



MINISTRY OF ENVIRONMENT AND ENERGY

MALE: REPUBLIC OF MALDIVES

CONSULTANCY SERVICES FOR SURVEY, DESIGN OF WATER FACILITIES IN SH. FOAKAIDHOO MALDIVES



VOLUME II

BIDDING DOCUMENT

DRAFT EMPLOYER'S REQUIREMENT

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IN ASSOCIATION WITH



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SECTION 8 – TECHNICAL SPECIFICATIONS (Employer Requirements)

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PART 2(A) PROJECT REQUIREMENTS

1.0 General

Ministry of Environmental & Energy (MEE) on behalf of the Government of Maldives seeking the assistance of a qualified and competent consulting firm for developing design of integrated water supply facilities in the Island of Sh. Foakaidhoo, Maldives.

Ministry of Environmental & Energy (MEE) on behalf of the Government of Maldives thus has awarded work of consultancy services for survey, design of water supply facilities and preparation of Tender Documents in Sh. Foakaidhoo, Maldives to M/s Shah Technical Consultants Pvt. Ltd., Mumbai, India in association with M/s Development Technologies, Maldives (DTM, via. Letter No. 438-PDU/438/2016/106 dated 29th September 2016.

1.0.1 Information about Sh. Foakaidhoo

Foakaidhoo is one of the inhabited islands of Shaviyani Atoll and geographically part of North Miladhunmadula Atoll in the north of Maldives. It is an island-level administrative constituency governed by the Foakaidhoo island council. The island of Sh. Foakaidhoo is located at 6° 19' 35" N and 73° 08' 57" E. The island measures approximately 1050 m in length and 680 m in width with a total area of 70.90 Ha.

The climate is tropical, warm and humid all year round with a mean annual temperature of 28°C and an average relative humidity of 80%. Since water surrounds the island from both sides, main livelihood of the population depends upon agriculture. The Island has mosque, schools, and health posts contributed to the infrastructure of the island.

According to population data collected from council office of Sh. Foakaidhoo Island the total population for year 2000 is 1137 and up to year 2015 is 1695.

1.0.2 Geography of Maldives

The Republic of Maldives is a chain of nearly 1190 tiny coral islands, which are grouped into 26 geographic atolls that together forming a chain of 820 km in length and 130 km at its widest point set in an area of more than 90,000 km² of the Indian Ocean. The island varies in size from 0.5 km² to around 5.0 km². The latitude and longitude of Maldives are from 07°06'30"N to 00°41'48"S and 72°32'30"E to 73°45'54"E respectively.

The total land area is about 300 km². The Island archipelago is located approx. 500 km southwest of India. Amongst these only 200 islands are inhabited, 90 islands are used as tourist resorts and the rest are uninhabited of which few are used for

industrial / agricultural purposes. The maximum height of land above mean sea level within the Maldives is around 2.5 m and around 80% of the land area is less than 1 m above mean sea level.

1.0.3 Geotechnical Information

The aquifer across the republic is relatively uniform so the properties determined on any island are essentially applicable to all others, although thicknesses may vary and there may be detailed variations in grain size. The consolidated coral rock underlying the sands may also form part of the aquifer and its significance also varies from place to place.

1.1 Description of Work

The work comprises of the following:

Development of proper water supply system to facilitate safe drinking water to the population of Sh Foakaidhoo Island

1.2 Water Supply System

The water supply system shall comprise:

- Collection
- Conveyance
- Treatment
- Storage
- Distribution

- A. **Collection:** Collection shall include rain water from roofs of institutional and community facilities during rain event. The total roof catchment area is 0.305 hectares from where the rain water shall be collected in rain water lifting well. The lifting well shall be 50 m³ of capacity, built in fibre reinforced plastic (FRP). The rain water shall be conveyed up to raw water storage tank through gravity.

Sea water through bore well shall be another source of raw water collection. The sea water shall be conveyed up to R.O plant.

Pumping shall be required to pump sea water from bore well to R.O plant. A minimum 2 nos. of pumps shall be required out of which 1 shall be working and other shall be stand-by. The bore well shall be 35 meters deep. The bore well conductivity shall reach up to 50,000 µS/cm at 35 meter depth, if not the bore well shall be further drilled to reach the required conductivity.

For brine/reject water disposal from R.O plant, the outfall pipeline shall be HDPE of minimum class PN 16 having dm. 75 mm. Diffuser shall be installed at the termination point of outfall.

- B. **Conveyance:** The conveyance shall be from raw water source to treatment facilities and from treatment facilities to treated water tank. The detail of conveyance is mentioned in the table below:

Type of water	From	To	Pipe Diameter	Pipe material	Total length	System
Raw water (Rain water)	Roof catchment	Rain water lifting well	110 to 315 mm	HDPE	1.209 Km	Gravity
Raw water (Rain water)	Rain water lifting well	Raw water storage tank	63 mm	HDPE	530.0 m	Pumping
Raw water	Raw water storage tank	Slow sand filter	63 mm	HDPE	15 m	Pumping
Treated water	Slow sand filter	Treated Water Tank	63 mm	HDPE	45 m	Pumping
Raw water (sea water)	Bore well	R.O Plant	63 mm	HDPE	25 m	Pumping
Treated water	R.O Plant	Treated Water Tank	63 mm	HDPE	25 m	Pumping

- C. **Treatment:** The treatment shall include slow sand filters (2 nos.) for filtration of rain water and ground water. The size of each filter shall be 3.0 m x 2.5 m and the capacity of each shall be 36m³/day. The slow sand filter shall have raw water turbidity less than 20 NTU for effective and efficient filtration process. If the raw water turbidity is high, simple pre-treatment such as storage, sedimentation or primary filtration shall be necessary to reduce it to within desirable limits.

The water treatment shall also comprise R.O plants (2 nos.) for treating sea water. The capacity of each R.O plant shall be 0.036 ML/day for intermediate stage.

- D. **Storage:** The water storage tanks shall be of two types; raw water storage and treated water storage. The raw water storage tank shall store raw water collected from rain water lifting well through pumping. A minimum 4 nos. of pumps shall be required out of which 3 nos. shall be working and 1 no. shall be standby. The raw water storage tank shall be a rolled tapered panel (RTP) steel tank with storage capacity of 800 m³.

The treated water storage tank shall have sufficient storage capacity to serve the island people. The treated water tank shall also be a rolled tapered panel (RTP) steel tank with storage capacity of 300 m³. The treated water tank shall receive filtered water from slow sand filter and R.O treated water, both through pumping. A minimum 2 nos. of pumps in each pumping case shall be required out of which 1 nos. shall be working and other shall be standby. The stored water in treated water tank shall be chlorinated with sodium hypochlorite before distribution to the consumers. All storage tanks shall be provided with external level indicators.

Pumping shall be required to pump water from raw water storage tank to slow sand filter and from treated water tank to island community through water distribution network. A minimum 2 nos. of pumps shall be required for each pumping case; out of which 1 nos. shall be working and other shall be standby.

Similarly, dosing pumps for dosing sodium hypochlorite solution into treated water tank storage tank shall be required.

- E. **Distribution**: The pumped water distribution system, shall distribute the treated water from treated water tank to the island community people. The total length of distribution network shall be about 13.60 Km. Water distribution shall be through HDPE pipeline network with pipe diameter varying from 63 mm to 180 mm.

In most communities, the water distribution system serves the secondary purpose of providing water supply for fire-fighting. This demand known as fire demand shall often be the most severe design condition for the water supply system. Fire hydrants shall be provided at every 300 m radius.

1.2.1 Pumping For Distribution System

Minimum two pumps shall be installed which will operate alternatively as working and stand by.

The pump operations shall be controlled through an ultrasonic sensor or float switches for low and high water level alarms. The pumps shall be fitted with overload protection device and thermal protection. All pumps shall be provided with necessary valve arrangements etc. The pumping details are mentioned in the table below:

Type	Application	Working Unit	Stand by Unit	Total Units	Capacity per Unit
Centrifugal dry mounted	Pumping from rain water lift well to raw water storage tank	3	1	4	2.41 Kw
Centrifugal dry mounted	Pumping from raw water storage tank to slow sand filter	1	1	2	0.28 Kw
Centrifugal dry mounted	Pumping from slow sand filter to treated water storage	1	1	2	0.28 Kw
Submersible	Feed water pumping from bore well to R.O plant	1	0	1	4.17 Kw
Centrifugal dry mounted	Treated water pumping from RO plant to treated water storage	1	1	2	0.14 Kw
Centrifugal dry mounted	Treated water pumping from treated water storage to distribution system	1	1	2	0.62 Kw
Positive displacement, reciprocating diaphragm pumps.	Chemical dosing to treated water storage	1	1	2	0.75 Kw

Submersible	Brine water disposal	1	0	1	1.33 Kw
Centrifugal dry mounted	Fire Fighting	1	1	2	8.00 Kw

1.2.2 Control System

The normal pump operation shall be controlled through an ultrasonic sensor or 'float-switches'. The pump control system shall consist of the following components:

- A. Ultrasonic sensor / switch for start / stop control of the pumps and maximum level over ride and alarm; or
- B. Float switches for low level to signal pump OFF, high level to signal pump ON; maximum level alarm and over ride.

The switches shall be set at a level recommended by the pump manufacturer to ensure that the pumps do not run dry. The switches shall activate the stand by pump when maximum water level is reached. If both pumps are operational, both pumps will pump at a higher rate. A common alarm output shall drive flashing amber light and an audible alarm sound.

- A. **Ultrasonic Sensors/Switches:** Ultra-sonic level measurement shall be by the use of non-contact, echo-time measuring equipment operating at ultrasonic frequency. The equipment shall transmit pulses, which shall reflect back to the sensor from the surface of the liquid whose level shall being measured.

The equipment shall consist of a sensor incorporating both transmitter and receiver, together with a separate control unit. The equipment shall be provided with automatic temperature compensation and shall be suitable for operation in the designated application under the climatic conditions. The overall accuracy of the level measurements shall be within $\pm 1.0\%$ of the instrument span. The connection between the sensor and control unit shall be via commercially available twisted and screened cable, of sufficient cable length to enable removal of pump well equipment. The sensor shall be suitable for mounting in the open, or within an enclosed tank, and shall be totally enclosed and hose proof with environmental protection to IP 67.

The sensor shall be installed on a robust and rigid structure provided for the purpose. The structure shall include a means of levelling the sensor so that the transmitted beam is perpendicular to the water surface and a safe and easy access to the sensor for servicing and maintenance.

The control units shall incorporate the following:

- Facilities for independently adjusting dead band zero and span, and shall have an output of 4-20 mA proportional to level.
- A 4 digit read out in meters to indicate water level.
- An entry for operating parameters without the need to physically measure the distance to water level or to remove the sensor head.
- Potential free change over contacts to provide a minimum of 5 control points.
- Secure access for parameters via a removable/fixed keypad.
- A common potential free alarm signal for system faults, echo loss and memory failure.
- An LED display to the level control unit shall illuminate on receipt of acceptable echoes and extinguish when echoes are not received.
- A LED for indication for dc power availability shall also be provided.
- A level control unit that shall be automatically checked for availability and any faults signalled back to the control panel.

The equipment shall be suitable for the application, particularly with regard to the blocking distance, transmitted beam angle or cone.

- B. **Float Switches:** The float shall be impact and corrosion resistant and of robust construction and supplied with a non-mercury switch, sealed neoprene jacketed cable and ABS shell with changeover contacts tether method of tie wrap nylon.

Contacts shall remain open when the tilting action changes over between opening of one contact and closing. This “dead band” shall operate over an arc of approximately 20 degrees on either side of horizontal, means for preventing the float from movement due to draft or water turbulence should be provided as also a means for raising the units for maintenance and repair.

Float switches shall be supplied with full-length flexes of equal length to run from pump well to junction box or socket unit. Cabling shall run back to the control panel cabinet. Excess lengths shall be neatly coiled. The float switch cable shall be installed in a manner that is clear from interference. A protective cover shall be placed in front of the float cables so as to protect against turbulence during pumping causing cable tangling which may interfere with the float operation.

1.2.3 Pump Controllers

Pump controllers shall be microprocessor or microcontroller based to meet pumping station requirements having the following features:

- Automatic pump sequencing determined by the specified level detection system.
- Monitoring and protection from over voltage, under voltage and phase imbalance, pump motor over current etc.
- LCD readout screen which shall show the system status i.e. pump running, level line voltage, pump motor current and pump starting sequence.
- Operating log which displays number of starts and total running hours for each pump.
- Fault log which displays all active alarms e.g. all parameters detailed.
- System configuration; this screen shall be pass-word protected to prohibit unauthorized changes to the system.
- Indicator lights for power ON, AUTO, OFF and processor fault.
- A membrane key pad to set system configuration and operating set points. It shall be provided with contacts of suitable rating to interface with the relevant pump motor to operate in auto mode. It shall accept potential free contact from the MCC to activate the auto mode from Pump auto/manual selector switch.

1.3 Task to be Undertaken during the Contract

Tasks to be undertaken during the contract by the contractor shall include the following, but not limited to:

- Conducting all the necessary detailed site surveys and soil investigations.
- Clearing of the total work place from debris and all trees and scrub within the project area, grading and/or filling the work place to the formation level and all importation and/or disposal of material for the preparation of the site.

- Construction of bore well for tapping of sea water for treatment up to R.O plant including pipeline laying with all appurtenances, accessories etc.
- Conveyance of raw water from source to treatment facilities and that of treated water from treatment facilities up to treated water tank.
- Distribution of treated water from treated water tank to island community people through distribution network.
- Construction of civil unit like slow sand filters, etc.
- Construction, set up, testing, commissioning, operation and maintenance of R.O plants. The works shall also include laying of all internal plant pipe line works with valves, penstocks, related accessories etc., set up all related electrical, instrumentation, mechanical works for plants etc.
- Construction, set up, testing, commissioning, operation and maintenance of Energy efficient Hybrid Solar Power System for R.O plant. The following points shall prevail, but not limited to:
 - The contractor shall check and confirm the area required by Solar PV panels with suitable angle to get maximum sun intensity.
 - The Solar hybrid system shall be available with change over and interlocking facility with required metering and protection as per electrical standards etc.
 - The Solar system shall be utilized only for plant load and the extra power generated shall not be given back to the grid.
 - Supply of power from solar system to the plant shall be the first priority, followed by through transformer. In case of failure of both, DG shall take critical loads.
 - The solar system shall include laying and set up of all accessories, related electrical, instrumentation, mechanical works etc. complete.
- Construction of administration building which shall include laboratory, office, control panels, switch gear, store, stand by generator, toilets etc.

- The contractor shall submit for approval lists of the laboratory equipment, workshop equipment, building services and furniture he shall supply and install.
- All construction and subsequent operation and performance testing of the entire water supply scheme together with all required consumables.
- Preparation and submission of draft As Built Drawings, shop drawings and operation & maintenance (O&M) and health and safety manuals to the employer for approval, by the contractor.
- Provision and supply of the required level of spares.
- Operating and maintaining the entire water supply scheme for one (1) year from the date of commissioning.

1.4 Detailed Scope of Work

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

- The contractor at his cost shall verify all ground levels; invert levels high tide levels, low tide levels, all dimensions and soil investigations.
- The contractor shall ensure construction of civil works for the water supply scheme plus all the ancillary building structures as detailed. Accessibility to all equipment/structures shall be ensured by providing necessary walkways for the operators for operation at all levels.
- Hydraulic testing of water retaining structures.
- Hydraulic testing of HDPE pipe lines all throughout the network.
- Supply, erection, testing and commissioning of mechanical equipment's.
- Providing, laying, joining and testing of inter connecting pipe lines. All puddle pieces shall be incorporated at appropriate positions and levels during civil construction.
- Providing, laying and joining of HDPE pipes including all necessary valves, accessories etc.

- Providing, laying and joining of brine water outfall pipe line with necessary valves, chambers and accessories etc.
- Construction of ancillary works for administrative building such as office, laboratory, stores, workshops, toilets etc.
- Providing furniture for office, laboratory, workshops etc.
- Providing essential chemicals and glass apparatus including spares for the laboratory enough to last for 1 year of operation.
- Providing area lighting all-round the water supply scheme.
- Providing necessary roads, footpaths and walkways throughout the work place, with necessary street lighting.
- Providing electrification as per approved layout plan.
- Providing telephone / communication arrangement for construction works, during obligatory O & M period and permanently for the security gate and for the administration office.
- Operation and maintenance of the constructed hydraulically tested and successfully commissioned water supply scheme along with electrical and mechanical equipment instrumentation for a period of one (1) year during which period all chemicals and consumables required for operation and maintenance staff shall be provided by the contractor.
- Training of local counterpart staff for running the water supply scheme and for day to day and periodic maintenance.
- Painting the entire water supply scheme (if required) at the time of final handing over after the O&M period etc.

1.5 Information Regarding the Site

Location: The proposed site for water treatment facilities located near the sea shore shall have water collection (RWH system) and water distribution network spread within the boundary limits of Sh. Foakaidhoo Island as shown in Figure no. 01; Sh. Foakaidhoo/WS/01.

Dewatering constraints: The freshwater lens below the island is a critical resource and thus any contamination or depletion shall be avoided. As the sub-strata being very porous, frequent dewatering shall be harmful. Dewatering therefore must be

minimized and shall be undertaken in such a manner that does not waste good quality of ground water nor does not draw up saline water into the ground water aquifer, nor impinge on nearby wells. As a consequence, structures should ideally not be too deeper below ground level wherever possible but the excavation depth for foundation shall be as per the approved drawings and inter-connecting pipe work shall be relatively shallow. The contractor shall describe his methods for dewatering and shall get approval from the Employer.

1.6 Proposed Water Supply Scheme

- There are currently no major water supply systems on the island and therefore there are no skilled technical people in these fields on the island.
- In tender, the bidder shall be deemed to have concurred that the Employer's requirements are sufficiently defined. The contractor shall incorporate all reasonable precautions and provisions for the safety of operation and for safety of those concerned in the erection, execution and subsequent maintenance of the contract works.
- Tenders shall be assessed not only on the basis of capital and operating costs but also on the robustness and proven reliability of their proposed systems.
- The entire water supply scheme must always operate in full safe mode that means overflows or spillages to the surface and to the ground water shall be avoided.

1.6.1 Components of Water Supply System

The following description generally summarizes the processes specifications envisaged. The specific process requirements are given below for:

A. Raw water

The main source of raw water for the island people for drinking purpose is the rain water and therefore rain water harvesting to convert rain water into potable water shall be the first priority.

Tapping of sea water and its proper treatment, making it potable for drinking shall also be another source of supplying water to island community people.

B. **Rain Water Harvesting (RWH)**

Rain water shall be collected from roofs of institutional and community facilities during rain event and shall be conveyed through gravity, to rain water lifting well. The RWH system shall consist of gutters and down take pipe which shall be of metal and plastic. The shape of gutters shall be semi-circular or rectangular, however, V-shaped gutters shall also be considered. First flush device shall be provided to flush off the first rain before entering the system.

Leaves and other floating debris shall be prevented from entering the system for which a leaf screen made of quarter inch wire mesh in a metal frame shall be installed along the length of gutter and a screen or wire basket shall be placed at the head of down spout. However, if the screens or wire basket not placed then cleaning of gutters regularly shall be done.

C. **Slow Sand Filter**

Two (2) nos. of slow sand filters shall be provided. The slow sand filter shall receive water from raw water storage tank through pumping. Filtration of water through slow sand filter shall remove bacteria, viruses, color, turbidity, fecal coliforms, organic matter, iron & manganese etc.

The slow sand filter shall consist of an open box of rectangular or circular type. The filter box shall contain supernatant water layer, a bed of filter medium, an under drainage system and a set of control valves and appurtenances.

The supernatant shall provide a driving force for the water to flow through the sand bed and overcome frictional resistance in other parts of the system. It shall also provide a storage of several hours to the incoming water before it reaches the sand surface.

The filter bed shall consist of natural sand with effective size between 0.25 mm to 0.35 mm and uniformity coefficient of 3 to 5. For best efficiency, the thickness of the filter bed shall not be less than 0.4 m to 0.5 m.

The under drainage shall be provided to support the sand bed and to prevent the filtered water to leave from under side of the filter. The under drains shall be made of un-jointed bricks laid to form channels, or perforated or porous tiles laid over the drains. Graded gravel of 0.2 m to 0.3 m shall be placed on the under drains to prevent sand from entering the under drains and to ensure uniform extraction of filtered water. A system of control valves shall facilitate regulation of filter rate and adjustment of water level in the filter at the time of cleaning and back filling.

D. **Reverse Osmosis (R.O) System**

Two (2) numbers of R.O plants shall be provided for which the feed water from sea shall be tapped and pumped to R.O plants where the pressurized water through pressure vessels with spiral wound RO membranes shall be treated. The spiral wound R.O membranes shall filter the feed water, producing 30-33 percent of fresh water and the rest as concentrated brine or reject water.

The quality and quantity of permeate shall be supervised by the conductivity meter and flow meter. When the permeate water quality drops below the preset level, it shall automatically divert to drain, preventing low water quality to treated water storage tank. Furthermore, the plant shall be equipped with flow meters for feed water and permeates as well as pressure transmitter/switches shall be incorporated so that it can automatically stop the plant in case of failure of feed water (low inlet pressure) and back pressure in the permeate line (high outlet pressure). The brine/reject water from the plant shall be disposed back to the sea.

The operation of R.O. plant shall be in two modes as described below:

- A. **Automatic mode:** To start up the plant, the operator shall select the operation mode to automatic after which the micro-processor in the control panel shall take care of the whole process until fully started. Success operation of each process shall follow the next process and failure of one process shall fail the next process and thus the startup. Therefore a safety precaution shall be made during programming of the processor.

The starting sequence of R.O plant shall be as follows:

- Selection of automatic mode by the operator.
- Starting of the feed water pump: As the pump starts, the sensor/transmitter checks the pressure across the R.O filter system. If the pressure is not within the set limits, the R.O. plant shall trip for necessary action such as backwashing the filter or changing of filter bags etc.
- After the feed water is circulated through the membranes for the set time period, the air locks within the feed water shall get removed.
- With the starting of the high pressure pump, the speed shall increase gradually until the set limit. This shall control the high starting current of the motor. The transmitter/ sensor in the high pressure pump line shall monitor the pressure increase of the system. If the pressure goes beyond the set limit, the R.O plant shall trip as a safety precaution. The transmitter/sensor shall monitor the membrane

inlet pressure, pressure difference across the membrane modules, conductivity of permeate etc.

- When the plant gets stabilized, the permeate valve shall open and the product water shall flow to the treated water storage tank.
- Water in the storage tank shall be designed to distribute to the network by pumping consisting of two pumps; one pump shall be in operation and the other as stand by. The control system shall maintain a constant pressure in the network and as such, the stand by pump shall start automatically in any instance if the set pressure limit cannot be maintained by the pump in operation.

B. Manual operation: In manual operation mode, each stage of the whole process shall have to start and stop manually.

Protection of R.O plant: The following protection points while operating R.O plant shall prevail:

- Operation of the plant shall be prevented with very low or no water flow to the plant.
- Very high pressure across the membranes shall be avoided.
- The permeate line shall be clear of any blockages and high pressure.
- Care shall be taken to prevent low quality of water flowing towards treated water storage tank.

Alarms: The system shall be designed and programmed for following alarm patterns:

- Feed pump failure alarm
- Low feed pressure alarm
- High pressure pump failure alarm
- High membrane inlet pressure alarm
- High permeate conductivity alarm.

Power Supply: The R.O plant shall be running from the island power source. However, a diesel generator set shall be provided to the power requirement as a back-up system with capacity to run up to minimum 8 hours in case of power failure.

E. **Master Balancing Reservoir (Treated Water Storage Tank)**

Treated water from R.O. plant and filtered water from slow sand filter both shall be pumped to treated water tank. This water shall be distributed to consumers through pumping for drinking within the island through a water distribution (HDPE) pipeline network. Water sampling taps shall be provided at the entry and outlet of storage tank for testing water quality. Additional sampling taps two (2) nos. for each square kilometer shall also be provided.

F. **Chlorination at Treated Water Tank**

Sodium hypochlorite solution shall be dosed for chlorination at treated water tank as it is normally available as a household disinfectant (E.g. bleaching powder) under many brand names. It can be produced by electrolysis of brine water too. It is a clear solution containing 14-15% of available chlorine. Special care shall be taken while supplied in small containers or in bulk as it loses its chlorine strength when exposed to atmosphere or sunlight for longer time. Dosing of hypochlorite solution shall be by positive displacement, reciprocating diaphragm pumps.

G. **Pumping from Treated Water Tank to Distribution**

Minimum two pumps shall be installed which shall operate alternatively as duty and stand by to supply the stored water through HDPE distribution network.

The pump operations shall be controlled through an ultrasonic sensor or float switches for low and high water level alarms. The pumps shall be fitted with overload protection devices and thermal protection.

Minimum two pumps shall be installed for emergency fire break; of which one shall be working and other shall be standby.

The diameter of HDPE pipes selected shall be such as to withstand sufficient water pressure at all times so that water shall reach to each and every household on the island. The HDPE pipes for distribution network shall be installed with:

- Fire hydrants at suitable intervals (about every 300 m radius).
- All necessary valves, fittings and accessories as required.
- Water meters, level indicators, sampling points etc. at suitable locations.

For excavation of trenches for pipeline, laying and joining of HDPE pipeline etc. and other allied works, refer chapter numbers 2 and 3 in this technical specification.

H. **Water Distribution Network:** The water distribution network shall convey potable water for the island community, public/private institutions, etc. For distribution

network, HDPE pipes confirming to PE 100 PN 6 fittings shall be used. Butt welding or electro fusion method shall be used for pipe joining. (Specification of HDPE pipes is given under chapter no. 3 of these technical specifications).

All the water distribution pipes shall be laid underground at a depth of 0.6 m to 1 m below the ground level to safeguard the pipes from road traffic. In case, if the cover available is less, concrete casing shall be provided. Proper pipe bedding shall be provided below the pipe (details of pipe bedding mentioned under chapter no. 3 of technical specifications). Necessary gate valves and sluice valves shall be provided as shown on the drawings. Minimum pipe size shall be 63 mm. Washout valves at dead ends for draining the pipe line shall be provided. Fire hydrants shall also be provided at suitable locations.

- I. **House hold Connections and Water Meters:** Each house shall be provided with a single water connection along with a water meter and a tap. The house connections shall serve the purpose of withdrawing water from the distribution mains. The minimum pipe size for house hold connections shall be: For single house connection, the pipe size shall be 18 mm; for commercial connection, the pipe size shall be 25 mm and for high rise and multi storied buildings, the pipe size shall be 63 mm as manifold.

1.6.2 Allied Works

- a. **Brine outfall pipeline to sea:** The brine outfall pipe shall be HDPE of minimum class PN 16, dm. 75 mm from the R.O plant up to the sea discharge point. The outfall pipe shall be fitted with a diffuser at the outfall end. The outfall pipe line shall be prevented from floatation using ballast blocks. The outfall shall be laid 0.5 m below the ground until it reaches the sea and then continue along the sea bed. The exact location of the outfall shall be approved by the employer before commencement of any construction. The outfall shall be laid on the sea bed with depths below sea level. The pipes shall be weighted down by pre-cast concrete anchors and shall rest on the anchor blocks. The pipe shall be placed in the natural rock bed grove. The contractor shall ensure that suitable methods, equipment and materials are employed. The contractor shall obtain all information regarding variation of tide levels, currents, winds and other relevant details. The contractor shall consult the Maldives Port Authority and provide suitable markers for the outfall pipe.
- b. **Area lighting:** All the rooms/facilities in the administration building and the entire water supply scheme shall be properly lighted.
- c. **Administrative/office building, laboratory, stores etc.:** An administration building where all the facilities such as R.O plant, slow sand filter unit, disinfection system, treated water storage tank and pumping facilities are built shall be established. The administration building shall have office space, laboratory, generator room, control panel room, equipment storage, workshops, toilet facilities, vehicle parking etc.

1.7 Completeness of the Offer

The contractor shall be fully responsible to ensure that the whole of the works, including each individual component, shall be constructed in a manner so that the water supply scheme as a whole operates as a fully integrated system which shall be capable of achieving the required output in an efficient and economical manner, and to include all scheme equipment and accessories required for the safe and satisfactory operation of the facilities. To achieve this, the contractor shall ensure that each individual component performs in a manner which shall compliment to that of all other components. Any accessories which are not specifically mentioned in the specifications, but which are useful or necessary for completion of the works and successful performance of the water supply facilities, shall be provided by the successful bidder within the tendered cost. The contractor shall, to the maximum extent practical and feasible, endeavour to standardize on the manufacture and scheme shall be deemed to be completed after supply of materials and equipment so as to minimize the operation and maintenance requirements. The contractor shall ensure that all items of equipment are installed in a manner which will facilitate routine and periodic maintenance operations with ease.

1.8 Time for Completion

The entire work, including mobilization, reconnaissance, manufacturing, transportation, construction, installation, trial runs, testing and commissioning shall be completed within the scheduled time for completion. The physical completion of the water supply scheme and facilities shall be achieved before commissioning. The contractor shall take care that commissioning of the entire water supply system shall be trouble free.

1.9 Trial Run of the System

After execution of the works the contractor shall trial run the whole system to demonstrate satisfactory performance to the Employer's representative prior to taking over by the Employer. The cost of electricity, chemicals and other consumables for operation and maintenance of the whole system during the period of trial run shall be borne by the contractor. The cost towards the contractor's PMU's representative and other operating personnel during the said period of trial run, along with cost of tools and spare parts, which are required for operation and maintenance of the system and equipment during the trial run period shall also be borne by the contractor and shall be included in contract price. In the event that the system or any of the facilities do not satisfactorily achieve the required performance standards during this period, the trial run period shall be extended until such time as the contractor have satisfactorily rectified any deficiencies as may be necessary to satisfy the performance requirements, at the risk and cost of the contractor.

1.10 Commissioning of the System

On completion of the trial run, commissioning of the water supply system shall be done by the contractor. All the costs thereof, electricity but inclusive of staff, maintenance, and any other consumables for operation and maintenance during the commissioning period shall be borne by the contractor. The cost of electricity and chemicals required during commissioning of system shall be borne by the contractor.

1.11 Training of Employers Personnel

The contractor shall be responsible to provide practical training on all aspects of the operation, maintenance and routine repair of the whole water supply scheme and facilities to all personnel selected by the employer who shall ultimately be responsible for the operation, maintenance and repair of the system and its facilities. For this purpose the contractor shall provide a comprehensive training program for the employer's personnel for a reasonably required period before end of operation and maintenance of contract period. To ensure that the designated personnel are adequately trained to take up their responsibilities for smooth and hassle free running of the water supply scheme, the contractor shall provide a full time trainer who shall be skilled in training and who shall be familiar with all the normal and special operational conditions of the process, including mechanical, electro-mechanical, electrical, instrumentation and control equipment of the work.

1.12 Communications

During the contract period the contractor shall maintain communication in the form of mobile/landline phone/emails trouble free through which the operators can be contacted in case of problems.

1.13 Operation and Maintenance of the System

The contractor shall be responsible for operation and maintenance of entire water supply scheme, for the period of one (1) year after completion of works (date of issue of "taking over certificate") or from date as directed from the Employer.

Notwithstanding the above, the contractor shall be required to rectify any deficiencies which are attributable to defects in the workmanship or quality.

PART 2(B) TECHNICAL SPECIFICATIONS

CHAPTER 1 PRELIMINARIES

1.0 General

This section contains technical specifications for water supply scheme facilities and supplementary information that describe the works to be procured. The cost for complying with the clauses in this chapter shall deem to be included in the contractor's rates including taxes, quoted in the Bills of Quantities for the works as a whole.

1.1 Standard Specifications

Except as otherwise indicated in these technical specifications, the contractor shall comply with the latest standard specifications as used by the Government of Maldives.

1.2 Substitutions

Substitution of materials other than those specified in the contract documents shall be approved by only Employers representative. If the material proposed for substitution is equal or superior to the material specified; or that the material specified cannot be delivered to the work place in time to complete the work of the contract due to conditions beyond the control of the contractor, in such case, the Employers representatives decision shall prevail. To receive consideration, request for substitution shall be accompanied by documentary proof of quality in the form of certified quotations and guaranteed date of delivery from suppliers of both the specified and the proposed substituted materials.

1.3 Documents and Drawings

The contractor shall use the approved drawings for construction purpose. The tender drawings are for reference only. The contractor shall assume all responsibilities for making of estimates of the sizes, kinds and quantities of materials and equipment included in the work to be done under the contract. He shall not be allowed to take advantage of any errors or omissions.

1.4 Costs for Mobilization and Temporary works

It shall be noted that no payment above the quoted prices and no extra payment shall be made to the contractor for mobilization costs, i.e. for providing transportation, light, power, tools, and equipment, or for furnishing building and maintaining construction plant, access roads, sanitary conveniences, disposal, work, water supply, fire protection, guards, trestles, telephone system and other temporary structures, and materials, or for medical attention or health protection,

or for watchmen or guards, or for any other services, facilities, or materials necessary or required to execute the work in accordance with the provisions of the contract as these shall be considered as having been included in the prices stipulated for the various items in price schedule.

1.5 Transportation and Storage of Materials

Transportation of any material by the contractor shall be by suitable vessels or vehicles which when loaded do not cause spillage and all loads shall be suitably secured. Any vessel or vehicle which does not comply with this requirement or any local traffic regulations and laws, shall be removed for work location.

All materials when brought by the contractor shall be stacked and stored in a manner suitable to protect against slippage, damage, breakage, pilferage etc., and readily available for checking by the Employers representative at any time. The contractor shall arrange for watch and ward of the materials at all times in a suitable manner satisfactory to the Employers representative, all at his own expense.

1.6 Office, Stores and Equipment

The contractor shall make his own arrangements for renting or acquiring sufficient land for the erection of his office and stores plus parking / maintenance area for vehicles and equipment to be used at works at his own expense.

The contractor shall also provide an air conditioned office space furnished with desk, chairs, filing cabinet, shelves, including washing and toilet facilities, for the sole use of the Employers representative and supervisory staff, which will be cleaned and maintained (inclusive of electricity and water) at the contractors expense.

1.7 Water and Power Supply

The contractor shall make his own arrangements for a hygienically clean and potable water supply for labor and work. The contractor shall be advised that the groundwater on the island may not be suitable for use in concrete mixes due to the high salinity. As a result the contractor should allow for acquiring sufficient quantities of water for use in concreting work either from rain harvesting or desalination or from any other source as approved by the Employers representative. Water required for general use may be drawn from ground water wells but only at a sustainable rate as deemed appropriate by Employers representative. The process of drawing water should not cause an intrusion of saline water from below or cause adverse effects on adjacent property wells. The water that the contractor plans to use for construction activities shall be tested in an approved laboratory for water quality parameters suitable for construction.

Only after approval of Employers representative and after satisfactorily verifying the laboratory results of water, the contractor shall use the water for construction activities.

The contractor shall make his own arrangements at his own expense for the supply of electricity services either by contacting the island office where connection from local mains shall be possible or by providing his own generating plant to meet the requirements.

1.8 Access to Private Property Work Place

The contractor shall obtain written permission from the property owner and from the Island office for access to private property and to any right of way for lying of pipelines or any other work, related to execution of the project. The contractor shall arrange to construct, maintain and afterwards remove and reinstate any access required for and in connection with the execution of the works. Reinstatement shall include restoring the area of any access route to at least the degree of safety, stability and drainage that existed before the contractor entered the property.

1.9 Setting out of the Works

The contractor shall be responsible to check and verify the basic information supplied and in no way shall be relieved of his responsibility, if such information is lacking or not authentic or correct. He shall, however, be subject to check and review of the Employer and in no case any deviation from the contract or tender drawings will entitle the contractor for any sort of compensation for corrections of such errors, mistakes or omissions.

The setting out of the works should avoid un-necessary disturbance or removal of garden plants and trees. Only the removal of plants and trees that is totally necessary for the construction of the works will be permitted following the approval of the Employers representative, and approval of the Island office for the right of way, for which a provisional sum has been allocated for replacement or compensation.

The contractor shall at his own expense establish working or construction lines and grades as required and shall furnish and maintain stakes and other such materials and give such assistance including qualified staff as may be required by the Employer for checking setting out lines and grade marks. The contractor shall be solely responsible for the accuracy thereof.

The contractor shall safeguard all points, stakes, grade marks and bench marks made or established on the work, bear the cost of re-establishing them if disturbed, and bear the entire expense of rectifying work improperly done due to not

maintaining or protecting, or removing without authorization, such established points, stakes and marks.

Any work done beyond the lines, levels and limits shown on the drawings or not agreed by the Employer shall not be paid for and the contractor shall make good over-excavation as directed by the Employers representative, at his own expense.

1.10 Public Utilities and other Services

The contractor shall consult all utility and service providers (i.e. electricity, telephones, cable TV, gas, etc.) before commencing any excavations, and shall satisfy himself as to the exact position of existing services which may affect or be affected by the construction of the works.

Prior to any construction activity, the contractor shall have utility lines located and marked in the field and shall have all rights-of-way cleared through the Island office and graded and ready for construction activities.

The contractor shall make his own arrangements at his own expense for any diversion or removal of services which he may require for his own convenience or because of his proposed method of working and shall in all cases, inform the Employers representative in advance of his proposals.

1.11 Work Photographs

The contractor shall arrange to take color photographs at locations of the works to demonstrate conditions of work before work commences, during the construction period and after completion of the works. The photographs may be required as evidence in defense of claims against the contractor for damage due to the execution of the works.

1.12 Cooperation at Work Place

If the construction shall have to be carried out in restricted area, the contractor's attention shall particularly be drawn to the following:

- The need to maintain existing services and reasonable access for local residents and traders during the construction period.
- The probable presence of other contractors on site with whom the work shall have to be coordinated.

All work shall be carried out in such a way as to allow access and afford all reasonable facilities for any other contractor and his workmen and for the workmen of the Employer and any other person who may be employed in the

execution and/or operation at or near the work place of any work in connection with the contract or otherwise.

In the preparation of program of work the contractor shall at all times take full account of and cooperate with the programming of the work of other contractors so as to cause the minimum of interference to them and to the public.

1.13 Protection of Work and Public

The contractor shall exercise precautions at all times for the protection of labor employed and public life and property at and around the work place. The safety provisions of applicable laws, building and construction codes shall be observed. Machinery, equipment and all hazards shall be guarded or eliminated in accordance with safety provisions.

During the execution of the work, the contractor shall put up and maintain during the night time barriers and lights effectively to prevent accidents. The contractor shall provide suitable barricades, red light "Danger" or "Caution" signs and watchmen at all places where the work causes obstructions to the normal traffic or constitutes in any way a hazard to the public.

1.14 Environmental Protection

The contractor shall ensure that all actions are taken to protect local environment of the work place and that groundwater, soil and air shall be kept free from pollution (including noise) due to the works being undertaken.

The contractor shall be required to prepare and undertake an Environmental Management Plan based on the monitoring requirements to the satisfaction of the Employers representative.

1.15 Record Drawings (As-Built)

The contractor shall prepare reproducible drawings of the whole works "as constructed" (As-Built). The drawings shall be produced to a standard similar to that of the construction drawings.

Record drawings shall include the positions and extent of all support construction left in any excavations and exact locations of all services encountered during construction.

Record drawings shall be prepared to the Employers representative's approval as the work proceeds and shall be handed to the Employers representative on completion. The record drawings shall then become the property of the employer.

1.16 Final Clearance of Work Place

On completion of work, wherever applicable, the contractor shall clear away and remove from work place all constructional equipment, surplus materials, rubbish, scaffoldings and temporary works of every kind and leave the whole of the work place in a clean condition. The final contract payment shall be withheld until this has been done, to the satisfaction of the Employers representative.

1.17 Water Supply System Training Program

The contractor shall be required to organize and implement awareness and training programs for the island community and island office staff that shall be directly involved in maintenance of the entire system including importance of rain water harvesting (RWH).

The awareness program should inform the community on all aspects related to the technical features of entire water supply system to ensure that the system can be properly maintained. It shall also include aspects related to community participation during the construction since most of the work shall be executed within or close to the proximity of community houses. The contractor shall also arrange training of the Island office staff which shall be responsible for the long term operation and maintenance of the system and water treatment facilities plus use of maintenance equipment. For the purpose of training, to maintain the said facilities and equipment, proper operation manuals and checklists should be prepared by the contractor, and approved by the Employers representative.

CHAPTER 2 EXCAVATION AND EARTHWORK

2.0 Scope of Work

The work covered in this chapter of the specifications consists of furnishing all labors, equipment, appliances and materials required in performing all operations in connection with excavation, trenching and backfilling for roads, water lines, and appurtenances.

2.1 Excavation General

All excavation of whatever substance encountered shall be performed to the depths and widths indicated in approved drawings or as otherwise specified. During excavation, material suitable for backfilling shall be stockpiled in an orderly manner at a sufficient distance from the banks of the excavation to avoid overloading and to prevent sides from caving in.

Top soil shall be stockpiled separately, for subsequent reuse as necessary. All excavated material unsuitable or not required for backfilling shall be removed to a location approved by the employer.

Excavation in the streets shall be done in such a manner that street passage is not blocked by excavated material. Grading shall be done as may be necessary to prevent surface water from flowing into trenches or other excavations, and any water accumulated therein shall be removed by pumping or by other approved methods at contractor's own cost.

Due to the high water table on the island, the contractor shall take adequate precautions to prevent 'boiling' of the sub-soil due to hydrostatic pressure that would make the formation for pipelines or structures unsound.

Unsound material or soft spots naturally occurring in the bottom of any excavation shall be removed and disposed of and the resulting void shall be filled with a suitable material or concrete, as directed by the Employers representative. It is anticipated that the majority of excavation work shall be earth excavation. The terms "earth" as used herein shall include all materials which do not in the opinion of the employer require blasting, barring or wedging of material for removal from its original bed.

2.2 Site Clearing

Only the approved working area required for laying of pipelines and construction of pumping stations and water treatment facilities shall be cleared of shrubs, plants, bushes, large roots, rubbish and other surface materials. All such material required to be removed shall be disposed of in a manner satisfactory to the Employer. All

trees and shrubs that are designated by the Employer to remain on ground shall be adequately protected and preserved in an approved manner.

All existing structures identified if any, to be demolished and disposed of shall be as directed by the Employers representative.

The contractor shall take all necessary steps to protect existing buildings, structures, boundary fences and services that shall remain.

2.3 Excavation of Trenches for Pipes

Unless otherwise directed or permitted by the Employers representative, not more than 30 meters of any trench in advance of the end of the pipeline already laid shall be opened at any time. The width and depth of pipeline trenches shall be as indicated in the approved drawings or as directed by the Employers representative.

Depressions for joints shall be dug after the trench bottom has been graded. The pipe, except for joints shall rest on the prepared bottom for its full length. Large stones shall be removed to avoid point bearing. Whenever wet or otherwise unsuitable material that is incapable of properly supporting the pipe, as determined by the Employers representative, shall encounter in the bottom of the trench, such material shall be removed to the depth required and the trench shall be backfilled to proper grade with coarse sand, or other suitable approved material.

2.4 Excavation for Structures

This clause includes excavation for pumping stations and water treatment facility structures. The excavation shall be done as per the depths indicated on approved drawings, or when foundation level is reached; the Employers representative shall inspect the exposed ground and shall give directions as to what further excavation, if any, shall be necessary. The excavation shall be done in such a manner as to ensure that the work rests on a solid and perfectly clean foundation. Where excavation shall be covered subsequently by permanent construction the contractor shall, immediately after exposing the specific satisfactory foundation, shall proceed with the construction on that foundation. If the contractor allows any portion of such foundation to deteriorate due to exposure, he shall make the foundations correct at his expense and to the satisfaction of the Employers representative.

2.5 Shoring of Structures

As part of the work under excavation items, the contractor shall shore up all buildings, walls and other structures, the stability of which shall be liable to endangered by the execution of the work, and be fully responsible for all damages

to persons or property resulting from any accident to any such buildings, walls and other structures.

Should any such property, structures, installations or services be endangered or damaged as a result of contractor's operations, he shall immediately report any such danger or damage to the Employers representative and any authority concerned and shall forthwith undertake remedial measures to the satisfaction of the Employers representative or the appropriate authority.

2.6 Shoring of Excavations

If ordinary open cut excavation is not possible or advisable, sheeting and bracing shall be furnished and installed in excavations to prevent damage and delay to the work and to provide working conditions which are safe. The contractor shall furnish and place all sheeting, braces, timber and similar items, necessary for the safety of the work, the general public and adjacent property. Sheeting and bracing shall be removed as the work progresses and in such a manner as to prevent damage to finished work and adjacent structures and property. As soon as sheeting and bracing are withdrawn, all voids left by them shall be carefully filled with selected material and compacted. The contractor shall be fully responsible for the safety of work in progress, for the finished work, the workmen, public and adjacent property. All sheeting and bracing shall be at the contractor's expense, as part of the work under the excavation items.

2.7 Maintenance of Excavations

All excavations shall be properly maintained, while they are open and exposed, both during day and night. Sufficient and suitable barricades, warning lights, signs, caution tapes, and similar items shall be provided by the contractor. The contractor shall be responsible for any personal injury or property damage due to his negligence.

2.8 Dewatering of Excavations

As part of the work under the excavation items, and at no extra cost to the Employer, the contractor shall build all drains and carry out ditching, pumping, bailing and all other work necessary to keep the excavation clear of excess water during progress of the work and until the finished work shall be safe from injury. Necessary precautions against flooding and floatation of structures shall be taken. The contractor shall provide all necessary pumping equipment for the dewatering work, as well as operating personnel, power, etc. all at no extra cost to the Employer.

The contractor shall take extreme care to avoid excessive de-watering that would cause damage or draw down of the fresh groundwater used for household use.

All water pumped from the excavation ditches shall be directed through settlement tanks of adequate capacity to remove silt before being disposed of. The location of disposal place shall be satisfactory to Employers representative. Groundwater shall not be discharged to the sea unless its salinity (to be checked by EC readings) in the opinion of the Employers representative would be detrimental to the existing ground water.

2.9 Shoring and Sheet piling Left in Place

The Employer may order in writing any or all shoring and sheet piling to be left in place for purpose of preventing injury to the structures, nearby property or persons, whether such sheeting was shown on approved drawings or placed at direction, or otherwise. If left in place, such sheeting shall be cut off at the elevation as directed by the Employers representative. The sheeting remained in place shall be driven tight and shall be paid for at rates mutually agreed upon between the contractor and the Employer either in the bid schedule or by written variation order.

2.10 Protection of Existing Services

The contractor shall take special care with existing subsurface services likely to be encountered during the excavation/execution of work which shall require special precautions for their protection, such as sewers, drain pipes, water mains, electric cables, telephone cables and the foundations of adjacent structures etc. The contractor shall be responsible for the damage of any such facility and shall repair the same at his expense whether or not such facility has been shown on the drawings. If appropriate authority chooses to carryout repairs to damaged services itself or by using its own nominated sub-contractors, the contractor shall reimburse all the costs incurred for such works and if he fails to do so, then such costs may be deducted from any payment due or which shall become due from the employer to the contractor.

2.11 Backfilling Material

Backfill material for structures and trenches shall consist of excavated soil which is free from stones and clay lumps larger than 75 mm in any dimension and shall also be free from timber, rubbish and other debris. It shall exclude clay of liquid limit greater than 80 and/or plastic limit greater than 55 or materials of excessively high moisture content. Backfill material shall have enough moisture for proper compaction, and shall be compacted in an approved manner to the satisfaction of the Employers representative.

2.12 Back Filling for Trenches

Back filling operations shall be performed as part of the contractor's work under the payment items for earth excavation. Trenches for water lines and excavation pits for water treatment structures etc. shall be back filled to the ground surface with selected excavated material or other material that is suitable for proper compaction, as decided by the Employers representative. Trenches improperly back filled shall be reopened to the depth required for proper compaction, then refilled and compacted to the specified density.

Normal backfilling operations in trenches shall be carried out as follows:

- a. In the lower portion of the trench the backfill material, up to a level of at least 300 mm over the top of the pipe line, shall be deposited in layers not more than 200 mm thick and compacted with approved type tampers to the density specified. The backfill material in this portion of trench shall consist of selected materials of approved quality, free from stones and hard pieces larger than 40 mm in any dimension, and also free from timber, rubbish and other debris as directed by Employers representative.
- b. The remainder of the trench shall be backfilled with excavated material free from a stones and hard pieces larger than 75 mm in any dimension and also free from timber, rubbish and other debris, deposited in layers not more than 300 mm thick and compacted with approved tampers to the density specified.

Required compaction for normal trench backfilling, as specified above, shall be 85 per cent of maximum density.

After the completion of backfilling and satisfactory compaction, the contractor shall carry out the finished grading of the site to such grades and elevations as may be shown on the approved drawings or as directed by Employers representative.

2.13 Disposal of Surplus Excavated Material

All surplus material excavated by the contractor shall be disposed of at locations approved by the Employer at no extra cost to the Employer. When it is necessary to haul earth material over streets or pavements, the contractor shall prevent such material from falling on the streets or pavements.

For contaminated demolition waste from the removal of old septic tanks if any, the waste shall be sterilized with lime powder, or other approved method, and then disposed of at locations approved by the Employer. The cost of waste sterilization and disposal shall be included in the contractor's rates.

2.14 Top Soil

Top soil which has been stockpiled during excavation shall be used for the top 150 mm of backfill, in locations as ordered by the Employers representative. Top layer shall be saturated with fresh groundwater and after it has dried, and shall be spread to the required final grade.

2.15 Earth Borrow (Backfill Material Brought from Outside)

Where satisfactory materials for backfill of depressions/trenches to the required level are not available in sufficient quantities from the on-site excavations, such satisfactory materials shall be obtained from sources approved by the Employer. The contractor at his own cost shall arrange with the owners of the land from which earth for back filling shall be taken for permission to have the required quantity of earth and shall bear all incidental charges what so ever.

CHAPTER 3 HDPE PIPES (FITTINGS, SPECIALS, LAYING & JOINING)

3.0 Scope of Work

The work covered in this chapter consists of furnishing all labors, equipment, appliances and tools for performing all operations required for the installing and testing the gravity and pressure water pipes and inspection devices in strict accordance with the specifications and the applicable drawings and subject to the terms and conditions of the contract.

3.1 Handling and Transportation of Pipes at Work Place

Water pipes shall be handled with care at all times, while transporting to the place of work, and while installing. The pipes should not be kept exposed to direct sunlight for lengthy periods during transportation and installation process. They shall be stored in a cool place free from sunlight until needed. Each pipe shall be carefully inspected according to standard specification requirements upon delivery and before being laid. No cracked, broken or defective pipe shall be used in the work. Chipping of the tongue and groove or bell and spigot pipe ends, which in the Employers representatives opinion may cause defective joints, shall be sufficient cause for the rejection of any pipe.

3.2 Excavation and Backfill

The excavation and backfill shall be as specified in Chapter 2 above (Excavation and Earthwork) of these technical specifications.

3.3 Trench Bedding and Pipe Protection

As soon as the trench conditions are approved by the Employers representative, the contractor should start placing the applicable bedding material as per schedule given on the approved drawings or as directed by Employers representative. The schedule shall be for guidance only and the Employers representative has the right to change the type of bedding if the site conditions demand. The three types of bedding may be used in this project are:

- | | | |
|------|---------------------|---------|
| i. | Granular Bedding | Class A |
| ii. | Concrete Hunching | Class B |
| iii. | Concrete Encasement | Class C |

Granular Bedding: This is designated as Class A bedding. It shall be composed of free flowing clean coarse aggregate with a maximum size of 10 mm. If through the contractor's negligence any trench bottom is excavated below the grade, it shall be refilled to the required level with bedding material and thoroughly compacted into place, at the contractor's expense.

Concrete Hunching: This is designated as Class B bedding. The trench shall be filled and compacted up to half of the pipe's diameter with granular material as specified for Class A bedding and the upper part will be encased in concrete. Concrete shall be un-reinforced of the Class or as directed by the Employers representative.

Concrete Encasement: This is designated as Class C bedding. The concrete shall be of the Class as directed by the Employers representative. Each pipe to be encased shall be supported on at least two points with pre-cast concrete wedge blocks. The wedge blocks should be located at a distance L/4 from the joint. To avoid movement of the pipe during concreting the concrete shall be carefully placed and tamped beneath the pipe, followed by pouring of concrete on both side of the pipe.

3.4 HDPE Pipes

HDPE pipes and fittings shall meet the requirements of BS 3284 and 5114 respectively.

3.4.1 Raw material

Raw material used to manufacture the HDPE pipes shall be virgin compounded or natural black PE 100 resin confirming to ISO 9080:1992 standards. The resin proposed to be used for manufacturing of the pipes for drinking water shall also comply with the following norms as per ISO 9080 standards.

- The resin should have been certified by an independent laboratory of international repute for having passed 10,000 hour long term hydrostatic strength (LTHS) test extrapolated to 50 years to show that the resin has a minimum MRS of over 10 MPa. Internal certificate of any resin manufacturer shall not be acceptable.
- Certificate for having passed the full scale rapid crack propagation test as per ISO 13478 or equivalent international standards.

3.4.2 Quality assurance certificate

Quality assurance certificate, for the raw material to be used for the project, shall be from certifying agencies or from any other internationally reputed organization or from any locally available agency approved by the employer that shall be submitted along with the bid.

3.4.3 Pressure Rating

The pressure rating of HDPE pipes and specials used for distribution shall be of PN 6 conforming to BS 3284 and 5114.

3.4.4 Color of pipes

The colour of the HDPE pipe shall be confirming to BS 3284 and 5114.

3.4.5 Reworked material

As per the provision of BS 3284 and 5114, addition of not more than 10% of the manufacturer's own reworked material resulting from the manufacture of pipes shall be permissible. No other reworked or recycled material shall be used. The material to be used shall be clean and should be derived from the same resin as used for the relevant production.

3.4.6 Dimensions

The pipe dimensions shall be as per latest revisions and amendment of BS 3284 and 5114. The pipes up to diameters 110 mm shall be supplied in coils of 50 m length. The coils shall be as per the provisions of clause 6.5 of IS 4984 or equivalent international standards. Pipes beyond diameters 110 mm shall be supplied in straight lengths of minimum 6 m.

The internal diameter, wall thickness, length and other dimensions of pipes shall be as per relevant tables of BS 3284 and 5114 for different class of pipes. Each pipe shall be of uniform thickness throughout its length.

The wall thickness of the PE 100, PN 6 pipes shall be as per the table given below:

Nominal Dm. of HDPE Pipe (mm)	Wall Thickness (mm)	
	Minimum	Maximum
63	2.9	3.4
75	3.5	4.1
90	4.1	4.8
110	5.0	5.7
160	7.3	8.3
180	8.2	9.3
200	9.1	10.3
225	10.3	11.6
280	12.8	14.3
315	14.4	16.1
355	16.2	18.1
400	18.2	21.2
450	20.5	23.8
500	22.8	26.5
560	25.5	29.6

3.4.7 Performance requirements

The pipe supplied should have passed the acceptance tests as per BS 3284 and 5114. The manufacturer shall provide the test certificates for the tests conducted along with the supply of pipes. These tests can be performed in the in-house laboratory of the pipe manufacturer or at an approved laboratory as directed by Employers representative.

3.4.8 Marking

As per the provisions of BS 3284 and 5114, each straight length of the pipe shall be clearly marked in inedible ink/paint on either end and for coils at every 5 m with the following information:

- The manufacturer's name and/ trade mark.
- Designation of the pipe as per standards (PE 100 & PN 6).
- Lot number/Batch number.
- Project Name.

3.5 Pipe Manufacturer's License

The pipe manufacturer who will supply the pipes for the project shall have a valid license for the kind of pipes that are required for this project. The bidders shall include this valid license along with their bid. Bid without these licenses may be treated as non-responsive.

3.6 Third Party Inspection

The HDPE pipes shall be accepted successfully after the third party inspection by any authorized agency as per Employers representative. The inspection charges for the same shall be borne by the contractor.

3.7 Fittings/Specials

All HDPE fittings/specials shall be fabricated in accordance with BS 3284 and 5114. PE injection moulded fittings shall also be as per BS 3284 and 5114. All fittings/specials shall be fabricated or injection moulded at factory only. No fabrication or moulding shall be allowed at work place, unless specifically permitted by the Engineer. All fittings shall be butt welded on to the pipes or other fittings by use of heat fusion.

Bends: HDPE bends shall be plain-square ended conforming to BS 3284 and 5114. Bends may be fabricated by jointing several small sections of pipes to reach the required angle.

Tees: HDPE tees shall be plain-square ended conforming to BS 3284 and 5114. The tees shall be equal tees or reduced take off tees and shall be moulded or fabricated from pipes elements.

Reducers: HDPE reducers shall be plain-square ended conforming to BS 3284 and 5114. Reducer must be moulded.

Flanged HDPE Pipe/Stub Ends: HDPE Stub ends shall be square-ended conforming to IS: 8008 Part I & VII or equivalent international standards. The stub ends shall be welded on the pipe. The flange shall be of slip-on flange type as described below.

Slip-On Flanges: Slip-on flanges shall be metallic flanges covered by epoxy coating or plastic powder coating. Slip-on-flanges shall be conforming to standard mating relevant flange of valves, pipes etc. The nominal pressure rating of flanges shall be PN 6 and thickness as per relevant BS 3284 and 5114.

3.8 Cleaning of Pipelines

Interior cleaning: As required by the specification, the interior of all pipe and fittings shall be thoroughly cleaned of any foreign matter before being installed. Precautions shall be taken to prevent foreign material from entering the pipe during installation. Debris, tools, clothing, or other material shall not be placed in or allowed to enter the pipe. Whenever pipe laying is stopped, the open end of the pipe shall be sealed with a watertight plug which shall prevent trench water and soil from entering the pipe. The contractor shall use suitable sterilization agent to clean the pipe before and after installation and such cost shall be bared by contractor.

Specifications: Immediately before pipelines and other works are taken over by the employer the contractor shall, at his own expense, flush all rising mains and other pipe work to ensure that there are no obstructions. The contractor shall repair out any defects located to the satisfaction of the employer. The contractor shall also, in presence of the Employers representative, pass a loose plug through the whole of the pipelines in order to ensure that they are entirely clear of obstruction and that the invert is smooth. The loose plug shall be in the form of a cylinder, made of timber not less than 25 mm thick or any other material approved by the Employers representative, and the outside diameter shall be 25 mm less than the pipe diameter or one tenth of pipe diameter whichever is the lesser and its length shall not be less than its diameter. The whole cost of providing the plugs and pipe cleaning work shall be borne by the contractor.

Cleaning of pipe lines: All pipelines conveying water which shall be installed including all valves and fittings therein shall be flushed or cleaned to the satisfaction of the Employer. Flushing shall precede disinfection with potable water for piping and valves. The cross-connection condition shall be allowed at any time.

Small pipelines shall be flushed with water at the maximum velocity which can be practically developed. The flushing velocity shall be at least one meter per second, unless otherwise permitted by the Employer. Booster pumps shall be used if required to obtain the necessary volume or velocity of water.

3.9 Welding

Joining between HDPE pipes and specials shall be done as per the latest BS 3284 and 5114. Method of joining from pipes to pipes and pipes to specials shall be with EF coupler up to 110 mm dia. and by using automatic or semi-automatic, hydraulically operated superior quality butt fusion machines which shall ensure good quality butt fusion welding of HDPE pipes. If approved by the Employer, the jointing with PP compression fittings may be carried out for smaller diameters of PE pipes (up to 110 mm).

3.10 Laying and Joining of HDPE pipes

Joining of HDPE pipes shall be made using auto/semi-automatic butt/EF welding machine only. Use of manual welding machines shall not be permitted except in exceptional cases that too with the approval of Employers representative. Joining shall be by Electro-fusion welding up to pipe size 110 mm & by Butt-fusion above 110 mm pipe size. Joining of HDPE pipes shall be done by qualified/certified welders only.

3.11 Specifications for Electro-fusion Fittings for HDPE Pipes

- All the electro-fusion fittings included in this document should be designed for use in water distribution systems and be manufactured/supplied by manufacturers having ISO 9001:2000 certification for their quality systems. The products should comply with the following specific requirements.

The products shall comply with the requirements of BS EN 12201-3: 2003, BS EN 1555-3 or ISO 8085-3. All the fittings shall be of SDR 11 rating.

- The product group used for drinking water applications should have undergone test by WRC-NSF, U.K according to BS 6920 in any of their certified laboratories and certificate of compliance shall be produced for the following parameters:
 - Odor & Flavor of Water.
 - Appearance of Water.
 - Growth of Micro Organism.
 - Extraction of substances that may be of concern to public health (Cyto Toxicity).

○ Extraction of Metals.

- All the products shall be manufactured by injection molding using virgin compounded PE 80 (MDPE) polymer having a melt flow rate between 0.5-1.1 grams/10 minutes and shall be compatible for fusing on either PE 80 or PE 100 distribution mains manufactured according to the relevant national or international standards. The polymer used should comply with the requirements of BS 3412 and/or BS EN 12201-1.
- The fittings intended for water distribution applications shall be of color blue for the clear identification of the services.
- All the electro-fusion products should be individually packed so that they can be used instantaneously at work place without additional cleaning process. The protective packing should be transparent to allow easy identification of the fittings without opening the bags.
- The electro-fusion products should be with only a single heating coil to fully electro-fuse the fitting to the adjoining pipe or pipe component as applicable. The heating coils shall be terminated at terminal pins of 4.0 or 4.7 millimeter diameter, protected with terminal shrouds. Each terminal shroud shall be additionally protected with polyethylene shroud caps.
- No heating element shall be exposed and all coils shall be integral part of the body fittings. The insertion of the heating element in the fitting should be part of the injection molding process and coils inserted after the injection molding process or attached to the body fitting as a separate embedded pad etc. shall be strictly not accepted.
- The pipe fixation shall be achieved by external clamping devices and integral fixation devices shall not be acceptable.
- The brand name, size, raw material grade, SDR rating and batch identification shall be embedded as part of the injection molding process. Each fitting should also be supplied with a barcode sticker for fusion parameters attached to the body for setting the fusion parameters on an automatic fusion control box. The barcode sticker shall also include the fusion and cooling time applicable for the fitting for the manual setting of a manual fusion control box.
- The fittings shall be V-regulated type designed to fuse at a fusion voltage of 40 volts AC.

- The heating elements shall be designed for fusion at any ambient temperature between -5 to 40°C at a constant fusion time i.e. without any compensation of fusion time for different ambient temperatures.
- A limited path style fusion indicator acting for each fusion zone as visual recognition of completed fusion cycle shall be incorporated into the body of each fitting near the terminals. The fusion indicators shall not allow the escape of the molten polymer through them during or after the fusion process.
- All the sockets in the electro-fusion fittings shall include a method of tapping and controlling the pipe penetration (pipe positioner/stopper).

All specials/fittings such as valves, flange adopters, cast iron (CI)/mild steel (MS) specials, galvanized iron (GI) pipes and GI specials, brass tap etc., shall be supplied by the contractor. The contractor shall install these specials/fittings as per the standards specifications and as per the instructions of Employers representative.

Layer of concrete of required grade shall be provided over the particular section the pipe line where contractor is not able to achieve the specified depth of excavation due to natural hard strata as instructed Employers representative.

The contractor shall submit detailed as built drawing of work done in latest Auto Cad version, showing the details of pipe line, specials/fittings, valves and joints in hard copies and soft copy as directed by the employer.

3.12 Pipes and Joints Adjacent to Structures

A flexible joint shall be provided as close as is feasible to the outside face of any structure into which the pipe is built, compatible with the satisfactory completion and subsequent movement of the joint.

The first pipe which is clearly in the external face of concrete wall or structure shall be of a short length of either spigot and socket or double spigot to suit the flow direction and pipe material. The effective length of this pipe shall be 2 times the nominal bore or 600 millimeters whichever is greater.

Any over-excavation adjacent to a structure and beneath the formation level of a pipe trench or excavation to make a connection to a plugged or capped pipe laid by the contractor shall be backfilled to the formation level of the pipe trench with compacted granular backfill material. This compacted material shall extend to the limit of over-excavation along the line of the pipe trench and across the full width of the pipe trench or to the limit of the excavation whichever is the lesser.

3.13 Connecting to Existing Pipes

Where a connection of any kind shall have be made into an existing pipe, such as connecting to household water pipes, the contractor shall investigate and verify all such connections at the start of the work, if necessary by excavating trial pits, to ensure that the materials to be provided under the contract shall be suitable for making the connections. The contractor shall note that the period of interruptions of the existing service pipeline shall be kept to the minimum and shall arrange in coordination with the Island office to make such connections at periods agreed with the property occupier/owner and/or the Employers representative.

3.14 Field Hydraulic Test

- The sectional hydraulic test shall be carried out after the pipeline section to be tested has been laid, joined, and backfilled to a depth sufficient to prevent floatation, but leaving the joints exposed which are to be tested. The sections to be tested shall have prior approval from the Employer and shall not be longer than 2000 m. When either the pipeline shall be laid adjacent to or underneath the carriageway or when section includes an air valve chamber, the joints between each tested section shall be left exposed until the pipeline has passed the test on completion.
- Each length of the pipeline to be tested shall be capped or blanked off at each end and securely strutted or restrained to withstand the forces which will be exerted when the test pressure is applied. Air valves already fitted shall be permitted to function during the test.
- Proposals for testing where thrusts on structures are involved, or where thrust flanges on the piping are installed, shall be made with prior approval of the employer.
- The method of filling the pipeline with water shall be approved by the Employer. The length under test shall be filled making certain that all air is displaced through an air valve or any other appropriate mechanism as approved by the employer. The test length shall then remain under constant moderate pressure, 10 to 20 m head of water, for a period of several hours until the pressure can be maintained without additional pumping. The cost of water shall be borne by the contractor.
- The pressure shall then be slowly increased at a maximum rate of 1 bar per minute to the full test pressure and pumping discontinued for 3 hours or until the pressure has dropped by 10 m, whichever occurs earlier. Thereafter, pumping shall be resumed and continued until

the test pressure has been restored. The quantity of water pumped to restore the pressure, called make up water, shall be the measure of thermal expansion or leakage from discontinuation of pumping until its resumption. The make-up water shall be as given in below table:

OD of pipeline (mm)	Litres per 1000 m of the pipe length tested		
	One hour test	Two hour test	Three hour test
63	9	14	24
110	16	31	50
160	37	74	112
200	50	87	124
315	136	285	422
400	174	347	521

- The maximum allowable test pressure shall be 1.5 times the system design pressure or pipe rating whichever is higher.
- Notwithstanding the satisfactory completion of the hydraulic test, if there shall be any discernible leakage of water from any pipe or joint, the contractor shall, at his own cost, replace the pipe, repair the pipe or re-make the joint and repeat the hydraulic test. Water used for hydrostatic test shall be clean and potable.
- Pipe lines shall be tested as above except where the employer issues such instructions which are necessary for testing parts of the works that have been designed for stresses limited by considerations other than those applying to the pipe line systems.
- Test pressures shall be measured in kg/cm² at the center of the blank flange situated at the lowest end of the pipe line under test.

3.15 Testing of Non-Pressure Pipelines

For non-pressure pipelines, the pipelines shall be tested in the shade with air or water as instructed by the Employers representative when they have been bedded and jointed and before any concrete surround or backfill shall be placed. A further test shall be carried out when any concrete surround has been completed and when backfill has been placed and compacted to a depth of 300 millimeters above the crown of the pipeline.

Air Test: Pipelines to be air tested shall have air pumped into the length under test until a pressure equivalent to 100 millimeters of water as indicated on a graduated glass U tube gauge is reached. After a period of five minutes without any further

pumping, this pressure shall not fall below 75 millimeters of water gauge. The method of pumping air shall be approved by the Employers representative and shall be such as to avoid significant changes in the temperature or humidity of air pumped into the pipeline.

Water Test: Pipelines to be water tested shall be filled with water under a pressure head of not less than 1.2 meters above the crown of the pipe at the high end. Unless otherwise agreed by the Employers representative the test shall commence one hour after filling the test section at which time the level of the water at the vertical feed pipe shall be made up to produce the required 1.2 meter minimum test head. The loss of water over a 30 minute period shall be measured by adding water at regular intervals to maintain the original water level and recording the amounts of water added. Each section of the pipeline passing the test shall be the volume of water added which does not exceed 0.12 liters per hour per 100 meters of pipeline per millimeter of nominal internal diameter of the pipe. The water used for the above test shall be obtained from an approved source.

3.16 Commissioning

After satisfactory installation and testing of entire pipeline including fittings, shall be disinfected as per relevant IS/ISO standard before commissioning of pipeline and fittings for operation and shall be certified by the employer.

3.17 Failure to Pass the Test

All pipes or joints which shall prove to be defective shall be replaced or remade and re-tested as often as may be necessary until a satisfactory test shall have been obtained. Any test which fails or shall prove to be unsatisfactory as per the employer in any way shall be redone by the contractor.

3.18 Flushing and Disinfecting of Pipelines

After testing and commissioning the contractor shall flush the pipes with disinfection water as per the Employers representative.

3.19 Store

The contractor shall establish his own store at work place for stacking materials/machines as per the relevant BS/ISO standards.

CHAPTER 4 WATER SUPPLY SYSTEM MATERIALS

4.0 Scope of work

This section covers the technical specification for the supply of pipe and materials suitable for water works.

4.1 Contractor Submittals

4.2.1 Standards

Except where otherwise specified all materials and workmanship shall comply with the standards of the British standards/American standards or International Organization for Standardization (ISO). Materials may be supplied to a different international code or specification only if it can be shown that the product offered is of equal or higher standard than the approved specified standard.

The supplier may be requested to present copies of standards to the contractor or his representative, and the Employers representative together with their English translations. He shall provide these as requested for prior assessment and for use during inspection and testing.

4.2.2 Test Certificates

Certificates in triplicate shall be provided by the supplier for each diameter of pipe and fittings supplied giving the process of manufacture and the results of the specified tests.

Similar certificates in triplicate shall be provided by the supplier in respect of materials to be used in the manufacture of the pipes and fittings giving the process of manufacture, chemical analysis (where relevant) and the results of specified tests. The materials shall be suitably marked to enable them to be identified from references on the certificates.

4.2.3 Independent and Local Tests

The Employers representative reserves the right to carry out any independent or local tests he may deem fit on the completed pipes and fittings or on any material provided at any stage during the contract including the guarantee period. Any materials, workmanship or completed pipes and fittings which are shown by such independent tests not to be in accordance with the specifications shall be rejected notwithstanding any previous certificates, which may have been provided.

4.2.4 Quality Assurance Certificates

The preference shall be given to the suppliers who could provide a quality assurance certificate established according to the quality assurance system of the international standard series ISO 9001/2000 or equivalent.

The certificate shall be valid for a period covering the manufacture of pipes and fittings. If the suppliers are not the manufacturer, the suppliers shall provide the quality assurance certificates of the original manufacturer.

The following shall be submitted by the contractor at time of bidding:

- Manufacturer's installation instructions.
- Manufacturer's certification of compliance with these specifications.
- Manufacturer's product data.

The contractor shall inform the Employer's representative of his proposed supplier and or manufacturer of the pipes and fittings. The Employer's representative may require a sample from the batch of pipes proposed to be supplied for the works to be forwarded for testing purposes to a testing station nominated by the Employer's representative.

4.2 Pipe Manufacturer Markings

Each pipe, fitting and special appurtenance shall be marked with permanent identification which should include but not necessarily limited to the following:

- Serial number
- Class of pipe, pressure rating in compliance with referenced standards
- Nominal diameter
- Name or trade mark of manufacturer
- Date of manufacture
- Type of service
- Full details on fittings such as angles of change and reduction.

4.3 Product Delivery, Storage and Handling

Transportation of any material by the contractor shall be by suitable vehicles which when loaded does not cause spillage and all loads shall be suitably secured. All vehicles must comply with this requirement or any local traffic regulations and laws.

The contractor shall arrange for any temporary watch and ward of the materials prior to handing over to the Employer, or his representative, all at his own expense. All materials and equipment when delivered shall be stacked and stored in a manner suitable to protect them against slippage, damage, breakage, pilferage etc.

The following shall be observed:

Delivery of Materials: Piping materials shall be delivered in original, unbroken packages, containers, or bundles bearing the name of the manufacturer.

Storage: Piping materials shall be carefully stored in a manner that will prevent damage and in an area that is protected from sunlight and other harmful elements.

4.4 MDPE Pipes

These specifications are for MDPE PE 80 Pipes for House Service Connections.

1. Raw Material

Raw material used to manufacture MDPE pipes shall be of Virgin Natural Resin PE 80 containing anti – oxidants, UV Stabilizers & Pigments necessary for manufacturing of pipes. The density of pipes shall be in the range 0.926 to 0.940 g/cm³ confirming to ISO 4427 Standard. The PE 80 resin shall have MRS of 8 Mpa.

2. Effects on Water Quality :

The MDPE PE 80 Pipes shall confirm to clause 3.5 of ISO 4427 for conveyance of Water for drinking consumption. The pipes intended for conveyance of potable water for consumption shall be tested to comply with BS 6920 specifications in any of the approved laboratories as directed by Employers representative and certificate of compliance shall be obtained by the contractor for the following parameters but not limited to:

- Odor & Flavor of Water
- Appearance of Water
- Growth of Micro Organisms
- Extraction of substances that may be of concern to Public Health (Cyto Toxicity)
- Extraction of Metals

3. Pressure Rating:

The Pressure rating of MDPE PE 80 pipes shall confirm to Clause 4.1 of ISO 4427.

4. Color of Pipes:

The color of MDPE PE 80 pipes shall be BLUE confirming to Clause 3.2 of ISO 4427.

5. Dimensions:

The pipe dimensions shall be as per latest revisions of ISO 4427. Pipes up to diameters 32 mm shall be supplied in coils of 300 m. The internal diameter, wall thickness, length and other dimensions of pipes shall be as per relevant tables of ISO 4427. Each pipe shall be of uniform thickness throughout its length. The wall thickness of the PE 80 pipes shall be as per the table given below:

Nominal outside dia. in mm (DN)	Nominal Wall thickness in mm for PN-10	Nominal wall thickness in mm for PN-12.5	Nominal wall thickness in mm for PN-16
16	-	-	2.3
20	-	-	2.3
25	-	2.3	2.8
32	-	3.0	3.6
40	-	3.70	4.5
50	-	4.6	5.6
63	4.7	5.8	7.1
75	5.6	6.8	8.4
90	6.7	8.2	10.1
110	8.1	10.00	12.30

6. Performance requirements

The Pipe supplied should have passed the acceptance test as per ISO 4427. The manufacturer should provide the test certificates for the following tests:

- Melt Flow Rate as per ISO – 440 / 1
- Density as per ISO 1183, ISO 1872 / 1
- Hydrostatic Test as per ISO – 1167
- Pigment dispersion test as per relevant international standards
- Longitudinal Reversion test as per relevant international standards
- Oxidation and Induction test as per relevant international standards

7. Specials and Fittings

MDPE compression fittings made of PP, AABS, are available for use with MDPE pipes. The joining materials for fittings shall consists of thermoplastic reins of polyethylene type, NBR 'O' ring of nitrite and clamp of polypropylene, copolymer body, zinc plated steel reinforcing rings, nuts and balls of special NBR gaskets.

8. Laying of pipes

The pipes shall be laid in accordance with ISO 4427. Since the pipes are supplied in coils, there will be no joints under the roads and bends resulting in fast, simple and efficient jointing. The work of excavation and refilling shall be done according to the line and gradient.

The pipes shall be laid on cushion of sand minimum 7.5 cm deep and filled up to 15 cm above the pipes. The remaining portion of the trench shall then be backfilled by selective material as directed by the Employers representative.

9. Testing

The pipes and fittings after they are laid and jointed shall be tested to hydraulic test pressure as per relevant code. The pipes shall be slowly and carefully charged with water allowing all air to escape and avoiding all shocks of water hammer, which may develop otherwise. The draw off taps and stop cocks shall then be closed and specified hydraulic pressure shall be applied gradually. A calibrated and accurate pressure gauge shall be used for testing the pressure. The test pump having been stopped, the test pressure should be maintained for at least half an hour. The pipes and fittings shall be tested in section. As the work of laying proceeds, pipes and fittings which are found defective shall be replaced without any extra cost.

The water for testing shall be provided by contractor. The quality of water should be approved by Employers representative.

CHAPTER 5 CONCRETE WORKS

5.0 General

5.1 Work Included

This section specifies requirements for construction cast-in-place concrete for structure bases, outfall ballast blocks and thrust blocks. The work includes supply and installation of formwork, reinforcement, concrete and accessories.

5.2 Certificates

Minimum 4 weeks prior to starting concrete works, the contractor shall submit to Employers representative manufacturer's test data and certificates by qualified independent inspection and testing laboratory that following materials shall be met with specified requirements:

- Portland cement, sulphate resistant cement (SRC)
- Supplementary cementing materials
- Admixtures
- Aggregates
- Water

Test certificates shall be provided by contractor indicating that the mix proportions selected for above materials shall produce concrete of high quality, yield and strength as specified in concrete mixes, and shall comply with BSEN 206-1.

5.3 Product Materials

5.3.1 Formwork

- The forms shall be of plywood or wood formwork material to international recognized standards or as approved by the Employers representative.
- Form release agent acceptable and approved by the Employers representative shall be of water based.
- The contractor shall submit shop drawings of forms.
- Lines, levels and centers shall be verified before proceeding with formwork and ensure dimensions shall be as per approved drawings.
- Fabricate and erect formwork to produce finished concrete conforming to shape, dimensions, locations and levels indicated within tolerances as required by international standards.

- Align form joints to have them watertight. Form joints shall be kept to minimum.
- Anchors, sleeves, and other inserts required to accommodate work specified in other sections shall be built in.
- Formwork shall be kept in place until concrete has attained sufficient strength to sustain all loadings.
- Re-shoring of members where early removal of forms may be required shall be provided or where members may be subjected to additional loads during construction as required.
- Formwork shall be re-used subject to requirements of international standards and as directed by Employers representative.
- Forms shall be coated with approved form based lubricating oil/ release agent/shuttering oil or as directed by Employers representative.

5.3.2 Reinforcement

- Reinforcement shall be high yield deformed bars or mild steel complying with B.S. 4449 or welded wire fabric complying with B.S. 4483, except that the characteristic strength for mild steel reinforcement shall be 250 N/mm^2 and for high yield steel shall be 415 N/mm^2 .
- Chairs, bolsters, bar supports; spacers shall confirm to ASTM A615 or equivalent standards.
- Epoxy coating of non pre-stressed reinforcement shall confirm to ASTM A775/A775M or equivalent standards.
- Reinforcing bars shall be stored clearly off the ground and shall be truly straight. Suitable cover shall be provided to protect against windblown sulphates, chlorides and other deleterious matter.
- Manufacturer's test certificates for all classes of reinforcement shall be supplied by the contractor when required. Specimens sufficient for three tensile tests and three cold-bending tests per ten tones of bars or fraction thereof and for each different size of bars shall be sampled. Testing shall be done in accordance with BS 4449 and batches shall be rejected if the average results for each batch are not in accordance with BS 4449.

- All steel shall be totally free from dirt, paint, loose rust or scale and shall be thoroughly brushed and cleaned after positioning and immediately prior to concreting.
- The bars shall accurately bend to the shapes indicated, and the bending must, wherever possible, be completed before the steel is fixed in position. Straight portions of bars shall be true and bends must be kept out of winding. The internal radius of bends shall not be less than four times the diameter of the bar, except for stirrups and column binders. Great care shall be taken to bend stirrups and column binders to fit closely around the main bars. In the absence of reinforcement bending schedules the bending requirements of B.S. 4466 "Bending Dimensions of Bars for Concrete Reinforcement" or other similar approved standard shall govern.
- Except where agreed by the Employer all bars are to be bend cold. Lengthening of bars by welding and re-bending of incorrectly bend bars shall not be permitted. Unless otherwise stated splices in reinforcing bars shall be formed by lapping. Such laps in bars in any member shall be staggered. Except as otherwise indicated on the drawings, the minimum overlap of lapped splices shall be 40 bar diameters or 300 mm, whichever shall be greater.
- The steel shall be fixed in position exactly as indicated and the bars shall be securely wired together with 1.6 or 1.4 mm soft iron wire or approved spring steel clips wherever necessary to prevent any displacement during concreting. Spacers, chairs and the like, temporary or permanent, shall be used as required to ensure that the steel has the exact amount of cover indicated. No permanent spacers shall show on the surface where a fair faced concrete finish or brushed aggregate finish shall require.

5.3.3 Placing of Reinforcement

- Reinforcement bars shall be thoroughly cleaned of rust buildup, mill scale or other coating that prevents or reduces bond with concrete.
- Reinforcing steel shall be placed as indicated on approved drawings.
- Epoxy coated portions of bars shall be protected with sufficient covering material during transportation and handling.
- Touch-up shall be applied on damaged and cut ends of epoxy coated or galvanized reinforcing steel with compatible finish to provide continuous coating.

- Prior to placing concrete, Employers representative's approval shall be obtained for checking reinforcing material and its placement.

5.3.4 Water

Water for concrete shall be clean potable water, acceptable for construction works. The contractor shall test water sample in the laboratory as directed by Employers representative to know its suitability for construction works.

5.3.5 Aggregates (Coarse and Fine)

Aggregates (coarse and fine) shall confirm to BS EN 12620 or equivalent standards. The contractor shall test aggregate sample in the laboratory as directed by Employers representative to know its suitability for construction works.

5.3.6 Chemical admixtures

Admixture shall confirm to ASTM C 494 or equivalent standards. The contractor shall test admixture sample in the laboratory as directed by Employers representative to know its suitability for construction works.

5.4 Cement

The type of cement used in various works shall be of recognized brand/make which shall be selected by the contractor or as directed by Employers representative. The cement shall be used in works only after its testing results are to the satisfactory of Employers representative. If the test results of cement are not satisfactory as per Employers representative, the brand/make shall be changed and again re-testing of cement shall be done. All the testing expenses shall be borne by the contractor.

Ordinary Portland cement shall comply with BS 12. Sulphate resisting cement shall comply with BS 4027. The cement shall either be delivered in sealed bags marked with the manufacturer's name, date/year/week of production/package, Quantity in bag, type of cement or in bulk consignments in a manner approved by the Employers representative. High alumina cement shall not be used in any circumstance.

5.4.1 Tests of Cement

The cement shall be tested as per BS 4550 or equivalent international standards. Before any cement is ordered in quantity or delivered to work place, the contractor shall submit to the Employers representative for his approval a detailed list of the sources, country or countries of origin and manufacturer's brand names of the types of cement which he proposes to use.

The contractor shall submit to the Employers representative, test certificates relating to each consignment of cement. Each certificate shall show that a sample of the consignment has been tested by the manufacture or by an approved laboratory and that it complies in all respects with the requirements of the specification.

When required by the Employers representative, the contractor shall supply samples of cement taken on delivery to work place, or during storage on the work place for testing at a nominated laboratory at the contractor's expense.

No cement from any consignment shall be used without the approval of the Employers representative and the contractor shall maintain a record of the locations of the concrete made from each consignment which record shall be available for inspection by the Employers representative.

If for any reason the contractor shall decide to vary the source of supply, country or manufacture in respect of any type of cement already approved by the Employers representative at any time during the contract, he shall give adequate notice of every such variation to the Employers representative and shall carry out all the tests called for by the Employers representative's written approval of such variation before ordering any material from the new source or supplier.

If the cement has been stored at work place for more than 40 days or in the opinion of the Employers representative is of doubtful quality, new tests may be required, at the contractor's expense to check whether the cement still conforms the requirements.

5.4.2 Delivery and Storage of Cement

All cement shall be delivered to the work place in properly and permanently marked, sound and sealed paper bags or other approved containers, unless written approval from the Employers representative shall be obtained for handling of cement in bulk.

Cement shall be delivered in quantities sufficient to ensure the proper progress of the works and the quantities held in stock on site shall be to the approval of the Employers representative. Such approval shall not in any way relieve the contractor of his responsibilities for providing cement. Cement from abroad shall be packed in sealed plastic bags and placed inside paper bags.

Cement when being conveyed to the island on landing craft or a ship, and to the work place in lorries or other vehicles, shall be adequately protected from the weather and from contamination by dust, sand or any organic materials. Any cement which shall prove to have been exposed to damage by water shall be rejected upon delivery.

All cement shall be stored in a weatherproof, waterproof and reasonably airtight condition provided solely to that purpose. The base of cement storage facility shall be raised at least 300 mm above the ground level to prevent the absorption of moisture.

5.4.3 Rejection of Cement

Notwithstanding the receipt of a test certificate the Employers representative may reject any cement as a result of further tests. The Employers representative may also reject cement which has deteriorated owing to inadequate protection or other causes or in any other case where the cement is not to his satisfaction. The contractor shall remove all rejected cement from the work place without any delay and at the contractor's expense.

5.5 Batching and Mixing of Concrete

All concrete shall be batched by weight and mixed mechanically. Hand mixing shall be allowed if written permission has been given by the Employers representative. The concrete may either be batched and mixed on work place or outside the work place and transported there to when mixed outside the work place and transported to it, batching and mixing shall be in accordance with ASTM Specification C 94 "Standard Specification for Ready Mixed Concrete".

When mixed on Site, batching and mixing shall be as follows:

Batching by Weight: Cement and aggregates shall be measured by weight. Water shall be measured by weight or volume. The weight batching machines used shall be of an approved type of standard/reputed manufacture make, and shall be kept in good condition while in use on the works. Checks shall be made as required to determine that the weighing device operates correctly.

Batching Aggregate by Volume: When batching aggregates by volume is allowed, as and when required, the cement shall be batched by weight and the water by weight or volume. Each size of aggregate shall be measured in metallic containers the depth of which is at least equal to their greatest width. The containers shall be of such shape that their volume can be easily checked by measurement.

5.5.1 Mixing Concrete

Mixing shall be done in a mechanical mixer. The mixer drum shall be free of hardened mortar adhering to its inner surface. Before mixing commences the drum shall be primed by washing with rich cement grout. A measured quantity of dry course aggregate shall be first placed in the hopper. This shall be followed with the measured quantity of sand and then cement. The skip shall be raised and the dry material shall be slipped into the drum.

The dry materials shall be mixed for at least four turns of the drum after which the correct quantity of water shall be added gradually while the drum is in motion, to ensure even distribution of the materials.

The total quantity of water for mixing shall be introduced before 25% of the mixing time has elapsed and shall be resulted to achieve the specified water cement ratio. The complete contents of the mixer shall be emptied before recharging. When the mixer is closed down for the day or for any period exceeding 20 minutes, the drum shall be flushed clean.

Concrete mixture shall be constantly controlled to obtain required workability and mix strength. Mixing time for each batch shall be not less than 3 minutes.

5.5.2 Placing of Concrete

Concrete shall be conveyed from the mixer to its final position in any suitable manner, provided there is no segregation, loss of ingredients or contamination. It shall be placed in its final position before initial setting takes place and within 20 minutes of the addition of the water to the mixer. However, when agitating equipment is used to convey concrete such as in ready-mixed concrete, the elapsed time between the addition of the water and placing may be increased to 45 minutes.

The order of placing concrete shall be such as to prevent water from collecting at the ends, corners and along the faces of forms. It shall not be placed in large quantities at any given point and allowed to run or be worked over a long distance in the form. Whenever possible concrete shall be placed and compacted in even layers with each batch adjoining the previous one. The thickness of each layer shall be between 150 and 300 mm. The layer thickness will depend on the width of forms, the amount of reinforcement and the need to place each layer before the previous one stiffens.

Concrete shall not be allowed to drop freely for more than 1.5 m. To convey the concrete as near as possible to its final positions, drop chutes of rubber or metal shall be used for small sections and bottom dump buckets or other suitable vessels for large sections.

Concrete shall be carefully compacted when placed to ensure a dense and uniform mass free from air holes and cavities. Concrete shall be compacted by vibration. Vibration shall be performed by mechanical or electro mechanical vibrators. The vibrators shall be of the plunger (poker) type for insertion in the concrete.

The poker type vibrators shall have a diameter compatible with spacing of reinforcement, sufficiently high frequency and shall be properly handled by experienced personnel. They shall be immersed at regular intervals close enough

to vibrate all the concrete, but not so close as to affect previously vibrated and partially set concrete. Each immersion shall continue until shortly after air bubbles cease to appear on the surface of the concrete, but shall not last more than 30 seconds. The vibrators shall be withdrawn gradually to ensure that no air pockets are formed. All vibrations, compaction and finishing operations shall be completed within 15 minutes from the time of placing the concrete in its final position.

Concreting for any one part or section of the work shall be carried out in one continuous operation, and no interruption of concreting work will be allowed. Where beams and slabs together form an integral part of the structure, they shall be poured in one operation, unless provision is made to form a construction joint. A record shall be kept by the contractor at work place of the time and date of placing the concrete in each portion of the works and the number and identification of the works tests cube corresponding to these portions.

5.5.3 Testing of Concrete Cubes

The frequency of testing shall be as noted in the clauses of this section. The works test cubes shall be made at least once for each individual part of the structure as agreed with Employers representative.

At least six cubes shall be made at one time. Three of the six cubes are to be tested at 7 days. The remaining three cubes are to be tested at 28 days, and their average strength shall not fall below the minimum strength specified and the lowest test result shall not be more than 20% below the average of the four cubes.

When the result of the 7-day test is unsatisfactory, the contractor may elect to remove and replace the defective concrete without waiting for the 28-days test. If the result of the 28-days test is unsatisfactory, all concreting shall be stopped at the contractor's expense and shall not proceed further without written permission from the Employer.

If concrete is unsatisfactory, and where requested by the Employer, the contractor shall remove and test cubes or conduct in-situ load tests from/on suspect portions of the works. Concrete found to be defective shall be cut out, removed and replaced by the contractor at his own expense.

5.6 Execution

5.6.1 General

The formwork lines, levels, centers, dimensions etc. before proceeding with concreting shall be verified as per the approved drawings. The contractor shall verify formwork and other necessary details along with Employers representative

before commencing concreting works. Only after verification by Employers representative, concrete work shall be started.

5.6.2 Preparation

- Employer's representative's approval of reinforcement quality/placement check in writing shall be obtained before placing concrete for which 24 hours' notice shall be given by the contractor prior to placing of concrete.
- Pumping of concrete shall be permitted only after approval of equipment and mix. All constructional materials required, or which may be required during the concrete work and for curing shall be at work place and the contractor shall be fully prepared for the work. The Employers representative's approval to place concrete will only be given after such preparations and other relevant requirements of the specification have been carried out and complied with.
- Prior to placing of concrete Employers representative's approval of proposed method for protection of concrete during placing and curing shall be obtained by the contractor.
- Ensure that reinforcement and inserts shall not be disturbed during concrete placement. If necessary and/or as directed by Employers representative, the contractor shall cool any shuttering that has become overheated or exceptionally dry through prolonged exposure to the sun. The contractor shall ensure that all shuttering retains a sufficient amount of humidity and has not become shrunk or warped. All soaking or spraying of shuttering shall be done with potable water.
- The Employers representative shall forbid altogether the placing of concrete in any shuttering which he believes has become too hot and/or dry and the condition of which could harm the quality and strength of concrete. No extra payment for cooling or soaking of shuttering shall be claimed and costs incurred by the contractor, due to shuttering becoming too hot or dry, shall be deemed to be included in the rates.
- Accurate records of daily poured concrete shall be maintained by the contractor indicating date, location of pour, quality, and air temperature and test samples taken for cube test.
- Loads upon new concrete shall not be placed until the concrete has attained sufficient strength to sustain loads without damage.

- In locations where new concrete shall be dowelled to existing work, holes shall be drilled in existing concrete and steel dowels shall be placed and packed solidly with shrinkage compensating grout to anchor and hold the dowels in position.

5.6.3 Construction

- Concrete shall be casted in accordance with BSEN 206.1 or equivalent standards.
- Employer's representative shall approve the use of set sleeves, ties, and other inserts and opening as indicated. Sleeves and openings greater than 100 × 100 mm not indicated must be approved by Employers representative prior to using in construction works.
- Elimination or displacement of reinforcement to accommodate hardware shall be avoided. If inserts cannot be located as specified, approval of modifications from Employers representative before placing concrete shall be obtained.
- Locations and sizes of sleeves and openings shown on approved drawing shall be checked along with Employers representative.
- Employer's representative shall be informed at least 24 hours in advance before each concrete planning operation.
- Anchor bolts shall be placed to templates under supervision of trade supplying anchors prior to placing concrete.
- Only tools and handling equipment that are clear of rust or other harmful and foreign material shall be used to avoid efflorescence and staining of slabs or hardened concrete.
- Concrete pumps to place concrete shall be used only with the approval methods, equipment and mix design.
- Continuous supervision during placement of concrete shall be provided by the contractor including concrete grout to ensure reinforcing steel have maintained in correct position.
- When ambient temperature exceeds 27°C, measures shall be placed in affect to minimize concrete temperature to less than 35°C for sections less than 0.3 m thick to avoid shading of aggregate piles.

5.6.4 Placing Grout

Grout shall be placed as per standard procedures in accordance with manufacturer's recommendation which results in 100% contact over grouted area.

5.6.5 Joint Fillers

Furnish filler for each joint in single piece for depth and width required for joint, unless otherwise authorized by Employers representative. When more than one piece shall be required for a joint, fasten abutting ends and hold securely to shape by stapling or other positive fastening.

5.6.6 Tolerances

Concrete tolerance shall be in accordance with straight edge method clause or equivalent international clause.

5.7 Plastering

Internal plastering shall to comply with BS 5492 or equivalent international standards.

The plaster for use internally shall be composed of 1 part cement, and 4 parts of sand, and shall be applied in 2 coats to the finished stated thickness. The render for use externally is to be composed of 1 part cement and 4 parts of sand, and is to be applied in 2 coats to the finished stated thickness externally. The plaster shall have water proofing quality by adding approved water proofing additives into the mix.

Plaster or render shall be mixed in clean buckets and gauge boxes. All tools shall be kept clean and fresh plaster or render shall not be contaminated with set plaster or render.

The ingredients for the plaster or render shall be mixed three times dry and three times while water is added. Alternatively mixing may be done by approved mechanical mixers, which shall be cleaned before use.

The working time permissible after the addition of water to the plaster or render mix shall be 30 minutes. Mixed plaster or render that has exceeded this limit shall be removed from the site and not re-tempered and used in the works.

The contractor shall ensure that before plastering or rendering commences the junctions between differing base materials are reinforced with a strip of galvanized expanding metal lath secured at both edges. All angle beads and the like shall also have been fixed.

All surfaces to be plastered or rendered shall be sprayed with water, which shall be allowed to dry out before a key coat of cement slurry is applied. All undercoats shall be scratched to form an adequate key for the next coat. The setting coat shall not be applied until the floating coat has been left in a moist condition for at least three days.

All plastering shall be executed in a neat workman like manner and made good to wood frames, skirting, pipes, fittings and the like. Plaster work shall be finished with a smooth, trowelled face, free from blemishes and fit to receive decoration. Render shall be finished with a wood float. Any blown, cracked or otherwise damaged plaster or render shall be condemned by the Employer and shall be hacked off and made good with quick setting plaster at the contractor's expense. Full use shall be made of grounds, rules and angle trowels to ensure that all wall faces finish plane and true to line in all direction and that all angles are straight, true and plumb. Prices for plastering and rendering shall ensure that work to walls and ceilings are effectively 'cut' at the joint so as to minimize damage due to movement.

5.8 Protection

When rate of surface moisture evaporation for concrete surfaces exceeds $0.75\text{kg/m}^2/\text{hr.}$, measures shall be taken to prevent rapid loss of moisture consisting of one or more of the following:

- Dampening forms prior to placing concrete.
- Erecting sun shades over concrete.
- Lowering concrete temperature.
- Covering concrete with white polyethylene sheeting.
- Applying fog spray.
- Beginning the concrete curing immediately after finishing.
- Placing and finishing at night.

The contractor shall always have approved available material to protect the finish surface of concrete during contact from rain. Any damage caused by rain to the finished concrete surface shall be replaced at contractor's expense.

5.9 Defective/Damaged Work

All defective or damaged work shall be cut out and patched as directed by Employers representative. All patched surfaces shall match the consistency and finish of the original surface and shall be level with adjoining surfaces.

Damaged or deteriorated materials and manufactured items shall not be used in the works. Any materials or manufactured items damaged during and after

bedding or setting in position shall be removed and replaced by and at the contractor's expense.

5.10 Curing

Freshly placed concrete shall be protected from rain, dust, chemical attack and the harmful effects of heat, wind, flowing water, vibrations and shocks. This protection shall continue until the concrete has sufficiently set such that it can no longer be damaged by these factors which shall not be less than 24 hours after the time of placing. Concrete shall be cured for at least 14 days or longer as instructed.

Timber formwork covering the concrete shall be moistened with water at frequent intervals to keep it from drying during the curing period. Metal formwork exposed to the sun must be shaded from its direct rays, painted white or otherwise protected during the curing period.

The contractor can use any suitable/appropriate method for curing. Any method applied for curing of concrete works shall have approval from Employers representative.

CHAPTER 6 ROLLED TAPERED PANEL (RTP) STEEL TANKS

6.0 General

6.1 Scope of Work

The scope of work shall include furnishing and erection of bolted rolled tapered panel (RTP) steel tanks for raw water storage (900 m³) and treated water storage (600 m³). The scope shall also include tank structure, factory powder coat process and all tank appurtenances with all the required labors, materials and equipment.

6.2 Qualifications of Tank Supplier

The employers selection of a fusion bond powder coated bolted steel tank shall be predicated on thorough examination of design criteria, construction methods, and optimum coating for resistance to internal and external tank corrosion.

Deviations from the specified construction or coating details shall not be permitted.

The manufacturer shall fabricate and coat the tank in the same facility which it owns and operates.

The tank shall be LIQ Fusion 7000 FBE™ powder coated, RTP bolted tank as manufactured by Tank Connection Affiliate Group.

Fusion bond powder coated tank products provided by other manufacturers shall be considered for prior approval by the Employers representative. Erection of the structure shall be by the tank manufacturer only. The contractor shall be fully responsible for the entire installation including tank erection, and the ultimate water tightness of the complete installation.

Strict adherence to the standards of fabrication, erection, product, quality, and long-term performance shall be met.

The tank suppliers wishing to pre-qualify shall submit the following to the employer for consideration:

- Typical tank structure drawings.
- List of tank materials, appurtenances and tank coating technical specifications.
- Resume/experience of job installation superintendent.

- The contractor shall have the experience and knowledge necessary to furnish and erect the tank with highest degree of precision. Under no circumstances shall an inexperienced contractor be awarded the contract. The contractor shall be fully responsible for the entire installation including appurtenances and the final product.
- If an aluminium geodesic dome roof system is required, the dome erector must have installed, and had in satisfactory service, at least one clear span aluminium dome with a diameter equal to or larger than the unit specified, and shall submit evidence of such with his bid proposal and/or pre-bid submittal.
- The components of the tank in contact with stored water shall be certified to meet ANSI/NSF additives standard No. 61.
- Only bids from tank suppliers who have successfully met pre-qualified criteria shall be considered.

6.3 Submittal Drawings and Specifications

Construction shall be governed by the approved drawings and specifications showing general dimensions and construction details. There shall be no deviation from the drawings and specifications, except upon written order from the Employers representative.

When approved, two sets of such prints and submittal information shall be returned to the contractor marked "APPROVED FOR CONSTRUCTION" and these drawings shall then govern the work detailed there on. The approval by the employer of the tank supplier's drawings shall be an approval relating only to their general conformity with drawings and specifications and shall not guarantee detail dimensions and quantities, which remains the contractor's responsibility.

6.4 Tank Dimensions

a. Raw Water Storage Tank

The fusion bond powder coated bolt tank shall have a diameter of 11.5 m with side wall height (to roof eave) of 8 m. The tank shall have a storage capacity of 800 m³.

b. Treated Water Storage Tank

The fusion bond powder coated bolt tank shall have a diameter of 7 m with side wall height (to roof eave) of 8 m. The tank shall have a storage capacity of 300 m³.

6.5 Tank Design Standards

The materials, design, fabrication and erection of the tank together with tank shall conform to AWWA standard for "Factory-Coated Bolted Steel Tanks for Water Storage"- ANSI/AWWA D103, latest addition.

The tank coating system shall conform solely to section 10.6 of thermoset powder coatings of ANSI/AWWA D103, latest addition.

All materials furnished by the tank manufacturer, which are in contact with stored water, shall be certified to meet ANSI/NSF additives standard No. 61. The certification of coating type alone shall not be sufficient to meet the requirement.

The RTP bolted tank shall have lap joint connections on both vertical and horizontal shell seams. American Petroleum Institute (API 12B) flanged panel tank shall not be acceptable.

6.6 RTP Tank Materials Specification

6.6.1 Plates and Sheets

The plates and sheets used in the construction of tank shell, tank floor (when supplied) and tank roof, shall comply with the minimum standards of AWWA D103.

Design requirements for mild steel strength of tanks shall be as per ASTM A36 or ASTM A1011 grade 30, 36, 40, or 50 with a maximum allowable tensile stress of 18,000 psi.

Design requirements for high strength steel shall be ASTM A1011 grade 42, 50, 55, or 60 with a maximum allowable tensile stress of 30,000 psi unless otherwise mentioned.

6.6.2 Rolled Structural Shapes

Material shall conform to minimum standards of ASTM A36 or ANSI 1010.

6.6.3 Horizontal Wind Stiffeners

- Web truss stiffeners shall be of steel with hot dipped galvanized coating.
- Rolled steel angle stiffeners are not permitted for intermediate stiffeners.

6.6.4 Bolt Fasteners

Bolts used in tank lap joints shall be ½ - 13 UNC-2A rolled thread, and shall meet the minimum requirements of AWWA D103, Section 2.2.

Bolt Material shall be of the following specifications:

- SAE Grade 5 (1" thru 1½").
- Tensile strength - 105,000 psi min.
- Proof Load - 74,000 psi min.
- SAE Grade 8 (1" thru 1½").
- Tensile Strength - 150,000 psi min.
- Proof Load - 120,000 psi min.
- Bolt Finish - JS500 electro-plated.
- Bolt Head Encapsulation.
- High impact polypropylene co-polymer encapsulation of entire bolt head up to the splines on the shank.

Resin shall be stabilized with an ultraviolet light resistant material such that the color shall appear black. The bolt head encapsulation shall be certified to meet the ANSI/NSF Standard 61 for indirect additives.

All bolts on the vertical tank wall shall be installed such that the head portion is located inside the tank and the washer and nut shall be on the exterior.

Bolt lengths shall be sized to achieve a neat and uniform appearance. Excessive threads extending beyond the nut after torquing shall not be permitted.

6.6.5 Sealants

The lap joint sealant shall be a one component, moisture cured, polyurethane compound. The sealant shall be suitable for contact with potable water and shall be certified to meet ANSI/NSF additives standard 61 for indirect additives.

The sealant shall be used to seal lap joints and bolt connections and edge fillets for sheet notches and starter sheets. The sealant shall cure to a rubber-like consistency, have excellent adhesion to the fusion bond coating, low shrinkage, and shall be suitable for interior and exterior use. The sealant shall have the following:

- Sealant curing rate: 73°F and 50% RH
- Tack-free time: 6 to 8 hours
- Final cure time: 10 to 12 hours
- Neoprene gaskets and tape type sealer shall not be used in liquid contacting surfaces

6.7 Factory Powder Coat Process

6.7.1 Cleaning

Following the fabrication process, sheets and tank components shall be thoroughly washed and rinsed and shall have the following criteria:

- Washing shall be with a 3-4% solution of Dubois MC-726 at 140°F water.
- The PH level shall be monitored and maintained at 10 to 12.
- Rinsing shall be in a two stage booth and ambient temperature of fresh water in the second stage.
- All water shall be removed from sheets and tank components with forced air at ambient temperature.

6.7.2 Surface Preparation

Sheets and tank components shall be blasted using steel shot S-230.

Sheets and tank components shall be blasted on both sides providing a surface profile of SSPC SP10. Anchor profile shall be 1.0 mil minimum.

6.7.3 Powder Coating System

After cleaning and blasting, the sheets and tank components shall receive fusion bond powder coating on both sides of steel. The powder coating shall be applied with an electrostatic process. The thermoset powder coat system shall be as specified:

Liquid Storage	Fusion System	DFT*	Range (min/max)
Interior lining	LIQ Fusion 7000 FBE™	7 mils	6-9 mils
Exterior primer	EXT Fusion 5000 FBE™	3 mils	3-5 mils
Exterior top coat	EXT Fusion SDP™	3 mils	3-5 mils

* DFT - Nominal dry film thickness

Interior lining, LIQ Fusion 7000 FBE™ will be applied at 7 mils nominal DFT, with a min/max range from 6-9 mils.

Exterior prime coat, EXT Fusion 5000 FBE™ will be applied at 3 mils nominal DFT, with a min/max range from 3-5 mils.

Coating thickness shall be maintained by the use of PLC controlled automatic spray guns pre-set for the application.

Visual inspection for coverage shall be made after powder application and before the first oven cure. Areas with light coverage shall be re-sprayed with a manual spray gun.

6.7.4 Powder Curing

Sheets and tank components shall then be heated in an oven to achieve a metal temperature of 375° and held for 15 minutes.

After oven curing, the sheets and tank components shall cool down to a metal temperature of 125° or less.

Both visual inspection and dry film test shall be randomly performed before the application of final coat.

6.7.5 EXT Fusion SDP™ Top Coat (super durable polyester)

SDP top coat shall be applied at 3 mils nominal on all exterior surfaces.

The SDP top coat shall provide excellent gloss retention and UV resistance. Color to be selected from 5 standard colors (chart) with special formulated and premium colors as available options.

Visual and wet mil thickness testing shall be randomly performed before the second oven curing.

6.7.6 Final Curing

Sheets and tank components shall then pass through the final cure oven where the oven temperature ranges from 300° to 475° based upon the metal thickness.

6.7.7 Inspection

- During final cool down, sheets shall be randomly inspected for cure, adhesion, coating thickness and holidays.
- Cure shall be confirmed using MEK rub.
- Adhesion shall be confirmed using 100 squares test.
- Coating thickness shall be confirmed using dry film thickness gage.
- Holiday testing shall be performed with tinker & razor wet sponge.

6.7.8 Packaging

After cool down and inspection, the sheets and tank components shall be unloaded and packaged for shipment.

Side wall sheets shall be stacked on wooden skids with paper placed between each sheet to prevent any scuffing. The skids shall be loaded to 5,600 pound maximum weight. Each skid shall be wrapped in heavy mil, black poly reinforced plastic and then steel banded.

Roof sheets and hopper or bottom sheets as well as other tank components shall be packaged to prevent damage and then wrapped and banded.

6.8 Tank Structure

6.8.1 Fusion Bond Powder Coated Steel Floor

The floor shall be a fusion bond powder coated bolted steel floor. Bolted steel panels shall be placed over a compacted gravel base having steel or concrete ring wall or concrete slab. Non-extruding and resilient bituminous type filler meeting the requirements of ASTM D1751 should be placed between the tank floor and concrete ring wall or between the tank floor and concrete slab to act as a cushion.

A plastic encapsulated nut shall be used to cover the bolt threads exposed on the inside of the floor.

6.8.2 Embedded Base Setting Ring

The floor design shall be of reinforced concrete with an embedded fusion bond coated steel starter sheet per the manufacturer's design and in accordance with AWWA D103, Sec. 11.4, and type 6.

A leveling assembly shall be used to secure the started ring, prior to encasement to concrete. Installation of the starter ring on concrete blocks or bricks using shims for adjustment shall not be permitted.

Leveling the starter ring shall be required and the maximum differential elevation within the ring shall not exceed 1/8 inch nor exceed 1/16 inch within any ten (10) feet of length.

One (1) butyl rubber elastomer water stop seal strip shall be placed on the inside surface of starter ring below the concrete floor line and one (1) conceals cs-231 impregnated water seal shall be placed below the butyl rubber seal. All the materials shall be installed in accordance with tank manufacturer's instructions.

6.8.3 Side Wall Structure

Field erection of the fusion bond powder coated, bolted steel tank shall be in strict accordance with the procedures outlined by the manufacturer using factory trained erectors.

Particular care shall be taken in handling and bolting of the tank panels and members to avoid abrasion of the coating system. Prior to a liquid test, the Employers representative may visually inspect all the surface area of the tank.

An electrical leak test shall be performed during erection using a wet sponge low voltage leak detection device. All electrical leak points found on the inside surface shall be repaired in accordance with manufacturer's published touch up procedures.

The placement of sealant on each panel shall be inspected prior to placement of adjacent panels. However, the Employers representative's inspection shall not relieve the contractor from his responsibility for liquid tightness.

No backfill shall be placed against the tank side wall without prior written approval and design review of the tank manufacturer. Any back fill shall be placed according to the strict instructions of the tank manufacturer.

6.8.4 Roof

The tank shall have a fusion bond powder coated steel deck. The tank shall also have a sectioned roof fabricated from fusion bond powder coated, bolted steel panels, as produced by the tank manufacturer and shall be assembled in a similar manner as the side wall panels. The roof shall be clear span and self-supporting or center supported. Both live and dead loads shall be carried by the tank walls and any center supports.

6.8.5 Clear Span Aluminum Dome

The roof of the tank shall be constructed of non corrugated triangular aluminum panels. The panels shall be sealed and firmly clamped in an interlocking manner to a fully triangulated aluminum space truss system of wide flange extrusions forming a dome structure.

The dome shall be clear span and designed to be self-supporting from the periphery structure with primary horizontal thrust contained by an integral tension ring. The dome dead weight shall not exceed 3 pounds per square foot of surface area.

The dome and tank shall be designed to act as an integral unit. The tank shall be designed to support an aluminum dome roof including all specified live loads.

6.8.6 Materials:

- Triangulated space truss: 6061-T6 aluminium struts and gussets.
- Triangulated closure panels: .050"t 3003-H16 aluminium sheet.
- Tension ring: 6061-T6 aluminium.
- Fasteners: 7075-T73 anodized aluminium or series 300 stainless steel.
- Sealants and gaskets: gun able silicone and neoprene rubber.
- Dormers, doors, vents and hatches: 6061-T6, 5086-H34 or 3003-H16 aluminium.

6.8.7 Appurtenances

Pipe Connections: An over flow pipe shall be provided of schedule 10 carbon steel coated externally or schedule 40 PVC. A 90 degree internal weir elbow with external down comer pipe and flap valve shall be provided for the overflow.

Outside Tank Ladder: An outside tank ladder in aluminum shall be furnished and installed. The ladder shall have an external cage with a locking system.

Safety cage and step-off platforms shall be fabricated of galvanized steel. Ladders shall be equipped with a hinged lock entry device.

Access Doors: One man way shall be provided as shown on the drawings in accordance with AWWA D103.

The manhole opening shall be a minimum of 24 inches in diameter. The access door (shell manhole) and the tank shell reinforcing shall comply with AWWA D103, Sec. 5.1.

Roof Vent: A properly sized vent assembly in accordance with AWWA D103 shall be furnished and installed above the maximum water level of sufficient capacity so that at maximum design rate of water fill or withdrawal the resulting interior design pressure / vacuum shall not exceed +2.0 / -0.5 ounces per square inch.

The overflow pipe shall not be considered to be a tank vent.

The vent shall prevent the entry of birds and/or animals by including a 4 mesh (1/4" opening size) galvanized screen. If required, a 16 mesh (1/16" opening size) galvanized screen shall be installed to prevent the entry of insects. However, if the tank is located in an area where heavy frost is common during the winter months an additional pressure/vacuum relief valve shall also be provided.

Roof Hatch: The tank manufacturer shall furnish a roof opening which shall be placed near the outside tank ladder and which shall be provided with a hinged cover and a hasp for locking. The opening shall have a clear dimension of at least twenty-four (24) inches square. The opening shall have a curb of at least four (4) inches in height and the cover shall have a downward overlap of at least two (2) inches.

Roof Perimeter Guard Rail: Perimeter guard rail and toe board around the perimeter of the deck shall be provided and installed.

Liquid Level Indicator: A liquid level indicator with stainless steel float, number board, and high visibility target shall be provided and installed.

Identification Plate: A manufacturer's name plate shall be affixed on the tank which shall list the tank serial number, tank diameter and height, and maximum design capacity. The name plate shall be affixed to the tank exterior side wall location approximately five (5) feet from the grade elevation.

6.9 Tank Installation

Field erection of the bolted steel tank shall be in strict accordance with manufacturer's procedures using factory trained and certified erectors.

Particular care shall be taken to protect the baked on powder coated panels from damage (i.e., scratches, abrasion etc.) during field installation.

The tank shall be constructed utilizing synchronized (hydraulic screw) jacking process, which keeps construction crews at grade level for safety and point access quality control. Any coating damage shall be repaired per manufacturer's recommendations. No back fill shall be placed against the tank side wall during or after the construction process.

6.10 Field Testing

After complete erection and cleaning of the tank, the structure shall be tested for liquid tightness by filling tank to its over flow elevation. The contractor in accordance with the manufacturer's recommendations shall correct any leaks disclosed by this test.

The contractor shall furnish water required for testing at the time of tank erection completion, and at no charge to the tank erector. Safe disposal of test water shall be the responsibility of the contractor.

6.11 Disinfection

The tank structure shall be disinfected at the time of testing in accordance with AWWA standard C652-02 "Disinfection of Water Storage Facilities" using chlorination method number two (2).

Disinfection shall not take place until tank sealant has fully cured.

6.12 Tank Manufacturer's Warranty

The tank manufacturer shall include a warranty on tank materials and workmanship for a specified period. As a minimum, the warranty shall provide assurance against defects in material, coatings and workmanship for a period of one (1) year and as a minimum, the warranty on the interior tank lining shall be of five (5) years.

CHAPTER 7 ROADWORKS

7.0 General

The works to be executed under this contract shall include, but not limited to, providing all labor, equipment, appliances, tools and materials for the construction of roads, all in accordance with the conditions of contract, technical specifications and approved drawings.

The road works in this contract shall comprise mainly the reinstatement of existing sand surfaced public roads.

The roads and pedestrian access pavements to be reinstated shall include the following types of surfacing:

- Sand-gravel roads and foot paths

Roadways within the project work place shall be constructed with coral sand-gravel pavements unless otherwise specified.

For the precise details of materials to be used and thickness of construction, the contractor shall confirm for a minimum twenty (20) tons loading and shall refer to the requirement of the ministry of atoll development or the island office.

7.1 Reinstatement of Trenches and Road Surfaces

Upon completion of back filling operations, the street shall be opened for traffic and the trench should be left without reinstating for the period set by Employers representative, if any, else for not less than 14 days, to allow for its consolidation. As soon as the road has been satisfactorily consolidated the contractor shall carry out the reinstating works.

Krebs, channels, edgings and quadrants disturbed by the works shall be re-laid with existing units, provided that they shall not be damaged. Where existing units are not suitable for reuse the contractor shall provide replacement units of similar texture, color and type, consistent with those adjacent and shall comply with the relevant requirements of the Employer.

Reinstatement of trenches with paving blocks shall be carried out in accordance in all respects, with the relevant requirements and to the satisfaction of the Employer. If a reinstated trench found sunken within a period of three months, the contractor shall remake the trench surface with his own expenses. Road surfaces shall be properly reinstated as per the requirements of the Employer.

CHAPTER 8 ELECTRICAL AND CONTROL EQUIPMENT

8.0 Scope of Work

The electrical scope for water treatment facilities briefly described below shall be under contractor's scope, but not limited to:

- Supply, installation, testing factory acceptance test (FAT) and site acceptance test (SAT) pre-commissioning, commissioning and operation and maintenance of 415 V switch board, motors, Hybrid solar invertors, 415V capacitor bank and APFC panel, 415 V XLPE insulated power and control cable, etc. as required.
- Illumination, lightning and earthing protection system for electrical equipment's, control panel and building services at water treatment facilities.
- All architectural and civil work comprising equipment and substation structure foundation, O&M of solar PV panels, soil treatment, fencing, gates, gravels, cable trenches, storm water drain system, drainage system, approach road, etc.
- Indoor illumination and electrification for electrical panel room and at water treatment facilities.
- Outdoor street illumination using lamps as per site requirement complying IS 3646 Part-II or equivalent international standards.
- Supply and delivery of personal protective equipment (PPE) in line with utility norms and confirming to Indian standards or equivalent international standards and latest IE rules.
- Ventilation of electrical panel building and pumping station as per national building code and confirming to Indian standards or equivalent international standards.
- All work to be performed and supplies to be effected as a part of contract shall require specific review and approval of client/employer or his authorized representative as per vendor data requirement.
- To obtain clearance for energizing the complete electrical facilities covered under this tender and approval of installation/drawings and documents from central electrical authority/state electricity inspectorate and any other concerned approving authority and follow up with electricity board for getting power approved by client. Any

other requirements as necessary by the statutory regulations which are not shown in typical installation shall be compiled by the contractor.

- To supply and deliver required commissioning spares.
- To make the provision of all testing instruments/kits for testing and commissioning of the system.

The contractor shall arrange technical experts of equipment from O&M as and when necessary until the commissioning and guaranteed run of the water supply system is completed.

The contractor shall also include in the project any other work/activity which specifically does not lists but shall be necessary for completeness of electrical system.

8.1 Supply, Testing, Commissioning and Installation of Electrical Equipment.

- Hybrid solar PV panels with battery and battery charger, solar invertor
- 1.1 kV XLPE cable
- 415 V LV switchboards with metering & protection and metering cubicle,
- 415 V APFC panel,
- 415 V motors,
- Auxiliary power distribution boards,
- 660 V grade control cable
- Earthing & lightning protection,
- Indoor & outdoor lighting
- Ventilation and fire protection

As the incoming supply details available at site are not known, the requirement for plant load shall be 415 V LV supply.

All equipment sizing, testing, commissioning & installation shall be as per applicable standards or else as mentioned in the specifications.

8.2 415 V Switchboard and Motor Control Centre

The 415 V switch board shall be of floor mounting metal-clad cubicle type equipped with MCCBs and fuse-switches as appropriate. Cable entry may be top or bottom with panel access to the front or rear to suit the requirements of site layout drawings.

Cable openings in the base of switchboards and motor control centers shall be fitted with plates and all cables shall be terminated at cable glands, to prevent the entry of vermin.

Provision shall be made on switch boards for supplying building and external services. Supplies to process plant and instrumentation shall be derived from a separate process/instrumentation services distribution board and not derived from building services distribution boards.

Switch boards shall be extensible to cater for the future designed development. The contractor shall take this requirement into account when designing switch and control rooms.

a. Technical Requirements

- Rated voltage: 415 V
- Three phase symmetrical short-circuit current: The maximum let-through current of the supply transformer or feeder protective device shall not be less than 16 kA
- Rated short-circuit current withstand time: Shall not be less than 1 second.

b. Incomer Units

Incoming supplies and associated bus-couplers rated at 630 Amps and above derived from transformer secondary circuit, solar inverter and DG incomer shall be controlled by withdraw able type air-break circuit breakers or fixed MCCB of required rating. All other incoming supplies of similar case shall be controlled by fixed type MCCBs. All incomer units shall be 4 poles.

Circuit-breaker type incomer units shall be equipped with the following minimum facilities:

- Voltmeter with phase to phase and phase to neutral selector switch.
- Power meter/load manager shall be provided to monitor kVA, kW, kWh, power factor, voltage and current with provisions for RS 485 communication ports. The outputs shall be wired to the ICA compartment of the switchboard/motor control center.
- Overcurrent and earth fault protection relays. The relay characteristics shall be selected to co-ordinate with upstream and downstream protection devices

- For solar inverter incomer overvoltage, under voltage, o/c, s/c and E/F protections are required. Refer solar PV specification in Chapter 10 for details.
- Auxiliary relay with hand reset operation indicators for transformer winding temperature high alarm and circuit-breaker trip initiation (for incomers derived from transformers only).
- Phase failure and under voltage relay/release for circuit-breaker trip initiation, alarm annunciation and remote indication. The relay shall be connected on the bus-bar side of the circuit-breaker.
- High voltage inter-trip receive relay (for incomers derived from transformers only).
- Current transformers of appropriate accuracy class and limit factor and output for instrumentation and protection.

Status Indicator lights shall indicate:

- Circuit-breaker open
- Circuit-breaker close
- Circuit-breaker trip supply healthy

Push-buttons shall indicate:

- Circuit-breaker open
- Circuit-breaker close
- Circuit-breaker trip supply test
- Lamp test

Switch dis-connector type incomer unit shall be equipped with the following minimum facilities:

- Voltmeter with phase to phase and phase to neutral selector switch.
- Ammeter with phase selector switch.
- Phase failure and under voltage relay for alarm annunciation and remote indication. The relay shall be connected on the bus-bar side of the switch dis-connector.
- Current transformers of appropriate accuracy class and limit factor and output for instrumentation.

- All switchboard shall comply IEC 60947 Part I, II, III and IV as per site conditions.

8.3 0.433 KV Induction Motors

Site and Operating Conditions	
a) Altitude	Not exceeding 1000 meters
b) Temperature	Max. ambient temperature 45°C
Reference standard	IS325, IS4029, IS4722:1992, IS12824:1989, IS12802:1989 or equivalent international standards IEC 6003430-2008
Degree of protection provided by enclosure	IP 66 for pumps IS: 12615:2011
Type of duty	S1
Method of cooling	IC 411 / IC 611
Type of construction and mounting	TEFC/TETV, mounting as per pump requirement
Frequency in Hz	50 Hz
Number of phases	3-Phase
Mechanical output in kW	As per pump requirement
Rated voltage	415/690V
Class of insulation	Class F with class-B temperature limits
Speed in R.P.M	As per pump requirement
Direction of rotation, viewing from the	As per pump requirement
Particulars of tests	As per Standards specified
Rotor	Squirrel cage
Method of starting	Suitable for Direct On Line starting
Method of starting	Direct online
Nature of load	Pump for water
Method of drive	Direct coupled
Breakaway torque and the corresponding breakaway starting	Adequate for smooth acceleration during starting as per specifications
Cable termination boxes	Phase segregated

8.4 Power Factor Correction

The power factor at each load center shall be corrected to no less than 0.99 lagging. The correction may be by means of capacitors connected to individual items of

system or by automatically controlling multistage capacitors connected to bus-bar sections.

For multistage power factor correction, capacitor ratings shall be selected to ensure that motors are not subjected to leading power factor conditions or abnormal operating conditions due to the effect of self-excitation when switched off.

Multistage capacitors shall be controlled by contactors via an automatic capacitor controller with target power factor setting adjustment and manual override facilities. The contactors shall be de-rated to compensate for zero power factor switching duty, the permitted capacitor positive tolerance and the presence of harmonic currents.

Capacitor installations shall comply following IEC standards:

IEC: 61921 (Power capacitors-low voltage power factor correction banks) is the international standard applicable for low voltage power factor correction banks and automatic power factor correction (APFC) equipment intended to be used for power factor correction purposes, equipped with built in switch gears and control gears. The guidelines for installation, operation and safety of APFC panels are followed based on this international standard.

The low voltage power factor correction banks and accessories shall comply with the following standards:

IEC 60831: Part 1 and 2- Shunt power capacitors of the self-healing type for a.c. systems having rated voltage up to and including 1 kv.

IEC 60439-3: Low voltage switch gear and control gear assemblies. Particular requirements for both assemblies intended to be installed in places where unskilled persons have access for their use-distribution boards.

IEC 60947: Low voltage switchgear

Part 2: Molded case circuit breakers and air circuit breakers

Part 4: Power contactors

Part 4-3: Thyristor Switch

IEC 60269: LV fuses

IEC 60076-6: Reactors

IEC 60529: Degree of protection provided by enclosure (IP code)

IEC 60041-1: Current transformers

IEC 60664-1/ IEC 61326: Power factor controller

Capacitors shall incorporate a discharge circuit and shall not contain polychlorinated bi phenols.

Calculations corroborating capacitor KVAR ratings shall be submitted to the Employer for approval.

8.4.1 APFC

Capacitor switching and automatic power factor correction panel shall be designed in such a way that power factor of 0.99 shall be obtained. Timings to cut in capacitor shall be provided in such a manner to facilitate capacitor discharging before next switching and shall also avoid hunting due to temporary fluctuations of load. The timer shall be provided in both auto and manual mode.

8.4.2 Emergency Stop Push-Buttons

An emergency stop push-button shall be installed adjacent to all motors.

8.4.3 Local Control Units (LCU)

Each motor shall be capable of being manually operated from a local operating position. Where motor starters are provided at remote locations, the contractor shall provide a local control unit (LCU) in a safe and accessible operating position adjacent to the motor. Each LCU shall be of robust construction suitable for environmental conditions. The LCU shall be provided with a start/stop or open/close push button.

Local control units installed externally shall be protected from sun with sun covers and constructed with an IP rating of IP 65.

The contractor shall submit drawings identifying the locations of LCUs to the employer for approval.

8.5 Cabling

8.5.1 General

The contractor shall provide a complete cabling installation comprising power, control, instrumentation, communications and telephone cables (if applicable) and all accessories including cable glands, terminations, cable markers, support systems, clips, fittings and fixtures to:

- Interconnect all plant provided under the contract;
- Interconnect ICA signals to the Local Control Panels;
- Interconnect existing system/plant (if applicable) with the system provided under the contract.

All calculations to corroborate current carrying capacity and compliance with the volt-drop criteria specified herein shall be submitted to the employer for approval as per IEC 60502, BS-5467.

The power, control and instrumentation cabling shall interconnect the entire Water Supply scheme including but not limited to:

- Solar PV panels, batteries, battery charger, inverter
- Valves actuators, pump sets, etc.;
- Switchgear and distribution boards;
- Motor control centers;
- Local Control Panels;
- Local control units;
- Measuring instruments and sensors

The contractor has to submit cable sizing calculations with all applicable de-rating factors under worst conditions to carry full load current.

8.5.2 Cable Grouping

The cables shall be grouped as follows:

- Power cables - 1.1 KV grade LV
- Control cables - 110 V dc / 660 V ac

8.5.3 Cable Types

High voltage power cables shall be of the XLPE/SWA/PVC type with a conductor size appropriate to short-circuit current and short-time requirements. The cable shall be suitable for prolonged operation at plus 10% rated voltage.

415 V power cables and control cables shall be 600/1000 V grade PVC or XLPE/SWA/PVC unless otherwise approved by the Employers representative.

8.5.4 Installation

Cables shall be installed externally below the ground as per following:

- Unless otherwise approved by the Employers representative all cables shall be installed in ducts and concrete trenches or shall be as per approved drawings.
- Duct systems shall be provided with draw chambers at the point of entry into buildings, at changes in direction and at suitable intervals in straight runs to permit the installation of cables without exceeding the manufacturers' recommended maximum tensile stress. Draw chambers shall have dimensions to enable cables to be pulled without damage or excessive stress due to bending.

Cables shall be installed externally above ground as per following:

- Cables on structural surfaces shall be installed on tray and ladder systems or in trunks and conduit as appropriate. Cable tray on structural surfaces shall be fitted with covers.
- Internal cables on structural surfaces shall be installed on tray and ladder systems or in trunks and conduit as appropriate. Cables in trenches shall be installed on tray and/or ladder systems.

Cable tray, ladder and trunk systems shall be installed as per following:

- Cable tray, ladder and trunk systems shall be of heavy duty hot dip galvanized steel with return flange at the upper stand. Cable tray on external structural surfaces shall be fitted with covers.
- Installations in the chemical and chlorine buildings shall be with heavy duty GRP systems.

Conduit systems shall be installed as per following:

- Conduit shall be heavy duty galvanized steel. Installations in the chemical and chlorine buildings shall be with heavy duty GRP systems.

8.6 Earthing

8.6.1 General

A complete and fully interconnected low voltage earthing installation comprising earth electrodes, earthing terminals and all earthing, protective and equipotential

bonding conductors shall be provided by the Contractor at each of the sites of reservoirs, sumps, tapping points from trunk mains, Chlorination stations and booster pumping stations. All earthing calculations shall be submitted by the contractor for approval as per IEEE 80.

8.6.2 Earth Electrode System

The contractor shall carry out a ground resistivity survey for each site and shall install the earth electrode system to provide an overall resistance to earth not greater than 1 ohm.

The earth electrode system shall comprise at least two separate group of rods located at agreed locations to allow for testing of one earth electrode system whilst the other shall be connected to the system.

The main earth bar shall be provided with test links to enable independent testing of each group of earth electrodes.

8.6.3 Earthing Terminals

Earthing terminals shall be located adjacent to the associated switch board or motor control center. The earth terminals shall be interconnected. The earthing terminal shall be used to connect the following conductors to the earth electrode system:

- (a) The circuit protective conductors;
- (b) The main bonding conductors; and
- (c) The functional earthing conductors (if required).

The size of bonding conductor connecting the main earthing terminals at the sites of this contract and the electricity supplier's transformer earth or metallic sheaths of service cable, should not be less than 150 mm² copper equivalent. Provisions should be made for disconnection of the bonding conductor for testing purposes.

A warning notice bearing the words 'SAFETY ELECTRICAL CONNECTION—DO NOT REMOVE' and in equivalent English and local language should be displayed in a conspicuous position at or near the main earthing terminal.

At the pumping station sites, the main earth terminal with test link shall be located inside the pumping station switch room. An auxiliary earth terminal with test link shall be provided and shall be located at the telemetry room inside the pumping station for the installation of the local control panels. At the tapping point from the trunk mains sites, the main earth terminal with test link shall be located inside the enclosures for the installation of the local control panels. At the reservoir/treated

water storage tank, the main earth terminal with test link shall be located inside the switch room. An auxiliary earth terminal with test link shall be provided and shall be located at the telemetry room for the installation of the local control panels.

8.6.4 Bonding to Structural Steel Work

Structural steelwork including concrete reinforcement bars shall be bonded to the earthing system. The method of connection to reinforcement bars shall be subject to the approval of Employers representative.

8.6.5 Equipotential Bonding

All metallic pipework and other extraneous conductive parts shall be provided with positive earthing terminals and provided with equipotential bonding.

In each installation, main equipotential bonding conductors should be connected to the main earthing terminal for all extraneous conductive parts to create an equipotential zone; such conductive parts shall include:

- All water pipes.
- All gas installation pipes.
- Other service pipes and ducting.
- Cable trays, cable ladders, conduits, trunks etc.
- Exposed metallic parts of structural framework.
- The lightning protection system.

In large installation, where there are a number of equipotential zones, these zones should be bonded together to form one equipotential zone.

Aluminum or copper clad aluminum conductors should not be used for bonding connections to water pipes as they are likely to subject to condensation in normal use.

Main equipotential bonding conductors should have cross-sectional areas not less than half the cross-sectional area of the earthing conductor of the installation, subject to a minimum of 6 mm² copper equivalents, and need not exceed 25 mm² copper equivalents.

Main equipotential bonding connections to any gas or water pipes should be practically near to the point of entry of those services into buildings; provided that where there is an insulating section or insert at that point, the connection should be made to the metal work on the consumer's side of that section or insert.

In particular, for gas services, bonding connection shall be made on the consumer's side of the meter (i.e. between the meter outlet union and any branch pipework). This connection shall recommend to be made within 600 mm of gas meter. Within the zone formed by the main equipotential bonding, local supplementary bonding connections should be made to metal parts, to maintain the equipotential zone, where those parts are:

- Extraneous conductive parts,
- Simultaneously accessible with exposed conductive parts or other extraneous conductive parts, and
- Not electrically connected to the main equipotential bonding by permanent and reliable metal-to-metal joints of negligible impedance.

Metal works which may require to be bonded shall include service pipes or substantial parts which are at a distance not exceeding 2 m from exposed conductive parts. Examples are water pipes adjacent to electric heater or window frame supporting a ventilation fan or air-conditioner or adjacent to a socket outlet.

Aluminum or copper clad aluminum conductors should not be used for bonding connections to water pipes as they are likely subject to condensation in normal use.

The minimum cross-sectional area of a supplementary bonding conductor should comply with the following table and with following conditions:

Installation method	PVC insulated (mm ²)		Bare (mm ²)	
	Copper	Aluminum	Copper	Aluminum
Surface wiring	2.5 (sheathed) 4 (non-sheathed)	16	> 6	16
In conduits or trunks	1.0	16	1.0	16

- The bonding conductor connecting to exposed conductive parts should have a cross-sectional area not less than that of the smaller protective conductor connected to the exposed conductive parts;
- The bonding conductor connecting to exposed conductive parts to extraneous conductive parts should have a cross-sectional area not less than half of the protective conductor connected to the exposed conductive part;
- The bonding conductor connecting to extraneous conductive parts, where one of the extraneous part shall connect to an exposed conductive part, should have a cross-sectional area not less than half of the protective conductor connected to the exposed conductive part.

8.7 Instrumentation earthing

The contractor shall provide separate earthing terminal for the local control panels and all the instrumentation in each telemetry room. Each separate earthing terminal shall be connected to the station earth system through the earth terminal inside the same room. Insulated earth cables shall be used to connect the instrumentation to these separate instrumentation earth terminals. The instrumentation signal earth cables shall have different outside insulation color to the power earth cables in order to make them easily detectable. Earthing system shall comply with local regulations.

8.8 Lightning Protection

A lightning protection system shall be provided on all main structures, complying with the requirements as per BS 6651. Air terminations and down conductors shall be of copper.

The contractor shall also provide all terminating equipment for all I/O and communication signals transmitted between buildings on a copper cable with lightning protection barriers. The barrier shall be installed in a barrier panel which shall be located adjacent to the main cable entry point into the building or in a small enclosure adjacent to the transmitter. The barriers shall be earth bonded in accordance with manufacturers' recommendations and standard specifications.

8.9 Building Services

8.9.1 Scope

The contractor shall include for the supply, delivery to work place, off-loading, storage, erection, testing and setting to work the complete building services installations at the work place. As a minimum, the contractor shall provide the following:

- Internal main and emergency lighting.
- External walkways and floodlighting.
- Small power.
- Air conditioning.
- Ventilation and ceiling fans.
- Telephone lines and telephone handsets.

The building services installation shall comply with standard specification and the following clauses herein. Where the standard specification, particular specification and drawings differ, the latter shall take precedence.

8.10 Lighting

8.10.1 Internal Main Lighting

Internal lighting shall be designed to provide the following minimum service luminance, measured at floor level:

Area	Luminance
Hall areas	200 lux
Switch rooms	300 lux
Control room/Telemetry room	350 lux
Workshop areas	300 lux
Office	350 lux
Staff room and reception area	150 lux
Toilets, washrooms, mess rooms	100 lux
Corridors and staircases	75 lux

Luminaires shall be fixed directly to, or suspended from, the underside of roof slabs, ceilings or fixed to walls as appropriate. To attain energy saving in operation, all fluorescent lightings shall be of T5 type with electronic ballast.

The hallways and other high bay areas shall be provided with high or low bay energy efficient lighting. The contractor shall provide all necessary equipment to ensure that lighting maintenance shall be performed in a safe and efficient manner. Where special provision would have to be made for accessing luminaires supported from the underside of the roof slab for maintenance, luminaires shall be wall mounted. Luminaires for the control room and offices shall be designed to minimize glare and shall be suitable for VDUs.

Light switches shall be located adjacent to doorways. Multi-way switching shall be provided for rooms and areas with more than one point of access. For large area light switching or high/low bay lighting, contactors shall be provided to switch lighting in blocks from each entry point.

8.10.2 Internal Emergency Lighting

Emergency lighting shall be provided and shall comprise of exit and escape route luminaires to facilitate safe movement of personnel in or from any building or major structure in the event of a mains supply failure. Exit luminaires shall be provided above all doors leading to or accessible to an outdoor area.

Emergency lighting shall also be provided in areas where essential operations may be required during a mains supply failure, for example, switch room and control rooms. The regional control center shall be provided with emergency luminaires to provide an average luminance of 50 lux for one hour during a mains/generator power failure. Through DCDB emergency DC luminaries shall be given supply for

emergency lighting.

8.10.3 External Walkway Areas

Luminaires shall be provided to illuminate all external personnel walkway areas around buildings and structures. The lighting shall be such way to provide an even minimum service luminance measured at ground level of 15 lux.

Lighting shall have switches at personnel access doors. Multi-way switching shall be provided where there is more than one point of access.

8.10.4 Flood lighting

Flood lighting shall be provided for the entrance of work place, at, loading/unloading areas, storage tank areas, slow sand filter area, R.O plant area, administration building, parking place etc. Flood lighting shall also be provided at all locations requiring inspection.

Flood lights shall be mounted on galvanized steel poles or on structure walls as appropriate.

Flood lighting shall provide a minimum service luminance of 50 lux measured at the working plane. Flood lighting shall be controlled from the main switch gear.

8.11 Small Power

Industrial switched type 230 Vac socket outlets with residual current devices for the connection of electric tools shall be installed at convenient places in all the areas.

A suitable rated 415 Vac/230 Vac socket outlet with residual current device shall be provided for each structure. The socket outlets shall be located in an IP 65 weather proof enclosure fixed to the structure wall.

For water process treatment and pumping areas, industrial type socket outlets shall be provided and spaced so that any location within the area shall not be greater than 20 m from an outlet. A minimum of two socket outlets shall be provided in each area.

Commercial type 230V 15A and 5A socket outlets shall be installed throughout all administrative office areas, the telemetry housing/room for installation of LCP and also including the associated corridor areas. A minimum of two socket outlets shall be provided in each room.

8.12 Ventilation

Mechanical ventilation shall be provided as follows:

Location	Air Changes/Hour (ACH)
Pump room	6
Toilets and washrooms	4
Mess rooms and kitchen	6
Electrical switch room	10
Filter room	10

8.13 Ceiling Fans

All administrative areas such as the control rooms and offices shall be provided with ceiling fans at a frequency of 1 per 15 m² of floor area. The fans shall be provided with local speed controllers and switches adjacent to each individual unit.

8.14 Air Conditioning

As a minimum, all the high voltage switch rooms, 415 V switch board and motor control center rooms, the telemetry rooms in the filter house and the pumping stations for the installation of local control panel shall be air conditioned. As a minimum, the contractor shall provide one 9,000 BTU air conditioner at each of the rooms/housings. The contractor shall submit calculation to the employer to select the size of the air conditioners based on the heat generating load that are to be installed. The air conditioning shall maintain a dry bulb temperature of 22°C and relative humidity of 50% under the outside means monthly maximum shade temperature and humidity specified elsewhere.

8.15 Telephone Facilities

The contractor shall provide, as a minimum, one telephone landline and one telephone handset at areas not limited to administration building office, slow sand filter unit, R.O plant, at both storage tank area, parking place etc. Telephone services wherever required in the whole water supply scheme or as directed by Employers representative shall be provided by the contractor.

8.16 Distribution Boards

Each work place shall be provided with suitably sized distribution board. Distribution board shall provide distribution to lighting, socket outlets, heating, ventilation and air conditioning. Circuits shall be arranged to provide a balanced load on each phase of the supply. The distribution boards shall be placed as per Employers representative.

8.17 Wiring

Internal wiring on concrete and block work surfaces shall be carried out using single core PVC insulated non-sheathed cables installed in surface mounted heavy duty galvanized steel conduit. Wiring in plastered and tiled areas shall be installed in concealed steel conduit.

External wiring shall be carried out using single core PVC insulated non-sheathed cables installed in heavy duty galvanized steel conduit or PVC covered material insulated copper sheathed cables.

Wiring associated with lighting and ventilation fans shall be carried out using heavy duty GRP conduits and/or cable tray/ ladder as necessary.

Within the rooms, the contractor shall provide computer raised floor. All communications, control, small power services and telecommunications cabling shall be contained within a three compartment cable management system to allow adequate segregation of cabling. The cable management system shall allow flexibility and future expansion as well as provide mechanical protection for all cables.

CHAPTER 9 HYBRID SOLAR POWER SYSTEM

9.0 The Solar PV system shall have the following specifications:

- Operating temperature- 0-85 deg. Celsius
- Operating voltage - 1000 V max
- Hybrid inverter (Solar/ Transformer /Battery)
- Vector modulated Inverter Control
- Multiple DSP control operation
- Power rating 30-40kW
- Battery less operation compatible
- Paralleling compatibility
- MPPT Based Solar Charger -2 modes of operations
- Higher capacity PV connection option available
- Multi-mode function: SGB/ SBG/GFM (selectable)
- BG Modes with Buffer level selection facility 25/50/75
- GFM FEED mode feeds power to load connected on solar bus when grid fails.
- GFM levels are selectable 0/25/50/75/100
- Unity power Factor
- Adjustable Charging Current:
- $V^{\text{th}} d < 3\%$
- Change over time less than 20 ms
- 40 X 4 LCD with backlight & Tactile Kay Pad Interface
- Detailed Metering : Solar KW, Solar KWH,

- Fault logs : 9 recent faults
- Auto fault reset for non critical faults
- Optional Input: Pyrometer, Wind speed, Battery Temperature, Heat sink Temperature
- Advanced Battery Management Feature
- Temperature Compensated Charging
- Generator compatible
- Communication Port: RS232
- GSM Based Remote Monitoring option

9.1 Compatible IEC standards-IEC-61683:1999-As per MNRE Requirement.

Protections:

1) PV Protection

Reverse Polarity Indication, Reverse Polarity Indication, Surge Protection

2) Battery

Reverse Polarity Over/ Under Voltage, Over Temp, Over Charge

3) Load Protection

Overloads, Short circuit

4) Circuit breakers

Transformer Input MCB/MCCB, Battery Input MCB/MCCB, PV Input MCB/MCCB, Load Rotary Switch

5) Inverter

Over temperature, over voltage short circuit, Overload as required.

9.2 PV Cells Specifications:

Cell Type	-	Multi crystalline
Irradiance capacity	-	1000W/mm ²
IP	-	IP65
By-pass arrangement	-	By-pass Diode

This specification covers the requirements of stationary storage battery and suitable battery charger required for the operation and control of centralized solar power system.

The design, manufacture and performance of the equipment shall conform to the following Standards or **equivalent international standards**.

CODES DESCRIPTION

1651 : 2013	:	Stationary cells and batteries, lead acid type [with tubular positive plates]
1885 (Part 15) IEC 60054:2004	:	Electro technical vocabulary: Part 15 2008 Primary and secondary cells and batteries (second revision)
13369: 1992	:	Stationary lead-acid batteries [with tubular positive plates] in mono block containers
15549 : 2005	:	Stationary valve regulated lead-acid batteries — specification
15767 :2008 IEC 62259:2003	:	Secondary cells and batteries containing alkaline or other non-acid electrolytes–nickel-cadmium prismatic secondary single cells with partial gas recombination
10893 : 1984	:	Specification for sealed nickel cadmium button type rechargeable single cells
10918 : 1984	:	Vented types nickel – cadmium batteries
16048 IEC:61951- 1:2008	:	Secondary cells and batteries containing alkaline or other non-acid electrolytes – Portable sealed rechargeable single cells:
(Part 1) : 2013	:	Part 1 Nickel-Cadmium

(Part 2) : 2013	:	Part2: Nickel metal hydride (second revision)
IRS: S 88/2004	:	Low maintenance lead-acid stationary cells for S&T installations
IS : 8320	:	General requirements and methods of tests for storage batteries.
IS : 6619	:	Safety code for semiconductor rectifier equipment.
IS : 2147	:	Degrees of protection provided by enclosures for low voltage switchgear and control gear.
IS : 4237	:	General requirements for switchgear for voltages not exceeding 1000 V AC
IS : 8623	:	Specification for factory built assemblies of switchgear and control gear (up to 1000 volts).
IS :9224(II)	:	Fuses with breaking capacity for industrial application.
IS : 4064	:	Specification for air break switches, dis-connector and fuse combination units.
IS : 266	:	Water for Storage Batteries.
IEC: 623	:	Vented type Ni cd batteries

DBO contractor shall comply with all standards applicable for Solar Based Inverter Battery and Battery charger.

9.3 Battery

Capacity - The ampere-hour capacity at ten-hour rate of discharge shall be based on the requirements of loads. It may be assumed that the battery is fully charged to 2.15 volts at the start of the cycle and is discharged to a voltage of 1.85V/cell at the end of the cycle.

The battery offered shall preferably be lead-acid (tubular) in transparent SAN container type, Li-Ion, Ni-Cd.

The contractor shall verify the DC Voltage level 12V-110V DC suitable for 30kW Solar PV Based System.

The batteries shall be maintenance free suitable for indoor installation.

The cell containers shall be of hard rubber / glass or plastic. Suitable acid level indicators shall be provided.

The cells shall be sealed and filter vent plugs shall be provided to avoid spillage, spray and emission of acid vapors.

Inter-cell and inter-tier connectors shall be of lead or lead-plated copper depending on the discharge rate to which the battery will be subjected.

Terminal posts shall be designed to accommodate external bolted connection. Each terminal post shall have two bolt-holes of the same diameter, preferably at right angle to each other. All metal parts of the terminals shall be of lead or lead-coated type. The junction between terminal posts and cover and between cover and container shall be so sealed as to prevent any seepage of the electrolyte.

The electrolyte shall be battery grade sulphuric acid conforming to relevant standards.

Required quantity of electrolyte for first filling with 10% extra shall be supplied in nonreturnable containers.

Battery shall be complete with battery racks preferably in single tier arrangement. For smaller units, utilizing sealed-in type of batteries, mounting of the battery in sheet metal cubicle will be acceptable.

Battery racks shall be constructed from good quality teak wood and painted with two coats of approved acid-resisting paint. The construction of the racks, unless otherwise specified in the data sheet, shall be suitable for fixing on a flat concrete floor. The racks shall be rigid, freestanding type and free from warps and twists. The complete rack shall be suitable for being bolted end to end to form a continuous row.

The battery shall be complete with accessories and devices including the following:-

- Battery racks
- Porcelain insulators, rubber pads, etc.
- Set of inter cell and interior connectors as required for the complete installation.
- Accessories for testing and maintenance:
- One - -3 to +3 volts DC voltmeter with suitable leads for measuring cell voltage.
- One - Hydrometer for measuring specific gravity of electrolyte in steps of 0.005.

- One – Filler-hole thermometer fitted with plug and cap and having specific gravity
- Correction scale.
- One - Pocket thermometer
- One - Acid-resisting funnel
- Two - Rubber aprons
- Four - Rubber gloves
- Two - Cell lifting straps
- One set - Terminals and cable boxes with glands for connecting cables as required.
- Spare Connectors
- Spare vent plugs
- Spare nuts and bolts
- Suitable set of spanner
- PVC spill trays under the battery cells.

Each cell shall be marked in a permanent manner to indicate the following information: -

- Cell number
- Type of positive plate
- Ampere-hour capacity at 10 hour rate
- Type of container
- Manufacturer's name
- Month and year of manufacture

The battery shall be transported in dry and uncharged condition. The acid shall be supplied separately in non-returnable sealed containers. Adequate quantity of distilled water shall also be supplied in a sealed container.

9.4 Battery charger and DCDB

The battery charger shall be indoor, cubicle type floor/wall mounted, dust and vermin proof and front attended.

The control panels shall comprise rigid structural frame enclosed by 2 mm thick cold rolled (CRCA) sheet steel. Doors and covers shall be from 1.6 mm thick CRCA sheet steel.

Structural frame-work with foundation bolts/fixing bolts, etc. at the bottom / back side shall be provided to mount the battery charger panels directly on concrete floor/steel channel base or directly on wall as required.

The charger and control equipment shall be arranged in the panels such that the components related to boost-charging, float-charging, common equipment and D.C. distribution are physically segregated in order to avoid haphazard placement and mix-up of the components. Location of the various equipment and components in the panels shall be as per proper logic and sequence.

All doors and removable covers shall be gasket all around preferably with neoprene gaskets.

The battery charger and control panels shall be complete with the following:

- Removable cable gland plate, brass cable glands and as specified in datasheet.
- 650 V grade terminal blocks. 10% additional terminal blocks shall also be provided as spare.
- Earth bus bar of size and material as specified in data sheet.

The battery charger shall be static type suitable for DC to DC converter with voltage regulation.

The composite (float/boost) charger, or separate float and boost chargers, shall be designed for supplying the DC loads for emergency lighting as specified in the data sheet in addition to float charging /boost charging the battery.

Recommended overcharge protection voltage thresholds according to battery chemistry are: 2.42 V/cell \pm 0.05 V/cell for lead-acid, 1.40 V/cell \pm 0.05 V/cell for NiMH and NiCd, 4.10 V/cell \pm 0.05 V/cell for Li-ion, and 3.60 V/cell \pm 0.05 V/cell for LiFePO₄.

The battery charger shall consist of:

- One (1) – DP DC incoming switch on Incoming side of the charger along with HRC fuses/MCB as required depending on DC supply voltage suitable for the DC System (one for boost charger and one for float charger) along with two nos. voltmeters with selector switches.
- Three (3)/one (1) - Multiple LED type potential indicating lamp(s) on Incoming supply side depending on DC supply Voltage.
- One (1) set - Automatic voltage regulator unit (for float charger) with auto/manual selector switch and Constant current controller for boost charger with auto/manual selector switch.

- One (1) set - Coarse and fine control knobs for manual control.
- One (1) - Selector switch for mode for charging i.e. float charging/boost charging.
- One (1) set - Double wound dry type main transformer of suitable rating with adequate primary and secondary windings.
- One (1) set - Taps for the charger output voltage control with off load tap changing switch for changing the taps on the transformer.
- One (1) set - Booster transformer, as required.
- One (1) set - Silicon rectifiers connected in three phase full wave bridge circuit/single phase circuit, as per requirement indicated in data sheet, with ripple filtering device
- Two (2) - D.C. Volt-meter
- Two (2) - D.C. Ammeter with Shunts
- One (1) - Switch fuse unit in D.C. output side of each charger, with HRC fuses.
- Two (2) - Silicon diodes in series in the boost charger circuit.
- Two (2) - D.C. contactors connected across the incoming supply to give alarm on
- Annunciator

9.5 Performance

The automatic constant voltage regulator shall regulate the DC voltage within +1% of the set value from no load to full load under fluctuations in supply voltage and frequency by + 10% and +5% respectively of their normal values.

The float charger shall have built-in current limiting feature to drop the output voltage for currents more than 110% of the rated current.

Suitable ripple filtering circuits shall be provided to give a smooth D.C. output. The ripple content shall be limited to less than +5% on resistive load.

9.6 Tests

Battery Test

The battery test is used to determine a SL's actual battery capacity and storage efficiency. This information is useful to determine if a battery is mislabeled or damaged. During the test the battery is connected to a battery analyzer, which performs charge-discharge cycles on the battery. The last charge-discharge cycle data from the battery test is analyzed to determine the actual battery capacity and battery storage efficiency

Routine tests (acceptance tests) such as visual inspection, dimensional check, etc. shall be conducted as per relevant B.S standards.

Type test certificates for retention of charge, etc. shall be submitted. Type tests shall be carried out if specified in data sheet.

Seven copies of the routine and type test certificates shall be submitted for the approval before dispatch of the equipment.

9.7 Technical Data

Battery:

Ambient temperature: 50°C max. :

Humidity: 95% Max.

Battery capacity: lead-acid (tubular) in transparent

SAN container type, Li-Ion, Ni-Cd, High discharge performance

Total effective voltage required: As required.

Voltage per cell: 2.2V

Total nos. of cells: As per requirement

Voltage per cell at the end of discharge: 1.85V

No. of identical batteries required: As per Requirement

Proposed application: Alarm, Closing and tripping circuits of Breakers,

Indicating lamps, Tripping of Protective Relays,

Annunciators, Hooters

Accessories and spares: As required

Approved makes: As per Approved vendor list

Battery charger and DCDB:

Rating: As required

Input voltage: 12V DC

Output voltage: Suitable for Battery charger

Type: Float cum boost with trickle charging facility and automatic battery over drain protection.

APPENDIX - A - LIST OF STANDARDS

	Abbreviations
ACI	American Concrete Institute
AWWA	American Water Works Association
BS	British Standards Institution
CIRIA	Construction Industry Research and Information Association
CP	British Standards Institution (Code of Practice)
ICE	Institution of Civil Engineers, UK
ISO	International Standard Organization
	Standards
BS 1377	Methods of test for soils for civil
BS 5930	Code of practice for site investigations
BS 6031	Code of practice for earthworks
BS 8004	Code of practice for foundations
BS 3416	Specification for bitumen-based coatings for cold application, suitable for use in contact with potable water
BS 4147	Specification for bitumen-based hot-applied coating materials for protecting iron and steel, including suitable primers where required
BS 4315	Methods of test for resistance to air and water penetration
BS 4483	Specification for steel fabric for the reinforcement of concrete
BS 4504	Circular flanges for pipes, valves and fittings (PN designated)
BS 5911	Precast concrete pipes, fittings and ancillary products
BS 7263	Precast concrete flags, Krebs, channels, edgings and quadrants
BS 8010	Code of practice for pipelines
BS 3284,5114	HDPE pipes and Fittings
ISO 9080:1992	Resin for manufacturing HDPE pipes
ISO 13478	HDPE crack propagation
BE EN 12201-3:2003; BE EN 1555-3; ISO 8085-3	Electro-fusion fittings for HDPE pipes
BS 6920	HDPE type test
BS 3412 BS EN 12201-1.	Polymer for HDPE pipes
BS EN 12201-3	HDPE pipe laying
ISO 4427	Specification for MDPE pipes
BS 534	Specification for steel pipes, joints and specials for water and sewage
BS 2569	Specification for sprayed metal coatings
BS 3416	Specification for bitumen-based coatings for cold application, suitable for use in contact with potable water
BS 4147	Specification for bitumen-based hot-applied coating materials for

	protecting iron and steel, including suitable primers where required
ES 4865	Dimensions of gaskets for flanges to BS 4504
BS 5255	Specification for thermoplastics waste pipe and fittings
BS 5556	Specification for general requirements for dimensions and pressure ratings for pipe of thermoplastics materials (metric series)
BS 5911	Precast concrete pipes, fittings and ancillary products
BS 6209	Specification for solvent cement for non-pressure thermoplastics pipe systems
BS EN 295	Vitrified clay pipes and fittings and pipe joints for drains and sewers
BS EN 545	Ductile iron pipes, fittings, accessories and their joints for water pipelines. Requirements and test methods
BS EN 598	Ductile iron pipes, fittings, accessories and their joints for sewerage applications. Requirements and test methods
WIS 4-52-01	Specification for polymeric anti-corrosion (barrier) coatings
BSEN 206-1	Concrete- part 1: Specification Performance, Production and Conformity (BS 8500-1 Concrete and BS 8500-2).
BS 4027:1996	Specification for sulphate resisting Portland cement (SRC)
BS EN 12504	Testing concrete
BS EN 12620	Aggregates for concrete.
(ASTM):	<ul style="list-style-type: none"> American society for testing and materials ASTM book of standards volume 1. 04:02 concrete and aggregates. ASTM A 615/A 615 M-05a, standard specification for deformed and plain carbon-steel Bars for concrete reinforcement. ASTM C 109/C 109M-05, test method for compressive strength of hydraulic cement mortars (using 2-in. or 50-mm cube specimens). ASTM C 150-05, Portland sulphate resistant cement. ASTM C 309-03, specification for liquid membrane-forming compound for curing concrete. ASTM C 494/C 494M-05, specification for chemical admixtures for concrete. ASTM A775/A775M-04a, standard specification for epoxy-coated steel reinforcing bars. ASTM C 827-01a (2005), test method for change in height at early ages of cylindrical specimen from cementitious mixtures. ASTM C 939-02, test method for flow of grout for preplaced-aggregate concrete (flow cone method).
BS 410	Specification for test sieves
BS 812	Testing aggregates
BS 882	Specification for aggregates from natural sources for concrete
BS 1377	Methods of test for soils