicable standards, implementation and supervising responsibilities and reporting requirements.
- ii) The Contractor shall regularly monitor the quality of the working sites and their surroundings in terms of social performance indicators as specified in SMP and submit the monitoring results to CMWSSB. The Contractor shall also be responsible for periodic submission of Monitoring Reports to the Regulatory Agencies in compliance with requirements of the SMP.
- iii) It may be noted that the status of social monitoring shall be communicated to JICA as part of the Quarterly progress report. JICA would disclose information on the status of social monitoring of the project in collaboration with CMWSSB on its website in order to ensure transparency, accountability and to promote the participation of various stakeholders.

16.2 Work Requirements

16.2.1 Site

The proposed Chennai Perur 400 MLD Desalination Plant (DSP) is located in Nemmeli revenue village, Nemmeli Panchayat in Thiruporur Taluk (Thiruporur Block) of Chengalpattu district (earlier Kanchipuram District), Tamil Nadu State, India. The village is bifurcated into East and West part by the State Highways- 49, i.e. East Coast Road (ECR) towards Mamallapuram. In North-to-South direction. The proposed desalination plant is located in the Eastern part of Nemmeli village and on the shore of Bay-of-Bengal. Moreover, this plant will be constructed about 0.8 kilometres distance on the North of already existing Nemmeli 100 MLD plant.

16.2.2 Socio-economic Profile

Nemmeli village comprises of ten habitations viz.: Pudukalpakkam, Nemmeli, Nemmeli Kuppam, Kannima Nagar, Perur, Perur colony, Sulerikadu, Sulerikadu colony, Sulerikaattu Kuppam and Krishnan Karanai, Out of these ten habitations, Pudukalpakkam, Nemmeli Kuppam, Sulerikaattu

kuppam habitations are on the eastern side of East Coast Road (ECR) with a distance of 1.865 Km, 815 m and 2.365 Km apart respectively. All these three habitations belong to fishermen communities and are covered under the Most Backward Class (MBC) category. Other habitations are on the Western side and are substantially distanced from seashore who would get affected from seawater flood in case of Tsunami and periodic cyclones.

Referring to Chennai Perur 400 MLD DSP; Nemmeli kuppam and Sulerikaattukuppam are two habitations adjacent to the plant in North and South direction respectively. However, from a plant construction and operation perspective, Nemmeli Kuppam habitation is expected to have a more interactive process than other habitations. Hence, a further detail socio-economic aspect of Nemmeli Kuppam is presented below.

There are 166 houses in Nemmeli kuppam, of which owners have occupied 142 houses, and rest are occupied by 24 tenants. All the 166 houses have patta land. After Tsunami devastation in the year 2004, 124 houses were being constructed in by the NGO 'World Vision'. The total population of this habitation is 442, of which 230 are male, and 212 are female. Of the 166 houses, owners have occupied 142 houses, and 24 tenants are there.

All 142 families of this fishermen habitation practice Hindu religion (Hindu Meenavar Parvatharaja Kulam) and belong to Most Backward category defined by Government of Tamilnadu. Only a few tenants who have come from other areas belong to Most Backward and Backward communities. The habitants are literate and educated, except few people above 80 years old.

Occupationally, in general, men are engaged in fishing and allied activities. Few men are working in the companies and offices during daytimes. Women are engaged in selling of fish in neighbouring areas and dry fish preparation. Educated youngsters are working in offices and companies located in ECR and OMR. Two of them are employed in the existing 100 MLD desalination plant located nearby. Few fishermen are doing fishing in the morning, and during the daytime, they are employed in the local companies. Nearly 30 members (women) from this habitation are employed under "The Mahatma Gandhi National Rural Employment Guarantee" program by Ministry of Rural Development, Government of India. They are getting employment for 100 days in a year on a wage rate of INR 256/day. On an average family earn INR 12000 to INR 15000 per month from fishing activity and around INR 10000 to INR 15000 as their wages from the companies.

There are 4 Self Help Groups run by women of this habitation, and mainly they do microfinance through their loan amount. There is only one Public health sub-centre available for this Nemmeli village panchayat wherein a nurse is available for vaccination and immunization purpose.

16.2.3 Issues and Impact

Chennai Perur 400 MLD DSP is planned to be constructed in a land belonging to M/s Arulmigu Alavandar Nayakkar Trust (a religious and charitable group) maintained by the Hindu Religious and Charitable Endowments (HR&CE) Department of the Government of Tamil Nadu (GOTN)). This land is leased for a period of 30 years to CMWSSB. There are no settlements or households that exist on the portion of the land leased. However, in the DSP site, there are two burial grounds; but the plant layout has been arranged in such a way that no facility would be constructed in the burial grounds. There is open-well with a pump house connected to three-phase line is used for daily water supply through transmission pipeline to Nemmeli Kuppam and Perur colony habitations. In case the construction and operation of the plant will require to interrupt the water supply to the said habitations; alternate arrangement should be placed for uninterrupted water supply prior to disconnecting existing water supply.

16.3 Components for Social Development

16.3.1 Peripheral Development

16.3.1.1 Nemmeli Kuppam Habitation

- i) Landing Centre Protection: During the intake well construction for Chennai Perur 400 MLD DSP there are possibilities of seawater flow towards Nemmeli Kuppam habitation from East-to-West direction causing soil erosion. As a result, the fishermen boat parking area and the landing centre might get affected. Contractor shall implement suitable construction activities for the protection of the landscape. Applicable permits from the relevant authorities shall be obtained for the purpose.
- ii) Community Toilet: One community toilet is present in the northern side of the plant site for the use of Nemmeli Kuppam habitation, which will be inaccessible once the boundary wall of the plant site is constructed. Currently this community toilet is not in use due to non-availability of water and is dilapidated; However, one new community toilet shall be constructed by the contractor with all the required provisions.
- iii) Bore Well for Community Product Water: There is an open-well within the plant boundary from where water is pumped through a three-phase connected pump house to Perur and Perur colony on the Western side of ECR. The contractor shall make sure that the existing arrangement of water supply remains.
- iv) Public Consultation

While there will be construction and operation of the plant activities, regular public consultations need to be conducted to develop a better understanding among the habitats around the plant area;

particularly Nemmeli Kuppam. The public consultation should be recorded audio-visually as well as in print material. The contractor shall organize the same.

16.3.2 Dispensary within Plant Premises

In the Nemmeli village, there is one Health Sub-centre that is managed by a Nurse. Hence, understanding the intensity of construction work is suggestive of setting up and operate a dispensary within the plant site during the construction period. Accordingly, 24 hours availability of one doctor and two health support staff within the plant site is felt highly essential. The dispensary should procure essential First aid material, medicines and health kits according to regulatory compliance. In addition, the contractor should procure an ambulance (Multipurpose with advance life support system) for 24 hours availability to cater to the emergency needs. Also, the ambulance service may be extended to the peripheral habitants in the high-end emergency case as part of humanitarian assistance and cordial rapport building.

16.3.3 Public Awareness and Capacity Building

Awareness programmes within the plant site and focussed periphery particularly related to health due to conglomeration of external and local manpower for engagement in the construction of the plant. Apart from HIV/AIDS-related issues; the recent Covid-19 pandemic is alarming for the contractor to conduct periodic health check-up camps within and periphery of the plant site. In addition, towards a goodwill building and long-term livelihood support strategy; vocational/skill development training needs to be conducted.

It is often observed that, there are gaps in understanding social issues by the personnel more involved/focused on engineering technical aspects. Hence, periodical orientation will help to handle some of the sensitive social aspects in the work environment.

16.3.4 Natural Disaster and Relief

The Bay of Bengal and the coast of Tamil Nadu is vulnerable to the impact of the cyclone and other natural disaster like Tsunami. Natural disaster relief shall be provided by the Government.

16.3.5 Engagement of Social specialist to implement and address related issues

Social Specialist having substantial experience in similar activities needs to be appointed by the Contractor after awarding of the contract and before the start of work; to carry out social safeguard intervention activities within the plant premise and the peripheral.

16.4 Technical Schedules for Social Management Plan

The Bidder shall provide his Social Management Plan (SMP) in detail to demonstrate the procedures that will be used to ensure that the social concerns and requirements as outlined in contract conditions are satisfactorily met.

After award of contract and before the start of work, the Contractor shall review the available Social Management Plan (SMP) for the project available below with CMWSSB. The contractor shall duly update the SMP to ensure compliance with all applicable legislation and regulations of State / Central Government and also with Sustainability Guidelines of JICA and IFC Performance Standards on Social Sustainability. The SMP shall incorporate the requirements stipulated in the Project's SIA Report and conditions of approval from State/Centre Regulatory agencies. The SMP shall also clearly define roles, responsibilities, reporting requirement and budgetary allocations for the implementation of mitigation measures. Any revision to SMP shall be submitted by the Contractor to CMWSSB for necessary approval before initiating any groundwork.

The SMP shall identify the potential social impacts from the various construction and operations and maintenance activities to be undertaken in the Contract and set out in detail the approach he will adopt in mitigating these impacts to ensure that the impacts are minor and confined to a short period.

The Bidder shall provide separate descriptions of its proposals for minimizing any adverse social impacts/effects during the construction phase and the subsequent operations and maintenance phase.

CONSTRUCTION, OPERATION AND DECOMMISSIONING PHASE MITIGATION MEASURES FOR DESALINATION PLANT AND ASSOCIATED INTAKE AND OUTFALL UNDERSEA PIPELINES

Required approvals and permits are also needed during operations and decommissioning phase, therefore, CMWSSB needs to ensure the required compliance

Sl. No	Systems/ Impacts	Action to be taken	Time frame	Responsible agencies	Responsible Agency for Review and Monitoring
1.1	Rapid Social Screening	<p>The contractor shall undertake the social screening survey within the proposed project area and identify potential social impacts due to proposed plants construction, operations decommissioning. Social screening should identify but not limited to the following aspects:</p> <ul style="list-style-type: none"> ▪ Permanent and temporary economic and physical displacement of the communities. ▪ Potential impacts of livelihood and income. ▪ Potential impacts on common property resources, fishing area 	Pre-construction, Operations & Decommissioning phase	Contractor	CMWSSB
1.2	Construction of labour camps	<ul style="list-style-type: none"> • Contractor shall follow all relevant provisions of the Contract Labour (Abolition and Regulation) Act, 1970 and the Building and the other Construction Workers (Regulation of Employment and Conditions of Service) Act, 1996 for construction and maintenance of labour camp and other applicable laws. • The location, layout and basic facility provision of each labour camp will be submitted to CMWSSB Engineer prior 	Pre-construction, Operations & Decommissioning phase	Contractor	CMWSSB

Sl. No	Systems/ Impacts	Action to be taken	Time frame	Responsible agencies	Responsible Agency for Review and Monitoring
		<p>to their construction.</p> <ul style="list-style-type: none"> The construction will commence only upon the written approval of the Engineer. The contractor shall maintain necessary living accommodation and ancillary facilities functionally and hygienically and as approved by the Engineer. The contractor shall provide an adequate number of toilets, bathing area, kitchen and safe fuel for cooking. The labour camps shall be designed to protect from heat, rains, flooding, insects, snakes and mosquitoes. It should have adequate provisions for an emergency response such as first aid and fire safety etc. All temporary accommodation must be constructed and maintained 			
1.3	Risk Assessment and preparation of management plans	<p>Risk and hazards associated with different construction activities shall be identified by the contractor, and accordingly, management plans shall be prepared for implementation on site such as :</p> <ul style="list-style-type: none"> Construction Labour Management Plan; Emergency Response Plan; and Construction Demobilization Plan. 	Pre-construction Operation & Decommissioning phase	Contractor	CMWSSB

Sl. No	Systems/ Impacts	Action to be taken	Time frame	Responsible agencies	Responsible Agency for Review and Monitoring
1.4	Disaster Management Plan	<ul style="list-style-type: none"> The CMWSSB shall identify the key risks associated with each component/ activity for entire project life cycle (construction, operations, & decommissioning) and shall prepare Disaster Management Plan (DMP) for the proposed plant. Further, the DMP for the plant should be synchronized with the district disaster management plan for off-site emergencies. Contractor shall ensure the availability of required resources for the implementation of DMP at the site and help local communities in handling disaster and emergency response. 	Pre-construction Operation & Decommissioning phase	Contractor	CMWSSB
1.5	Information disclosure and stakeholder consultations	The contractor, in consultation with CMWSSB, shall undertake detailed mapping and analysis of key stakeholders which includes the community. Based on the outcomes of stakeholder analysis, shall prepare and implement a stakeholder engagement plan and regularly update the plan and undertake the proper reporting & documentation (minutes and photographs) of the stakeholder engagements. The CMWSSB and contractor shall ensure that stakeholder, including impacted communities, are consulted and made aware of the project's outcome, risks/ impacts, mitigation measures and time frame.	Pre-construction Operation & Decommissioning phase	Contractor	CMWSSB

Sl. No	Systems/ Impacts	Action to be taken	Time frame	Responsible agencies	Responsible Agency for Review and Monitoring
1.6	Grievances management	The CMWSSSB and contractor shall establish the formal system for Grievance management (GRM). The GRM should cover the staff, contracted workers and community. The contractor shall ensure the wider publicity of the functioning and availability of GRM and designate the required resources for the effective functioning of GRM. The stakeholders, including communities, shall be made aware of the presence of GRM since the inception of the project.	Pre-construction Operation & Decommissioning phase	Contractor	CMWSSB
1.7	Living and Livelihood	Intake/outfall installation sea areas <ul style="list-style-type: none"> • Visual inspection on turbid water in the sea during installations of intake/outfall pipelines • Pipelines installation schedules • Installation (Construction) Management 	Daily for the installation period	Contractor	CMWSSB
1.8	Social Infrastructure and Services	<ul style="list-style-type: none"> • Implementation of meetings with communities, • Organising awareness camps 	Construction site and surrounding communities where necessary	Contractor	CMWSSB
1.9	Risks of cyclones and tsunami	<ul style="list-style-type: none"> • Contractor shall ensure that adequate measures and communication system is available in case of any natural hazard; • Evacuation plan shall be in place for the site. 	Construction, operation and decommissioning phase	Contractor	CMWSSB

Sl. No	Systems/ Impacts	Action to be taken	Time frame	Responsible agencies	Responsible Agency for Review and Monitoring
2.0	Risk of Pandemic diseases such as COVID-19	Implementation of Health and Sanitation awareness and education	Construction site and surrounding communities Once/Month	Contractor	CMWSSB
2.1	Risk of infectious diseases such as HIV/AIDS	Implementation of Health and Sanitation education on STD.	Construction site and surrounding communities Twice/Year	Contractor	CMWSSB
2.2	Working Conditions/Work Safety	Visual inspection on the utilisation of PPE by workers/labours	Construction site Daily	Contractor	CMWSSB
2.4	Removal of temporary construction Structures and demobilization of construction machinery	<ul style="list-style-type: none"> Contractor to prepare site restoration plans, the plan is to be implemented by the contractor prior to demobilization. On completion of the works, all temporary structures will be cleared away, all rubbish cleared, excreta or other disposal pits or trenches filled in and effectively sealed off and the site left clean and tidy, at the contractor's expenses, to the entire satisfaction of the engineer. 	After completion of the project	Contractor	CMWSSB
2.5	Labour camp & facilities	Setting up of labour camps needs to be done as per the above-mentioned guidelines and procedures. <ul style="list-style-type: none"> Adequate product water facilities, sanitation and drainage, 	Construction operation and	Contractor	CMWSSB

Sl. No	Systems/ Impacts	Action to be taken	Time frame	Responsible agencies	Responsible Agency for Review and Monitoring
		<p>etc., in conformity with the Indian labour laws such as building and other construction workers act and IFC guidelines for workers accommodation, shall be ensured.</p> <ul style="list-style-type: none"> The contractor shall also guarantee the following: <ul style="list-style-type: none"> i. The location, layout and basic facility provision of each labour camp will be submitted to Engineer prior to their construction. ii. The construction will commence only upon the written approval of the Engineer. iii. The Contractor shall construct and maintain all labour accommodation in such a fashion that uncontaminated water is available for drinking, cooking and washing. iv. Supply of sufficient quantity of product water (as per IS) in every workplace/labour campsite at suitable and easily accessible places and regular maintenance of such facilities. v. The sewage system for the camp shall be designed, built and operated in such a fashion that no health hazards occur and no pollution to the air, groundwater or adjacent watercourses take place. Ensure adequate water supply is to be provided in all toilets and urinals. 	decommissioning phase		

Sl. No	Systems/ Impacts	Action to be taken	Time frame	Responsible agencies	Responsible Agency for Review and Monitoring
2.6	Compliance to Indian labour Laws	<ul style="list-style-type: none"> The contractor and CMWSSB should ensure the compliance of applicable Indian Labor Laws such as Factories Act 1948, Building and Other Construction Workers act 1996, Inter-State Migrant Workmen Act 1979, Contract Labor (Regulation & Abolition) Act 1971, Workmen Compensation Act 1923 Child Labour Prohibition & Regulation Act 1986, Minimum Wages Act 1948, Employee state insurance Act 1948, Employees Provident fund Act 1991, Payment of Wages Act 1936, Payment of bonus act 1965, Equal Remuneration Act 1976, and Payment of Gratuity Act 1972 and other International Labour organization conventions ratified by India. Maintain the required document at the site and regularly submit the compliance report to the concerned department and conduct internal and external labour audit. 	Construction/Maintenance, Operations and decommissioning phase	Contractor	CMWSSB & External Auditor
2.7	First Aid	<p>The contractor shall arrange for:</p> <ul style="list-style-type: none"> A readily available first aid unit, including an adequate supply of sterilized dressing materials and appliances as per the Factories Rules in every work zone. Availability of suitable transport at all times to take an injured or sick person(s) to the nearest hospital. Tie up with nearby hospitals. 	Construction, maintenance, operation and decommissioning phase.	Contractor	CMWSSB

Annexures

The following annexures are included with this RFP Report:

Annexure 1 – Social Policy, Legal and Administrative Framework

- Annex 1.1: JICA Environmental and Social Framework
- Annex 1.2: Screening and Categorisation
- Annex 1.3: Regulations, Laws and Permitting
- Annex 1.3: Institutional Arrangements

Annexure 2 – Salient Features of Key Applicable Labour Laws

ANNEXURE 1: SOCIAL POLICY, LEGAL AND ADMINISTRATIVE FRAMEWORK

Annex 1.1. JICA Environmental and Social Framework

JICA requires the consideration of social matters in all aspects of JICA operations and the requirements for social considerations as described in JICA guidelines (April 2010). In addition, adherence to International Performance Standards has been suggested. JICA guidelines endeavours to achieve transparency, predictability, and accountability in support for and examination of social considerations.

Annex 1.2. Screening and Categorisation

The requirement of the JICA's Guidelines is dependent on "project categorization" of the Project, which is stipulated in the JICA's Guidelines, as shown in Table 1. Currently, the Chennai Seawater Desalination Project (I) (the Project) has been classified as "Category B" by JICA. However, in the study, if the project is likely to have any significant adverse impact on the environment and society, the Project may be recategorized as "Category A".

Table 1. Project Category in the JICA Guidelines

Category	Description
A	Proposed projects are classified as "Category A" if they are likely to have significant adverse impacts on the environment and society. Projects with complicated or unprecedented impacts that are difficult to assess, or projects with a wide range of impacts or irreversible impacts, are also classified as "Category A". These impacts may affect an area broader than the sites or facilities subject to physical construction. "Category A", in principle, includes projects in sensitive sectors, projects that have characteristics that are liable to cause adverse environmental impacts, and projects located in or near sensitive areas.
B	Proposed projects are classified as "Category B" if their potential adverse impacts on the environment and society are less adverse than those of "Category A" projects. Generally, they are site-specific; Few, if any, are irreversible; and in most cases, normal mitigation measures can be designed more readily.
C	Proposed projects are classified as "Category C" if they are likely to have a minimal or little adverse impact on the environment and society.

Based on the Initial Environmental Examination carried out by JICA, the proposed Chennai Seawater Desalination Plant (I) is categorised under "B". Since the project is not located in a socially sensitive area, nor has sensitive characteristics, nor falls into sensitive sectors under the JICA guidelines for environmental and social considerations (April 2010), its potential adverse impacts on the environment are not likely to be significant. Details of categorisation are available in JICA website:

https://www.jica.go.jp/english/our_work/social_environmental/id/asia/south/india/c8h0vm0000ahdaf4.html

Annex 1.3. Regulations, Laws and Permitting

There are various acts, rules, policies and regulations currently in force in India that deal with social issues that could apply to infrastructure development. Some of the specific regulatory compliance requirements of the subproject are presented below.

i) Tamil Nadu Right to Fair Compensation and Transparency in Land Acquisition, Rehabilitation and Resettlement Rules, 2017

The Act provides for transparent and acceptable fair and enhanced compensation and assistance measures. It stipulates a more consultative and participatory approach in dealing with the Project Affected Persons. It emphasizes the rehabilitation and resettlement of the PAPs before the implementation of the actual project.

ii) The Street Vendors (Protection of Livelihood and Regulation of Street Vending) Act, 2014

This act aims explicitly to protect the rights of urban street vendors and to regulate street vending activities. It provides for Survey of street vendors and protection from eviction or relocation; issuance of a certificate for vending; provides for rights and obligations of street vendors; development of street vending plans; organizing of capacity building programmes to enable the street vendors to exercise the rights contemplated under this Act; undertake research, education and training programmes to advance knowledge and understanding of the role of the informal sector in the economy, in general, and the street vendors, in particular, and to raise awareness.

iii) The Scheduled Tribes and other Traditional Forest Dwellers (Recognition of Forest Rights) Act, 2006.

An Act to recognise and vest the forest rights and occupation in forest land in forest-dwelling Scheduled Tribes and other traditional forest dwellers who have been residing in such forests for generations but whose rights could not be recorded; to provide for a framework for recording the forests rights so vested and the nature of evidence required for such recognition and vesting in respect of forest land.

iv) Right to Information (RTI) Act, 2005

The basic object of the Right to Information Act is to empower the citizens, promote transparency and accountability in the working of the Government, contain corruption, and make our democracy work for the people in the real sense. It says that an informed citizen is better equipped to keep necessary vigil on the instruments of governance and make the government more accountable to the citizens.

v) National Fisheries Policy (Draft) 2020

The policy aims at comprehensive development of the fisheries sector through appropriate interventions to address the critical gaps with an overarching goal for growths in exports, an increase in farmer's income and better choice for consumers. It aims for robust management and regulatory framework with necessary legal backing for effective fisheries resource management through an Ecosystem Approach of Fisheries (EAF) management within the overall framework of relevant national and international instruments, policies and standards. To generate gainful employment and entrepreneurship opportunities along the value chain leading to the higher

income of fishers and fish farmers, improve their living standards and usher in economic prosperity.

vi) Tamil Nadu Marine Fishing Regulation Act 1983 (Amended in 2016)

An act to provide for the regulation, restriction and prohibition of fishing by fishing vessels in the sea along the whole or part of the coastline of the State.

vii) The operational policy of the World Bank on Social Safeguard

- Indigenous People: This policy applies for both positive and negative impacts on tribal population wherever the project activities are undertaken. Accordingly, the policy creates scope to study whether the project will have an impact on any individual or cluster of tribal people during any phase of the project.
- Involuntary Resettlement: Involuntary resettlement should be avoided where feasible, or minimized, exploring all viable alternative project designs. Where it is not feasible to avoid resettlement, resettlement activities should be conceived and executed as sustainable development programs which provide sufficient investment resources to enable the persons displaced by the project to share in project benefits. Displaced persons should be meaningfully consulted and should have opportunities to participate in planning and implementing resettlement programs. Displaced persons should be assisted in their efforts to improve their livelihoods and standards of living or at least to restore them, in real terms, to pre-displacement levels or to levels prevailing prior to the beginning of project implementation, whichever is higher.
- Policy on Access to Information and Disclosure: World Bank safeguards policy requires consultation with PAPs during planning and implementation of resettlement action plan and tribal development plan and public disclosure of drafts. Once the draft is prepared, it is to be made available at a place accessible to, and in a form, manner and language understandable to the displaced or affected people and local NGOs. RTFCTLARR, 2017 also requires disclosure of draft SIA and RAP and other project reports followed by mandatory Public Hearing. Consultations with PAPs or interested people, people in the vicinity of the project area is to be done and public disclosure on the project details, positive/negative social impacts and to get their feedback is to be carried out at appropriate intervals of the project period.

viii) India enacted the Wildlife (Protection) Act 1972

ix) ADB's Safeguard Policy

Safeguard policy statement (SPS) are generally operational policies that seek to avoid, minimize, or mitigate adverse environmental and social impacts, including protecting the rights of those likely to be affected or marginalized by the development process. ADB's safeguard policy framework consists of three operational policies on the Environment, Indigenous Peoples, and

involuntary resettlement and brings them into a consolidated policy framework that enhances effectiveness and relevance. Accordingly,

- i) impacts are to be identified and assessed early in the project cycle;
- ii) plans to avoid, minimize, mitigate, or compensate for the potential adverse impacts are developed and implemented; and
- iii) affected people are informed and consulted during project preparation and implementation.

Annex 1.4. Institutional Arrangements

Under overall direction, guidance and coordination of the CMWSSB Project Implementation Unit (PIU), the contractor will implement Chennai Seawater Desalination Plant (I). The Project Management Consultant (PMC) appointed by Employer comprises of the subject, and sector-specific specialists will provide onsite expert guidance as well as supervise the progress and attainment of drafted specified guidelines by the contractor in compliance with the regulatory mandates. Referring to the Social Management Plan (SMP) and implementation; Social Communication Specialists will be interacting on a regular basis with the social specialist appointed by the contractor for social safeguard compliance.

ANNEXURE 1: SALIENT FEATURES OF KEY APPLICABLE LABOUR LAWS

(Latest laws will apply)

- 1) Payment of Wages Act, 1936: It lays down as to by what date the wages are to be paid, when it will be paid and what deductions can be made from the wages of the workers.
- 2) Minimum Wages Act, 1948: The employer is supposed to pay not less than the Minimum Wages fixed by appropriate Government as per provisions of the Act if the employee is scheduled employment. Construction of buildings, roads, runways etc. are scheduled employments.
- 3) The Building and Other Construction Workers (Regulation of Employment and Conditions of Service) Act, 1996 and the Cess Act of 1996: All the establishments who carry on any building or other construction work and employs 10 or more workers are covered under this Act. All such establishments are required to pay cess at the rate not exceeding 2% of the cost of construction as may be modified by the Government. The Employer to whom the Act applies has to obtain a registration certificate from the Registering Officer appointed by the Government.
- 4) Inter-State Migrant Workmen's (Regulation of Employment & Conditions of Service) Act, 1979: The Act applies to an establishment which employs 5 or more inter-state migrant workmen through an intermediary (who has recruited workmen in one state for employment in the establishment situated in another state). The Inter-State migrant workmen, in an establishment to which this Act becomes applicable, are required to be provided certain facilities such as housing, medical aid, travelling expenses from home up to the establishment and back, etc.
- 5) Employees P.F. and Miscellaneous Provision Act, 1952: The Act provides for monthly contribution by the employer plus workers @ 10% or 8.33%. The benefits payable under the Act are:
 - (i) Pension or family pension on retirement or death, as the case may be.
 - (ii) Deposit linked insurance on the death in a harness of the worker.
 - (iii) Payment of P.F. accumulation on retirement/death etc.
- 6) Employees Compensation Act, 1923: The Act provides for compensation in case of injury, disease or death arising out of and during employment by certain employers to their employees for injury caused to them by accident. It enables an employee, and in case of death of an employee, his dependents, to get, at the cost of his employer compensation for employment injury if an employee contracts an occupational disease while in employment, it is also treated under the Act as injury caused by accident.
- 7) The Personal Injuries (Compensation Insurance) Act, 1963: This Act provides for the employer's liability and responsibility to pay compensation to employees where workmen

sustain personal injuries in the course of employment. The employer has to provide workmen with insurance against the liability. The Act describes the term which is of major importance under the Act is called as partial disablement and total disablement.

- 8) Employer's Liability Act, 1938: This Act protects workmen who bring suits for damages against employers in case of injuries endured in the course of employment. Such injuries could be on account of negligence on the part of the employer or persons employed by them in the maintenance of all machinery, equipment etc. in healthy and sound condition.
- 9) Employee's State Insurance Act, 1948: The Act provides for certain benefits to insured employees and their families in case of sickness, maternity and disablement arising out of an employment injury. The Act applies to all employees in factories (as defined) or establishments which may be so notified by the appropriate Government. The Act provides for the setting up of an Employees' State Insurance Fund, which is to be administered by the Employees State Insurance Corporation. Contributions to the Fund are paid by the employer and the employee at rates as prescribed by the Central Government. The Act also provides for benefits to dependents of insured persons in case of death as a result of an employment injury.
- 10) Payment of Bonus Act, 1965: The Act applies to all establishments employing 20 or more employees. The Act provides for payments of annual bonus subject to a minimum of 8.33% of the wages drawn in the relevant year. It applies to skilled or unskilled manual, supervisory, managerial, administrative, technical or clerical work for hire or reward to employees who draw a salary of Rs. 10,000/- per month or less. To be eligible for the bonus, the employee should have worked in the establishment for not less than 30 working days in the relevant year. The Act does not apply to certain establishments. The newly set-up establishments are exempted for five years in certain circumstances. Some of the State Governments have reduced the employment size from 20 to 10 for applicability of this Act.
- 11) Payment of Gratuity Act, 1972: Gratuity is payable to an employee under the Act on the satisfaction of certain conditions - on separation if an employee has completed 5 years of service or more or on death, the rate of 15 days wages for every completed year of service. The Act applies to all establishments employing 10 or more employees.
- 12) Labour (Regulation and Abolition) Act, 1970: The Act provides for certain welfare measures to be provided by the contractor to contract labour, and in case the Contractor fails to provide, the same is required to be provided, by the Principal Employer by Law. The Principal Employer is required to take Certificate of Registration, and the Contractor is required to take a license from the designated Officer. The Act applies to the establishments or Contractor of Principal Employer if they employ 20 or more contract labour.
- 13) Equal Remuneration Act, 1979: The Act provides that no employer shall pay to any worker employed by him in an establishment or employment, remuneration whether payable in

cash or in-kind at the rates less favourable than those at which remuneration is paid by him to the workers of the opposite sex in such establishment or employment. The Act further provides that no discrimination should be made against women at the time of recruitment. The Act also provides for not for making discrimination against female employees in the matters of transfers, training and promotions etc.

- 14) Maternity Benefit Act, 1951: An Act to regulate the employment of women in certain establishments for certain periods before and after child-birth and to provide for maternity benefit and certain other benefits. It provides for maternity benefits, including leave, wages, bonus, nursing breaks etc.
- 15) Sexual Harassment of Women at the Workplace (Prevention, Prohibition and Redressal) Act, 2013: This Act defines sexual harassment in the workplace, provides for an enquiry procedure in case of complaints and mandates the setting up of an Internal Complaints Committee or a Local Complaints Committee.
- 16) Child Labour (Prohibition and Regulation) Act, 1986 amended in the year 2016: The Act prohibits employment of children below 14 years of age in certain occupations and processes and provides for the regulation of employment of children and adolescent in all other occupations and processes. Employment of child and adolescent labour is prohibited in the Building and Construction Industry.
- 17) Bonded Labour System (Abolition) Act, 1976: The Act provides for the abolition of bonded labour system with a view to preventing the economic and physical exploitation of weaker sections of society. Bonded labour covers all forms of forced labour, including that arising out of a loan, debt or advance.

CHAPTER - 17**17. LIST OF APPROVED VENDORS/ SUPPLIERS**

The bidders shall use the following vendors or equivalent to these vendors to procure the equipment.

S. No.	Equipment	Supplier
1.	DAF	Leopold (Xylem)
		Degremont
		Veolia Water Technologies
		United Engineers
		IDE Technologies Ltd
2.	Cartridge Filters	PARKER HANNIFIN Corporation
		Pall Corporation
3.	High Pressure Pumps	Flowserve Corporation
		KSBAG
		WILOSE
		Sulzer
		Andritz AG
		Ruhrpumpen
		Torishima Pump Mfg. Co. Ltd.
4.	Energy Recovery Device	Flowserve Corporation
		Energy Recovery Inc.
		KSBAG
5.	RO pressure vessels	Bekaert (Protec)

S. No.	Equipment	Supplier
		Pentair pic (Codeline)
6.	RO Membranes	Dow Filmtec
		Hydranautics
		LANXESS AG
		Toray Industries, Inc.
7.	Seawater Supply Pumps (Vertical Turbine)	Flowserve Corporation
		KSBAG
		Sulzer
		WILOSE
		Andritz AG
		Ruhrpumpen
		Torishima Pump Mfg. Co. Ltd.
8.	Cleaning and flushing pumps	Flowserve Corporation
		KSBAG
		WILOSE
		Sulzer
		WEIR
		Andritz AG
		Ruhrpumpen
		Torishima Pump Mfg. Co. Ltd.
9.	Air Blowers	Everest Blowers
		Ingersoll Rand
		Kaeser Compressors
		Swam Pneumatics Pvt Ltd,

S. No.	Equipment	Supplier
		Roots
10.	Product Water Transfer Pump	Torishima Pump Mfg. Co. Ltd.
		Flowserve Corporation
		KSBAG
		WILOSE
		Andritz AG
		Ruhrpumpen
		Kirloskar
11.	Centrifugal Submersible Pumps for Product Water and other pit pumps.	Grundfos
		ABS
		Aqua Machinery
		WILOSE
		Ruhrpumpen
		KSBAG
12.	Special Duplex Material for Piping	Outokumpu
		Sandvik
		ThyssenKrupp AG
13.	Plug Valve	MTS- Victaulic
		KSBAG
		XOMOX
14.	Butterfly Valve	VAG
		Talis Belgicast
		GEMU

S. No.	Equipment	Supplier
		Audco
		BDK
		KSBAG
		Singer
		Tyco (Pentair)
		Bayer
15.	Expansion Joints	Angst+Pfister
		Idrosapiens
		KSBAG
16.	HP/LP Check Valve	Goodwin
		Talis Belgicast
		KSBAG
		Singer
		VAG
		L&T (Audco)
17.	Dual Plate Check Valve	Talis Belgicast
		KSBAG
		Singer
		VAG
		Tyco (Pentair)
		BDK
		L&T (Audco)
17A.	Valves for Product Water Main (For Treated Water Main)	Tyco
		KSBAG
		BDK

S. No.	Equipment	Supplier
		Singer
		VAG
		DVPL
		L&T (Audco)
18	Self Cleaning Filters	Amiad
		STF
		FILTRO
		Taprogge GmbH
		Azud
18 A.	Ultrafiltration	X-Flow (Pentair)
		Inge AG
		Dow
		Hyflux
19.	Air Valves	VAG
		Tyco (Pentair)
20.	Gate Valves	Tyco (Pentair)
		KSBAG
		H. Sarkar
		Bayer
		VAG
21.	Travelling Band Screen	Bilfinger SE
		OVIVO
22.	Chemical Dosing Pumps	Milton Roy Asia LMI
		ProMinent GmbH
		Doaspro

S. No.	Equipment	Supplier
23.	Filter Press	Andritz AG
		Dinshaw
24.	CO2 Generation Plant	ASCO
		Universal Industrial Gases, Inc. USA,
		Trinity Containers LLC.
25.	Gas Chlorination	Capital Control
		Penwalt
		Metito
		Wallaces Tiernan
26.	Air Compressor	Kirloskar Pneumatics
		Ingersoll-Rand
		Atlas Copco
		ELGI Equipments
27.	CRANE & HOIST	Hercules
		Electromech
		Eddy Cranes
		Consolidated Hoist
		W H Brady
28.	Electric Actuators	Rotork
		Auma
		Keystone
29.	Reinforcement Steel	SAIL
		VIZAG STEEL
		Electrosteel Steel Ltd.

S. No.	Equipment	Supplier
		Jindal steel
		Shyam Steel
		TATA
30.	Cement	ACC
		Lafarge
		Ambuja
		Coromandel
		Zuari
		Ultratech
31.	Structural Steel	SAIL
		VIZAG STEEL
		TATA
		Jindal steel
		Shyam Steel
		Electrosteel Steel Ltd.
32.	Ductile Iron Pipes	Electrosteel Steel
		Kobota-TATA
		Jindal
		Srikalahasthi Pipes
33.	Mild Steel Pipes	SAIL
		TATA
		Wellspun
		JINDAL
34.	GRP Piping	CPP
		Protesa
		Amiantit

S. No.	Equipment	Supplier
35.	HDPE pipes & fittings	JAIN IRRIGATION SYSTEMS LTD,
		DURALINE
		Timeplast
36.	H.V.A.C	Blue Star
		Hitachi
		Voltas
37.	Exhaust Ventilation	GEC
		Almonard
		Khaitan
38.	Cooling Tower	Crompton
		Voltas
		Paharpur
39.	Glassed Fused Steel Tanks	Permastore
		Omerastore
		Schumann
	ELECTRICAL EQUIPMENT	
1.	Air Circuit Breakers	ABB
		Alstom
		BHEL
		CGL
		Larsen & Toubro
		Legrand
		Schneider
		Siemens AG
2.	Alternators	AVK/SEGC
		Leyroy Sommers
		Stamford
3.	Annuciator (Facia Type)	Digicont
		Larsen & Toubro

S. No.	Equipment	Supplier
		Procon
4.	Anti Vibration Spring Mounts / Pads	E&B Rubber Metal (EGAMA)
		Resistoflex
5.	Automatic Voltage Regulating Relay (AVR)	ABB
		Alstom
		Emco
6.	Balancing Valves	Advance
		Zoloto
7.	Battery (Ni-Cd / Lead Acid - sealed maintenance free)	Amara Raja
		AMCO
		Chloride / Exide
		HBL Nife
		Sab Nife
8.	Battery Charger & DCDB	Amar Raja
		Automatic Electric
		Caldyne
		Chhabi
		Chloride / Exide
		HBL Nife
		Masstech
		Sab Nife
		Universal
9..	Bimetalic Overload Relay	ABB
		Larsen & Toubro
		Siemens AG
10.	Buchholz Relay	Prayog / Equivalent
11.	Bus Ducts / Bus trunking	Ducati
		Elpro
		Globe Electricals
		Larsen & Toubro
		Legrand

S. No.	Equipment	Supplier
		Schneider
		Stardrive
		United Electric
		Audco
		Castle
		Zoloto
12.	Cable Jointing Kit	Raychem / Equivalent
13.	Cable Termination Kits (HT - Heat Shrunk)	Densons
		Mahindra (MECP)
		Raychem
14.	Cable Trays - FRP / GRP	Densons
		Ercon
		Indiana
		Premier
		Sumip
15.	Cables (1.1 kV Grade XLPE / PVC / FRLS IS 1554)	CCI
		Finolex
		Gemscab
		Lapp
		Nicco
		Polycab
		RPG
		RR Kable
		Satna
		Thermo Cables
		Universal
16.	Cables (1C Unsheathed Cu - 1.1 kV Grade PVC/FRLS)	Finolex
		Larsen & Toubro
		Polycab
		RR Kable

S. No.	Equipment	Supplier
		Skytone
		Thermo Cables
17.	Cables (Control & Instrumentation)	Delton
		Lapp
		Nicco
		Polycab
		RPG
		Satna
		Thermo Cables
		Universal
18.	Cables (Power- 11kV UE, XLPE)	CCI
		Havels
		ICL
		INCAB
		Nicco
		Polycab
		RPG
		Satna
		Universal
19.	Capacitor Bank (11 kV)	ABB
		Asian
		CGL
		EPCOS
		Khatau
		Larsen & Toubro
		Manohar Brothers / Powercap
		Meher
		Unistar
		Universal
20.	Capacitor Bank (415V)	ABB
		Asian

S. No.	Equipment	Supplier
		CGL
		Ducati
		EPCOS
		Khatau
		Larsen & Toubro
		Meher
		Powercap
		Unistar
		Universal
21.	Ceiling Fans	Bajaj
		Crompton Greaves
		Havels
		Orient
22.	Change Over Switches	Control & Switchgear
		HPL
		Kirloskar
23.	Circuit Breaker (110kV/ 132kV)	ABB
		Alstom
		BHEL
		Crompton
		Siemens AG
24.	Connector Upto 32 Amps Screw less type	LEGRAND
		Phoenix
		Wago
25.	Contactors / Auxiliary Contactors	ABB
		Larsen & Toubro
		Schneider
		Siemens AG
		Telemecanique
26.	Control & Relay Panel (110kV/ 132kV)	ABB
		Alstom / Areva
		Bharat Bijlee

S. No.	Equipment	Supplier
		CGL
		Easun
		Enpro
		Siemens AG
27.	Control Transformers	AE
		Kappa
		Pragathi
		Precise
		Salzer
28.	Cooling Tower	Advance
		Bell
		Flow Tech
		Mihir
		Paharpur
29.	CT&PT (11 /6.6/3.3kV)	ABB
		Alstom
		CGL
		Kappa
		TELK
30.	CT&PT (110kV/132kV)	ABB
		Alstom
		Automatic
		BHEL
		CGL
		Pragati
		TELK
31.	CTs & PTs	ABB
		AE
		Crompton
		Kappa
		MECO
		Pragati

S. No.	Equipment	Supplier
		Precise
		Siemens AG
32.	Diesel Generator	Caterpillar
		Kriloskar
		Ashok Leyland
		Sterling Wilson
		Cummins
33.	Distribution Boards (Lighting & Power)	Adlec
		Advance Panel & Swgr
		Asiatic Switchgears
		Hensel
		Pustron
		Unilec
		United Electric
34.	Distribution Boards (PCCs / MCCs)	ABB
		Larsen & Toubro
		Legrand
		Pustron
		Schneider
		Siemens AG
35.	Distribution Transformer	ABB
		Alstom / Areva
		Bharat Bijlee Limited
		CGL
		Wilson
36.	Earthing (Maintenance Free)	ALTEC
		CAPEELECTRIC
		KASA-ERICO
37.	Electronic Timer	Larsen & Toubro
		Siemens AG
38.	Emergency Exit Lights	Agni Suraksha

S. No.	Equipment	Supplier
		MK
39.	Energy Meter (Digital)	ABB
		AE
		Alstom
		Larsen & Toubro
		Siemens AG
		GE
40.	Energy Saving Lighting Transformer	Indian Transformers Ltd.
		Rakesh Transformer / Equiv.
		Transformers & Electrical
		Transformers & Rectifiers
41.	Engineering Plastics / GRP DB's & Panel Enclosures	Hensel
		Sumip
42.	Exhaust Fans	Bajaj
		Crompton Greaves
		GE
		Havels
43.	Fuses (Solid State)	Ferraz
		GE Power
		Siemens AG
44.	Feeder Pillar (Non-Magnetic Stainless Steel)	ABB
		Amptech Electric
45.	Fuses with Fuse Base (HRC Link type)	ABB
		Alstom
		CGL
		Cooper Busmann
		GE
		Larsen & Toubro

S. No.	Equipment	Supplier
		Siemens AG
46.	Fusible Switches	ABB
		Alstom
		Bussman
		GE Power
		Siemens AG
		Larsen & Toubro
47.	Glands (Brass - Single & Double Compression)	Comet
		Dowell
		Electromac
		HMI
		Lotus
48.	Glands (Brass - Single & Double Compression)	Leader
		Sant
		Zoloto
49.	Indicating Lamps	ABB
		AE
		Alstom
		Bhartia Cutler Hammer
		Binay
		Larsen & Toubro
		Siemens AG
		Teknik
		Vaishno
50.	Indicating Lamps (LED type)	ABB
		Binay
		Larsen & Toubro
		Raas Controls
		Siemens AG

S. No.	Equipment	Supplier
51.	Indicating Meters (Analogue / Digital / Taut Band)	Automatic Electric
		Enercon
		IMP
		Larsen & Toubro
		Meco
		Rishabh
		SIEMENS AG
52.	Insulators (110kV/132kV)	AMEI
		BHEL
		Jayshree
		Modern
		MPL
		SIL
		WS Industries
53.	Intelligent Modules / MCCs	ABB
		Larsen & Toubro
		Rockwell
		Schneider
		Siemens AG
54.	Isolator (110kV/132 kV)	ABB
		Elpro
		GR Power
		S&S
		Siemens AG
		SMC
55.	KW Transducer	ABB
		Alstom
		Canopus
		Larsen & Toubro
		Rishabh
		Siemens AG
56.	Lamps	Bajaj

S. No.	Equipment	Supplier
		GE
		Osram
		Philips
57.	Lightning Arrestors (98kV /110kV)	ABB
		Alstom
		ALTEC
		CAPE ELECTRIC
		CGL
		Elpro
		Jayshree
		Lam co
		OBLUM
58.	Liquid Resistance Starters (LRS), Grid Rotor Resistance (GRR)	BCH
		Enterprising
		Poineer
		Resitech
59.	Load Break Switch	ABB
		Alstom
		H.H.E(Elecon)
		Larsen & Toubro
		Siemens AG
60.	Lugs (Copper)	Comet
		Dowell
		Forward
		HMI
		Lotus
61.	Luminaires	Bajaj
		Crompton
		GE
		Philips
		Wipro

S. No.	Equipment	Supplier
62.	Magnetic Oil Level Indicator	Sukrut/ Equivalent
63.	MCBs, ELCB's, RCCB's & MCB DBs	ABB
		Alstom
		GE
		Larsen & Toubro
		Legrand
		Schneider
		Siemens AG
64.	Meters / Multi Function Meter (Digital / Microprocessor Based)	ABB
		Automatic Electric
		Conserve
		Enercon
		IMP
		Larsen & Toubro
		MECO
		Neptune
		Rishabh
		Secure
		Siemens AG
		Socomac
65.	Motors (LT 415 V, 690V & HT 11 / 6.6 / 3.3 kV)	ABB
		BBL
		BHEL
		CGL
		KEC
		Siemens AG
66.	Moulded Case Circuit Breaker (MCCB)	ABB
		Alstom
		Larsen & Toubro
		Legrand
		Schneider

S. No.	Equipment	Supplier
		Siemens AG
67.	Neutral Grounding Resistance	Cutler Hammer
		National
		Ohmark
		Pioneer Electricals
		Resitech
		RSI
		SR Narkhede
68.	Oil / Winding Temperature Indicators	Perfect Controls
		Scientific Controls
69.	OLTC Mechanism	Crompton
		CTR
		Easun MR
70.	Plug & Socket Units (20/32A Metal Clad / Moulded)	Clipsal
		Hensel
		Legrand
		Pustron
71.	Plug & Sockets (Computer)	AMP
		AVAYA
		SIMON
		SYSTIMAX
72.	Poles (MS/FRP/GRP)	Bajaj Sumin
73.	Power Transformers (Oil & Dry Type)	ABB
		Alstom / Areva
		Bharat Bijlee (BBL)
		CGL
		EMCO
74	Protection Relays (Conventional / Electromechanical)	ABB
		Alstom / Areva
		BCH

S. No.	Equipment	Supplier
		Easun
		GEC
		L&T
		Minilec
		Omron
		Schneider
		Siemens AG
75.	Protection Relays (Numerical / Microprocessor based)	ABB
		Alstom
		BCH
		Easun
		GEC
		Larsen & Toubro
		Minilec
		Schneider
		Siemens AG
76.	Protection Relays (P.F. Correction)	ABB
		Alstom
		DUCATI
		Larsen & Toubro
		SIGMA
77.	Push Button Stations	Asiatic
		Controls & Switchgear
		Powergear
		Pustron
		United Electric
78.	Push Buttons	ABB
		Bhartia Cutler Hammer
		Larsen & Toubro
		Siemens AG
		Teknic
		Vaishno

S. No.	Equipment	Supplier
79.	Rotary / Toggle Switches	ABB
		Alstom
		Kaycee
		Larsen &Toubro
		Siemens AG
		Switron
80.	SCRs and Diodes	ABB
		BHEL
		Hind Rectifier
		Schneider
		Siemens AG
		Usha Rectifier
81.	Selector Switches (Rotary Type)	Kaycee
		Larsen & Toubro
		Salzer
		Siemens AG
82.	Selector Switches (Voltmeter / Ammeter)	ABB
		Kaycee
		Larsen&Toubro
		Salzer
		Siemens AG
83.	Series Reactor (11 kV)	ABB
		Mehar
		PS Electricals
		Sagaon Power
		Shrihans
		Universal
84.	SFU, Load Break Switches, Fuses	ABB
		GEPC
		L & T
		Schneider
		Siemens AG

S. No.	Equipment	Supplier
85.	Shunt Release	ABB
		Alstom
		Larsen & Toubro
		Siemens AG
86.	Single Phasing Preventer	ABB
		Larsen&Toubro
		Siemens AG
87.	Sockets (230 Volt, 20 Amps & 24 Volt, 10 Amps)	Hensel
		Legrand
		MDS
		Pustron
88.	Soft Starters	ABB
		CGL
		Schneider
		Siemens AG
89.	Switchboards (110kV / 33 kV / 11kV - VCB Panels)	ABB
		Alstom / Areva
		Siemens AG
90.	Switches, Fan Regulators & Sockets	Clipsal
		Legrand
		MK
		Siemens AG
91.	Tacho Generators	Allen Bradley
		EFKTOR-IFM
		STROTER
		Telemecanique
92.	Telephone Tag Blocks	KRONE
		POYUTS
93.	Terminal Block (Screw less type)	Phoenix
		Wago
94.	Terminal Blocks	Connectwell
		Elmex

S. No.	Equipment	Supplier
		Essen
		Phoenix
		S & S
		Wago
95.	Timer (Pneumatic / Electronic)	ABB
		Bhartia Cutler Hammer
		Larsen & Toubro
		Siemens AG
96.	Trivector Meter (Digital)	ABB
		Alstom
		Enercon
		GE
		Larsen & Toubro
		Siemens AG
97.	Vaccum Circuit Breaker (Indoor & Outdoor)	ABB
		Alstom / Areva
		Siemens AG
98.	Vacuum Contactors	ABB
		Alstom / Areva
		BHEL
		CGL
		Siemens AG
99.	Variable Frequency (Speed) Drives	ABB
		Larsen & Toubro
		Siemens AG
100.	Welding Socket, 63 Amps With Interlocking Switch	ABB
		Hensel
		Pustron
		Siemens AG
	CONTROL & INSTRUMENTATION	
1	Air Filter Regulator	Placka

S. No.	Equipment	Supplier
		Schrader-Schovill
		Shavo-Norgren
2	Annunciation System	IIC
		Instrumentation Ltd
		Lectrotek
		Minilec
3	Auxiliary Relays	OEN
		Siemens AG
4	Barrier	MTL
		Obo Betermann (Cape Elect. Corpn.)
		P&F
5	Battery (Ni-Cd / Lead Acid - sealed maintenance free)	Amara Raja
		AMCO
		Chloride / Exide
		HBL Nife
		Sab Nife
6	Battery Charger & DCDB	Amar Raja
		Automatic Electric
		Caldyne
		Chhabi
		Exide
		HBL Nife
		Masstech
		Sab Nife
		Universal
7	Cable Glands	Comet
		Dowell's Elektro Werke
		Gland Mech Industries
		Sunil And Company
8	Cable Power	Finolex
		Havell's India Ltd.

S. No.	Equipment	Supplier
		KEI Industries
		Nicco
		Polycab
		Uniflex Cables
		Universal cable Ltd
9	Cable Trays - FRP / GRP	Densons
		Ercon
		General composites
		Indiana
		Premier
		Sumip
10	Cables (Control & Instrumentation)	CMI
		Delton
		Finolex
		Havells
		KEI Industries
		Lapp
		Nicco
		Polycab
		RPG
		Special Cables Pvt Ltd
		TCL
		Thermo Cables
		Universal
11	Cables (Data - CAT-VI)	AMP
		AVAYA
		SIMON
		SYSTIMAX
12	Cables (Telephone)	Delton
		Finolex
		Skytone

S. No.	Equipment	Supplier
13	CCTV	Honeywell
		Panasonic
		Pel co
		Sony
14	CCTV System Controller	Honeywell
		Panasonic
		Pel co
		Sony
15	CCTV Monitor / Large Screens	LG
		Panasonic
		Samsung
		Sony
16	Chlorine Measurement	ABB
		Chemtrac
		ProMinent GmbH
		E&H
		YIL
17	Computer	Compaq
		Dell
		HP
		IBM
18	Control Desk, I/O Panels& PLC Panels / Consoles	Chemin
		Instrumentation Limited
		Lotus
		Pyrotech Control India
		Rittal
		Siemens AG
19	DC Power Supply Unit	Aplab
		Elnova
		Phoenix
		Schneider

S. No.	Equipment	Supplier
		Siemens AG
20	DCS Display Unit	LG
		Philips
		Samsung
21	Digital Indicator	Chino
		Laxsons
		Lectrotek
		Master Electronics Pyrotech Instruments
		Micro systems
22	DP type Flow / Level Transmitters	ABB
		Chemtrols (Fuji)
		Emerson (Rosemount),
		Honeywell
		Siemens AG
		Yokogawa
23	Earthing (Maintenance Free)	ALTEC
		CAPEELECTRIC
		KASA-ERICO
24	Electrical Actuator	Auma
		Beacon Rotork
		IL (Vaas Bernard)
		Keystone
		Limitorque
		Marsh
25	Electro- Pneumatic Positioner	Dresser Industries (Masoneilan)
		Samson Controls.
		Siemens AG
26	Electro-Hydraulic Actuator	Askania
		Reineke
27	Electromagnetic Flow Meter	ABB
		Emerson (Rosemount)

S. No.	Equipment	Supplier
		Endress & Hauser.
		Krohne - Marshall
		Siemens AG
		Yokogawa
28	Ethernet Switch & Terminal Server	Cisco
		Extreme
		IBM
		Nortel Networks
29	Fiber Optic Cables	Amp
		Krone
		Molex
30	Fire Detection & Alarm System	GE/ EST
		Honeywell
		Monely/AS
		Notifier
31	Flow Switch	D.K. Instruments
		Krohne-Marshall
		Siemens AG
		Levcon
		Switzer
32	Fuses with Fuse Base (HRC Link type)	ABB
		Alstom
		CGL
		Cooper Busmann
		GE
		Larsen & Toubro
		Siemens AG
33	Glands (Brass - Single & Double Compression)	Comet
		Dowell
		Electromac
		HMI
		Lotus

S. No.	Equipment	Supplier
34	Hand Held Calibrator	Emerson
		Honeywell
		YIL
		REX
35	Input Converters	ABB
		Fisher-Xomax
		Forbes Marshall (Moore products)
		MIL controls
		Shreyas-Barton
36	Impulse Pipe & Fittings	Parker Hannifin Corporation
		Swagelok,
37	Instrument Panels	Instrumentation Ltd
		Pyrotech
		Rittal
38	Instrument Transformer	Automatic Electric Ltd.
		Indcoil Manufacturing Company
		National Engineering Corporation
39	Instrument Tubing	Apex Tubes Pvt Ltd.
		Choksy Tube Co Ltd.
		Maharashtra Seamless Ltd.
		Ratnamani Metal & Tubes Ltd.
		Saw Pipes Ltd , Zenith Ltd.
		Swage lock
40	Junction Boxes, Transmitter Protection Boxes	Baliga
		Flame Proof Equipment Pvt. Ltd.
		Flamepack
		Sudhir Switch Gears Pvt. Ltd.,
41	Large Video Screen Display	Barco
		Sharp

S. No.	Equipment	Supplier
		Viewsonic
42	Level (Ultrasonic Type) Transmitter	ABB
		Chemtrols (Fuji)
		Chemtrols (Vega)
		Emerson (Rosemount)
		Endress & Hauser
		Honeywell
		Krohne Marshall
		Siemens AG
		Yokogawa
43	Level Gauge (Magnetic & Reflex Type)	Levcon Instruments
		Chemtrols (Vega)
		Endress & Hauser
		Level-Tech
		Nivo Controls
		Pratolina Instruments
		SBEM
		Sigma
		Switzer Instruments
		Techtrol
		Waaree Instruments
44	Level Switch (Capacitance / RF Type)	Chemtrols (Vega)
		Endress & Hauser
		Level-Tech
		Nivo Controls
		SBEM
		Switzer Instruments
45	Level Switch (Conductivity Type)	Chemtrols (Vega)
		Endress & Hauser
		Level-Tech
		Nivo Controls

S. No.	Equipment	Supplier
		SBEM
		Switzer Instruments
46	Level Switch (Float type)	D K Instruments
		Emerson (Mobrey)
		Forbes Marshall
		Levcon Instruments
		SBEM
		Techtrol
		Trac
47	Limit switches	Bhartia Cutler Hammer
		Electromag
		Electronic & Power Control Company
		Honeywell Automation (1) Ltd
		Jayashree Electronics
		Kaycee
		Siemens AG
		Speed 0 Controls Pvt Ltd
		Telemecanique
48	Lugs (Copper)	L & T
		Comet
		Dowell
		Forward
		HMI
		Jainson
49	Master Station	Lotus
		Limatorque
50	MCBs, ELCB's, RCCB's & MCB DBs	Rotork
		ABB
		Alstom
		GE
		Larsen & Toubro

S. No.	Equipment	Supplier
		Legrand
		Schneider
		Siemens AG
51	Microprocessor based Controller (One Loop / Two Loop)	Chemtrols (Fuji).
		Eurotherm
		Honeywell
		Siemens AG
		Yokogawa
52	Network Rack	APW
		NETRACK
		PRESIDENT
53	Orifice Plate & Flanges Assembly / Venturi, Flow Nozzle	Chemtrols-Samil
		Engineering Specialities
		Hydro-pneumatics
		Instrumentation ltd.
		Micro-precision
54	ORP / pH / Conductivity Measurement	ABB
		Ametek
		Emerson (Analytical),
		Forbes Marshall (Polymetron)
		Foxbro
		Hertman & Brown
		Honeywell
		Ion Exchange
		ProMinent GmbH
		Siemens AG
		Servomax
		Yokogawa
55	Panels/ Auxiliary Panels/ Control Desk,	BCH

S. No.	Equipment	Supplier
		Hoffmann
		Pyrotech
		Rittal
		Siemens AG
56	Passive Components including FO Cable	AMP
		Krone
		Molex
		Sysyimax
57	Plant Control System / Process Controller Distributed Control System (DCS)	ABB
		Emerson (Rosemount)
		Honeywell
		L&T
		Rockwell Automation
		Schneider
		Siemens AG
		Forbes Marshall
		Yokogawa
58	Plug & Sockets (Computer)	AMP
		AVAYA
		Pustron
		SIMON
		SYSTIMAX
		Anchor
59	Pneumatic Actuator	ABB
		Dresser Industries (Masoneilan)
		Fisher-Xomox
		Forbes Marshal (Area)
		Instrumentation Ltd. (Palghat)
		MIL Controls
		Samson Controls
60	Pneumatic Positioner	ABB

S. No.	Equipment	Supplier
		Dresser Industries (Masoneilan)
		Fisher-Xomox
		Forbes Marshall (Area)
		Instrumentation Ltd. (Palghat)
		Auma
		Samson Controls
61	Pressure / Differential Pressure Gauge	AN Instruments
		General Instruments
		Manometer India
		KSBAG
		Siemens AG
		Waaree instruments
		Walchandnagar (Tiwac).
		WIKA
62	Pressure / Differential Pressure Switches	Indfoss
		Switzer
		Vasutech
63	Pressure / Differential Pressure Transmitter	ABB
		Chemtrols (Fuji)
		Emerson (Rosemount)
		Honeywell
		KSBAG
		Siemens AG
		Yokogawa
64	Pressure Relief Valve	Tyco Sanmar
		KSBAG
		Instrumentation Ltd.
		Keystone valves Ltd.
		Sebim valves
65	Printer	Canon

S. No.	Equipment	Supplier
		Epson
		HP
		TVSE
		Wipro
66	Public Address System & Associated Equipments	Philips/ BOSCH
		Neumann
67	Relays & Contactors	JVS Electricals
		ABB
		Omron
		Siemens AG
68	Rotameters	Eureka instruments.
		Chemtrols
		Instrumentation Engineers
		Krohne-Marshall
69	Rotary / Toggle Switches	Trac
		ABB
		Alstom
		Kaycee
		Larsen &Toubro
		Siemens AG
70	SCRs and Diodes	Switron
		ABB
		BHEL
		Hind Rectifier
		Schneider
		Siemens AG
71	Selector Switches (Rotary Type)	Usha Rectifier
		Kaycee
		Larsen & Toubro
		Salzer
72	Self Regulating Pressure Control Valve	Siemens AG
		Forbes Marshall

S. No.	Equipment	Supplier
		Instrumentation Ltd.
		Nirmal Industries
		Samson Controls
73	Signal Isolators	MTL, Stahl
		Chino
		Forbes Marshall (Protech)
		Pepperl & Fuchs
		Yokogawa
74	Sockets (230 Volt, 20 Amps & 24 Volt, 10 Amps)	Hensel
		Legrand
		MDS
		Pustron
75	Soft Starters	ABB
		CGL
		Schneider
		Siemens AG
76	Solenoid Valve	Asco
		Avcon
		Herion, Rotex
		Jucomatic
		Schrader-Schovill
77	Speakers, Audio System	BOSCH
		BOSE
		PHILIPS
78	Surge Protection Device	MTL
		Obo Betermann (Cape Elect. Corpn)
79	Telephone Tag Blocks	Krone
		Poyuts
80	Temperature Gauges	AN Instruments
		General instruments
		Manometer India

S. No.	Equipment	Supplier
		ODIN
		Waaree instruments
		WIKA
81	Temperature Switch	AN Instruments
		General Instruments
		Indfoss
		Manometer India
		Switzer
		Vasutech
		WIKA
82	Temperature Transmitter	ABB
		Chemtrols (Fuji)
		Emerson (Rosemount)
		Honeywell
		Siemens AG
		Yokogawa
83	Terminal Block (Screw less Type)	Phoenix
		Wago
84	Terminal Blocks	Connectwell
		Elm ex
		Essen
		Phoenix
		S & S
		Wago
85	Terminals	Elm ex
		Phoenix
		Wago
86	Thermocouple & RTD / Thermowell	General Instruments
		Industrial
		Nagman Instruments
		Pyroelectric Instruments
		Tempsens

S. No.	Equipment	Supplier
		Toshniwal Industries
87	Thermocouple Compensating Cable	General Instruments
		Paramount
		Therm cables
		Toshniwal Cables
		Udey Pyrocables
88	Turbidity Measurement	ABB
		E&H
		GE Instrumentation
		YIL
89	UPS	Amar Raja
		APC
		Chloride (Emerson)
		DB Power Electronics
		Emerson Process Management
		GE
		Hirel Electronics Ltd
		PCI
		Siemens AG
90	Vibration Monitoring System	Bentley Nevada
		Schenk Avery Corporation
		SPM Instruments
91	Wireless Data Communication System	
		Motorola
		SPM Instruments
		Radwin
91	Wireless Data Communication System	
		Motorola
		Radwin