**VOLUME II**

**SECTION 8 – TECHNICAL SPECIFICATIONS (Employer Requirements)**

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# PART 2 (A) PROJECT REQUIREMENTS

* 1. General

Ministry of Environmental & Energy (MEE) on behalf of the Government of Maldives is seeking the assistance of a qualified and competent contractor for construction/execution of Rain Water Harvesting in 8 Islands of Package – V in Maldives.

Ministry of Environmental & Energy (MEE) on behalf of the Government of Maldives has identified the following 8 Islands of Package – V consisting of Gaafu Alifu (Ga) Atoll and Gaafu Dhaalu (Gdh) Atoll. The islands of these atolls are: (1) Ga. Kondey (2) Ga. Maamendhoo (3) Ga. Nilandhoo (4) Gdh. Nadella (5) Gdh. Faresmaathodaa (6) Gdh. Fiyoari (7) Gdh. Hoadehdhoo and (8) Gdh. Rathafandhoo. The selected/preferred contractor shall be awarded the work of construction/execution work for the above islands.

* + 1. Information About 8 Islands (Package - V)

The climate is in all the 8 Islands is normally tropical, warm and humid all year round with a mean annual temperature of 28oC and an average relative humidity of 80%. Since water surrounds all the islands, the main livelihood of the population depends upon fishing and agriculture. All the Islands have Mosques, Schools, Pre-Schools, Council Office, Courts, and Health centers in common which have contributed to the infrastructure development of the islands.

The geographical information for all the 8 Islands of Package – V is mentioned in **Table 1.1**.

**Table 1.1: Geographical Information for 8 Islands of Package – V**

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Island Name** | **Location** | | **Island Measurements** | | **Area (Ha.)** | **Census Population** | | **Projected Population** |
| **Northing** | **Easting** | **Length (km)** | **Width (km)** | **2006** | **2014** | **2027** |
| Ga. Kondey | 00°29′55″N | 73°32′55″E | 2.24 | 0.675 | 118.2 | 213 | 220 | 232 |
| Ga. Maamendhoo | 00°43′05″N | 73°26′25″E | 1.425 | 0.43 | 51.70 | 1000 | 1138 | 1421 |
| Ga. Nilandhoo | 00°38′5″N | 73°26′50″E | 1.575 | 0.475 | 57.40 | 534 | 592 | 705 |
| Gdh. Nadella | 00°17′45″N | 73°02′25″E | 0.875 | 0.575 | 43.50 | 614 | 725 | 969 |
| Gdh. Faresmaathodaa | 00°11′55″N | 73°11′25″E | 1.36 | 5.07 | 44.90 | 936 | 1059 | 1309 |
| Gdh. Fiyoari | 00°13′25″N | 73°8′10″E | 1.73 | 0.73 | 80.50 | 673 | 825 | 1185 |
| Gdh. Hoadehdhoo | 00°26′45″N | 73°00′15″E | 1.80 | 1.00 | 93.70 | 668 | 796 | 1083 |
| Gdh. Rathafandhoo | 00°15′13″N | 73°06′18″E | 1.275 | 0.25 | 37.20 | 492 | 553 | 675 |

* + 1. 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. 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. Description of Work

The work comprises of the following:

Development of proper Rain water supply system in dry period to facilitate safe drinking water to the population of 8 Islands of Package – V

* 1. Water Supply System

The water supply system shall comprise of:

* Collection
* Treatment
* Storage and
* Supply to Tap Bay points

1. **Collection:** Collection shall include rain water from roofs of institutional and community facilities during rain event. The total roof area by addition of all possible catchment communities from each Island is given in **Table 1.2**. The rain water shall be collected in rain water lifting well. The lifting well shall be built in reinforced cement concrete (RCC). The rain water shall be conveyed up to lift well based on the pressure resulting from the static head due to difference in elevation. The collection system as such shall be designed as a pressure system. The capacity of lift well in each island is given in **Table 1.4** of this section.

**Table 1.2 Roof Areas in 8 Islands of Package – V**

|  |  |  |  |
| --- | --- | --- | --- |
| **Island Name** | **Roof Area (Ha)** | **Island Name** | **Roof Area (Ha)** |
| Ga. Kondey | 0.107 | Gdh. Faresmaathodaa | 0.464 |
| Ga. Maamendhoo | 0.310 | Gdh. Fiyoari | 0.281 |
| Ga. Nilandhoo | 0.255 | Gdh. Hoadehdhoo | 0.266 |
| Gdh. Nadella | 0.279 | Gdh. Rathafandhoo | 0.275 |

1. **Conveyance**: The conveyance shall be from raw water source to treatment facilities and from treatment facilities to treated water tank. The details of conveyance system are given in **Table 1.3**. The flow of raw water from roof catchment to lift well shall be through pressurized system resulting from the static head due to difference in elevation whereas the flow of water from lift well to raw water tank, from raw water tank to ultrafiltration unit and from ultrafiltration unit to treated water tank shall be by pumping.

**Table 1.3 Conveyance System Details in 8 Islands of Package – V**

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Island Name** | **From – To** | | **From – To** | | **From – To** | | **From – To** | |
| **Roof Catchment** | **Lift Well** | **Lift Well** | **Raw Water Tank** | **Raw Water Tank** | **Ultra filter** | **Ultra filter** | **Treated Water Tank** |
| **Pipe Dia. (mm)** | **Pipe Length (m)** | **Pipe Dia. (mm)** | **Pipe Length (m)** | **Pipe Dia. (mm)** | **Pipe Length (m)** | **Pipe Dia. (mm)** | **Pipe Length (m)** |
| Ga. Kondey | 75-180 | 583 | 125 | 5 | 63 | 11 | 63 | 12 |
| Ga. Maamendhoo | 75-250 | 1110 | 200 | 5 | 63 | 9 | 63 | 12 |
| Ga. Nilandhoo | 90-250 | 1064 | 180 | 5 | 63 | 10 | 63 | 12 |
| Gdh. Nadella | 63-315 | 1155 | 180 | 5 | 63 | 9 | 63 | 13 |
| Gdh. Faresmaathodaa | 63-315 | 1767 | 250 | 11 | 63 | 11 | 63 | 11 |
| Gdh. Fiyoari | 75-250 | 1135 | 180 | 6 | 63 | 9 | 63 | 12 |
| Gdh. Hoadehdhoo | 63-250 | 1232 | 180 | 10 | 63 | 12 | 63 | 11 |
| Gdh. Rathafandhoo | 63-225 | 682 | 180 | 5 | 63 | 12 | 63 | 8 |

1. **Treatment:** The treatment shall include ultrafiltration unit for filtration of rain water and disinfection. The size of ultra-filter unit shall be 2 m x 2 m and the capacity shall be 2m3/hr. For disinfection, ultraviolet radiation shall be adopted. Water from ultrafiltration shall pass through UV lamp before entering the treated water storage tank. For maintenance of ultrafiltration system, service shall be available locally, preferably in Male.
2. **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 by pumping. A minimum 2 nos. of pumps shall be required out of which 1 no. shall be working and 1 no. shall be standby. The raw water storage tank shall be a rolled tapered panel (RTP) steel tank.

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. The treated water tank shall receive filtered water from ultrafiltration unit. The stored water in treated water tank shall be supplied to tap bay points located on the islands. All storage tanks shall be provided with external level indicators and flow meters.

Pumping shall also be required to pump water from raw water storage tank to ultrafiltration unit. The water shall flow by gravity from treated water storage tank to the tap bap bay points, however; two distribution pumps are proposed as optional which shall operate alternatively as duty and stand-by.

As the water level in treated water tank drops 1 m to 1.5 m below FSL, ultrafiltration unit shall start for filling the treated water tank for maintaining the required water level.

When ultrafiltration is under maintenance, then only the distribution pumps shall supply the water to tap bay points through pumping.

The capacity of raw water storage tank shall be 100 m3 and treated water storage tank shall be 50 m3. The capacities of lift wells of package – V are given in **Table 1.4**.

Even though the treated water storage capacity is 50 m3, only the required quantity of water which is for 7 days shall be stored in the tank.

The dimensions raw water storage tank and treated water storage tank for all the 8 Islands of package – V are given in **Table 1.5**, whereas the dimensions of lift well is given in **Table 1.6**.

**Table 1.4 Island Wise Capacities of Lift Wells**

|  |  |  |  |
| --- | --- | --- | --- |
| **Island Name** | **Lift Well (m3)** | **Island Name** | **Lift Well (m3)** |
| Ga. Kondey | 3.0 | Gdh. Faresmaathodaa | 8.0 |
| Ga. Maamendhoo | 8.0 | Gdh. Fiyoari | 7.0 |
| Ga. Nilandhoo | 7.0 | Gdh. Hoadehdhoo | 7.0 |
| Gdh. Nadella | 7.0 | Gdh. Rathafandhoo | 7.0 |

**Table 1.5 Dimensions of Raw and Treated Water Storage Tanks**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **S. No** | **Description** | **Capacity (m3)** | **Dia. (m)** | **Height (m)** |
| 1 | Raw water storage tank | 100 | 5.5 | 4.6 |
| 2 | Treated water storage tank | 50 | 4.2 | 4.0 |

**Table 1.6 Dimensions of Lift Wells**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Island Name** | **Lift Well** | | **Island Name** | **Lift Well** | |
| **Diameter (m)** | **Approximate Depth Below GL (m)** | **Diameter (m)** | **Approximate Depth Below GL (m)** |
| Ga. Kondey | 2.0 | 2.0 | Gdh. Faresmaathodaa | 3.30 | 2.0 |
| Ga. Maamendhoo | 3.25 | 2.0 | Gdh. Fiyoari | 3.25 | 2.0 |
| Ga. Nilandhoo | 3.0 | 2.0 | Gdh. Hoadehdhoo | 3.25 | 2.0 |
| Gdh. Nadella | 3.25 | 2.0 | Gdh. Rathafandhoo | 3.25 | 2.0 |

1. **Water Supply to Tap Bay:** The water supply network, shall supply the treated water from treated water tank to tap bay points. The total length of water supply network for each of 8 Islands is given in **Table 1.6** below. The pipe material shall be HDPE and the diameter of pipes to supply the treated water from treated water tank up to tap bay points shall be 63 mm.

**Table 1.6 Island Wise Pipe Lengths of Water Supply to Tap Bay Network**

|  |  |  |  |
| --- | --- | --- | --- |
| **Island Name** | **Pipe Length (m)** | **Island Name** | **Pipe Length (m)** |
| Ga. Kondey | 402 | Gdh. Faresmaathodaa | 1736 |
| Ga. Maamendhoo | 1088 | Gdh. Fiyoari | 964 |
| Ga. Nilandhoo | 590 | Gdh. Hoadehdhoo | 1022 |
| Gdh. Nadella | 879 | Gdh. Rathafandhoo | 1276 |

* + 1. Pumping For Water Supply System

Minimum two distribution pumps as optional shall be installed at treated water storage tank 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.

For all the 8 Islands of package – V, the pumping from RWT to UF; from UF to TWT and from TWT to Tap bay points shall have 2 nos. of centrifugal dry mounted pumps of which 1 no. shall be working and 1 no. shall be stand by. All these pumps shall consume a nominal power of 0.5 KW for smooth operation. The pumping KW of lift well pumps for all the 8 Islands of package – V are given in **Table 1.7.**

**Table 1.7 Lift Well Pumping Details**

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **Island Name** | **Pump Type** | **Application** | **Working** | **Stand by** | **Total** | **Total Capacity (kw)** |
| Ga. Kondey | Submersible | Pumping from Lift Well to RWT | 1 | 1 | 2 | 3.15 |
| Ga. Maamendhoo | 9.15 |
| Ga. Nilandhoo | 7.52 |
| Gdh. Nadella | 8.23 |
| Gdh. Faresmaathodaa | 13.70 |
| Gdh. Fiyoari | 8.29 |
| Gdh. Hoadehdhoo | 8.17 |
| Gdh. Rathafandhoo | 8.11 |

* + 1. 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:

1. Ultrasonic sensor / switch for start / stop control of the pumps and maximum level over ride and alarm; or
2. 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.

1. **Ultrasonic Sensors/Switches**:Ultrasonic 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 ± 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.

1. **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. 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. 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.
* Constructions of foundations for all the storage tanks and filter unit installations.
* Constructions of RCC lift wells as per approved drawings.
* Constructions of boundary fencing for treatment facility
* Housing for ultrafiltration, pumps, electric panels etc. as per approved drawings
* Installation of gates and fencing at treatment facility.
* Conveyance of raw water from source to treatment facilities and that of treated water from treatment facilities up to tap bay points.
* All subsequent performance, testing and maintenance of the entire water supply scheme together with all required consumables for one (1) year from the date of commissioning.
* 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 spares for all major components such as ultrafiltration unit, storage tanks, pumping units etc.
  1. 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. 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 all the storage tanks, ultrafiltration unit and 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 execution.

* Providing, laying and joining of HDPE pipes including all necessary valves, accessories etc.
* Providing area lighting all-round the water supply scheme where required.
* Providing proper boundary fencing all-round the treatment facility.
* Providing housing for all the pumps, ultrafiltration unit, electric panels etc. wherever required.
* 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.
* Training of local counterpart staff for running the water supply scheme and for day to day and periodic maintenance.
  1. 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 supply network spread within the boundary limits of respective islands.

Dewatering constraints: All water removed during excavation for trenching and construction shall be disposed of inland from the excavation for re-percolation back into the water table as outlined in the EPA guide lines; dewatering regulation no. 2013/R-1697. Care shall be taken to avoid excessive dewatering that would cause damage or draw down of the fresh ground water used for house hold use.

* 1. Proposed Water Supply Scheme
* There are currently no major water supply systems on the islands and therefore there are no skilled technical persons in these fields on the islands.
* 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. Components of Water Supply System

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

1. **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.

1. **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. Manual and Automatic both first flush diverters shall be provided to flush off the first rain before entering the system. The manual first flush diverter shall be operated when the automatic diverter is under maintenance.

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.

1. **Ultrafiltration**

For treatment of rain water, ultrafiltration shall be provided. The ultra-filter unit shall receive water from raw water storage tank through pumping. Filtration of water shall remove bacteria, viruses, color, turbidity, fecal coliforms, organic matter, iron & manganese etc.

It is a package type treatment plant which can be used in remote areas and local communities in an affordable manner.

It is an ultrafiltration based water treatment system that produces drinking water quality by filtering bacteria, viruses and particles from raw source water.

It is delivered pre-fabricated and pre-wired, almost as a plug-and-play water treatment system.

The raw water shall have the following characteristics for effective ultrafiltration process considering rain water as source.

|  |  |
| --- | --- |
| Water Quality Parameters | Raw Water Characteristics for Rain Water |
| Turbidity (NTU) | < 3 |
| TSS (mg/l) | < 5 |
| SDI15 | < 5 |
| DOC (mg/l) | < 5 |
| UV254 (1/m) | < 0.1 |
| COD (mg/l) | < 15 |
| Oil (mg/l) | < 0.1 |
| Fe/Mn (mg/l) | < 0.05 |
| Water Hardness (mg/l) | < 60 |
| Conductivity (µS/ cm) | < 500 |

Technical specifications of ultrafiltration are given below:

|  |  |  |
| --- | --- | --- |
| Water Production rate | - | 2 m3/hr. |
| Membrane Type | - | Hollow Fiber, dead-end, outside-in |
| Membrane Material | - | PVDF |
| Membrane Pore Size | - | 0.03 micro meter |
| Control Strategy | - | Parametric to be very flexible |
| Inlet Pressure | - | Max. 1 bar at 1 m3/hr. |
| Power Supply | - | 200-240 V, 1-phase, 50/60 Hz |
| Control Interface | - | PLC based 7” touch screen |
| Weight | - | Empty: 400-615 kg; Filled 750-1165 kg |
| Dimensions | - | Ma. Length 1600 mm, max. width 800 mm; max ht. 2300 mm |

1. **Treated Water Storage Tank**

Treated water from ultrafiltration shall be pumped to treated water tank. This water shall be supplied to tap bay points for drinking through gravity however, optional distribution pumping shall be proposed to supply treated water from treated water tank only when ultrafiltration is under maintenance through a water supply (HDPE) pipeline network. Water sampling taps shall be provided at the entry and outlet of all storage tanks for testing water quality. A minimum of 7 days of water demand shall be provided as water storage in all the islands.

1. **Disinfection**

Disinfection through Ultraviolet radiation shall be adopted. Ultraviolet radiation is suitable for disinfection of water which is free from suspended matter, turbidity and color. It is more effective against bacteria and viruses. Proper maintenance of UV system shall be taken by replacing the UV lamp every 10-12 months. For maintenance of ultrafiltration system, service shall be available locally, preferably in Male.

1. **Pumping from Treated Water Tank to Tap Bay Points**

The water shall flow by gravity from treated water storage tank to the tap bay points, however; a minimum two distribution pumps as optional shall be installed which shall operate alternatively as duty and stand by to supply the stored water through HDPE pipe supply 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.

The diameter of HDPE pipes selected shall be such as to with stand sufficient water pressure at all times. The HDPE pipes for supply network shall be installed with:

* 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.

1. **Water Supply Network**: The water supply network shall convey potable water for the island community, public/private institutions, etc. For water supply 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 supply 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 layout drawings. Minimum pipe size shall be 63 mm. Washout valves at dead ends for draining the pipe line shall be provided.

1. **Housing/Roof Shed:** Housing shall be provided for ultrafiltration unit and for electric panel. The size of housing shall be 5.0 m X 4.0 m. Steel structure housing of GI pipes and sheets shall be provided. The housing shall be as per approved drawings.

Similarly housing shall be provided for all the dry mounted centrifugal pumps of the plant. For pumps, the housing shall be in the form of GI/aluminum sheet as per the requirements depending on number of pumps installed.

* 1. 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/installed in a manner so that the water supply scheme as a whole operates as a total 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. 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. 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. 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. 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. 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.

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

## 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.

## 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.

## 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.

## 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.

## 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.

## 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.

## Office, Stores and Equipment

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

## 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 ground water 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 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.

## 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 laying 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.

## 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.

## 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.

## 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.

## Cooperation at Work Place

If the construction/execution 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.

## 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.

## Environmental Protection

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

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

## 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.

## 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.

## 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



## 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.

## 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 back filling 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.

Topsoil shall be stock piled separately, for subsequent reuse as necessary. All excavated material unsuitable or not required for back filling 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.

## Site Clearing

Only the approved working area required for laying of pipelines 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.

## 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 back filled to proper grade with coarse sand, or other suitable approved material.

## Excavation for Structures

This clause includes excavation for 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.

## 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.

## 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.

## 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.

## 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 house hold 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. Ground water 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.

## Shoring and Sheeting 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.

## 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.

## Backfilling Material

Back fill 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. Back fill material shall have enough moisture for proper compaction, and shall be compacted in an approved manner to the satisfaction of the Employers representative.

## Backfilling 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 back filling operations in trenches shall be carried out as follows:

1. In the lower portion of the trench the back fill 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 back fill 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.
2. The remainder of the trench shall be back filled 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 back filling, as specified above, shall be 85 per cent of maximum density.

After the completion of back filling 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.

## 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.

## Top Soil

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

## Earth Borrow (Back Fill Material Brought from Outside)

Where satisfactory materials for back fill 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)



## 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.

## 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.

## Excavation and Back Fill

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

## 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.

## HDPE Pipes

HDPE pipes and fittings shall meet the requirements of BS EN 12201-2:2003, BS EN 12201-1:2001, BS EN 12201-2:2011+A1:2013.

* + 1. **Raw material**

Raw material used to manufacture the HDPE pipes shall be virgin compounded or natural black PE 100 resin confirming to IS 4984, IS 7328 or equivalent international 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 or equivalent international 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.
  + 1. **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.

* + 1. **Pressure Rating**

The pressure rating of HDPE pipes and specials used for distribution shall be of PN 6 conforming to latest BS codes or equivalent international standards.

* + 1. **Color of Pipes**

The colour of the HDPE pipe shall be confirming to latest BS codes or equivalent international standards.

* + 1. **Reworked Material**

As per the provision of latest BS codes or equivalent international standards, 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.

* + 1. **Dimensions**

The pipe dimensions shall be as per latest BS codes or equivalent international standards. 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 latest BS codes 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 latest BS codes or equivalent international standards for different class of pipes, for different class of pipes. Each pipe shall be of uniform thickness throughout its length.

The wall thickness of PE 100, PN 6 (SDR 26) pipes shall be as per table 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 |

* + 1. **Performance Requirements**

The pipe supplied should have passed the acceptance tests as per latest BS codes or equivalent international standards. 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.

* + 1. **Marking**

As per the provisions of latest BS codes or equivalent international standards, 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.

## 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.

## 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.

## Fittings/Specials

All HDPE fittings/specials shall be fabricated in accordance with latest BS codes or equivalent international standards. PE injection moulded fittings shall also be as per latest BS codes or equivalent international standards. 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 latest BS codes or equivalent international standards. 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 latest BS codes or equivalent international standards. 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 latest BS codes or equivalent international standards. 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 latest BS codes or equivalent international standards

## 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 water tight 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 pipe lines 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.

## Welding

Joining between HDPE pipes and specials shall be done as per the latest BS: 534 or equivalent international standards. 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).

## 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.

## Specifications for Electro-Fusion Fittings for HDPE Pipes

* All the electro-fusion fittings included in this document should be designed for use in water supply 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 supply 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 supply 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 40oC 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.

## 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 mm 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.

## Connecting to Existing Pipes

Where a connection of any kind shall have be made into an existing pipe, such as connecting to house hold 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.

## Field Hydraulic Test

* The sectional hydraulic test shall be carried out after the pipe line 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 pipe line 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:

|  |  |  |  |
| --- | --- | --- | --- |
| **Pipeline OD (mm)** | **Litres per 1000 m of the Pipe Length Tested** | | |
| **1 - Hour Test** | **2 - Hour Test** | **3 - 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.

## 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 back fill has been placed and compacted to a depth of 300 millimeters above the crown of the pipeline.

**Air Test**: Pipe lines 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 mm 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**: Pipe lines 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 mm of nominal internal diameter of the pipe. The water used for the above test shall be obtained from an approved source.

## 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.

## 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.

## Flushing and Disinfecting of Pipelines

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

## 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



## Scope of work

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

## Contractor Submittals

* + 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.

* + 1. **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.

* + 1. **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 not withstanding any previous certificates, which may have been provided.

* + 1. **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.

## 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.

## 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.

# CHAPTER 5 CONCRETE WORKS



## General

## 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.

## Certificates

Minimum 4 weeks prior to starting of any 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.

## Product Materials

* + 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.
  + 1. **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/mm² and for high yield steel shall be 415/450/500/550 N/mm².
* 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.
  + 1. **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.
  + 1. **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.

* + 1. **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**.**

* + 1. **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.

## 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 (OPC) 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.

* + 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.

* + 1. **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 form 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.

* + 1. **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.

## 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.

* + 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.

* + 1. **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.

* + 1. **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.

## Execution

* + 1. **General**

The formwork lines, levels, centers, dimensions etc. before proceeding with concreting shall be verified. 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.

* + 1. **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.
  + 1. **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 27o C, measures shall be placed in affect to minimize concrete temperature to less than 35o C for sections less than 0.3 m thick to avoid shading of aggregate piles.
  + 1. **Placing Grout**

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

* + 1. **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.

* + 1. **Tolerances**

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

## 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.

## Protection

When rate of surface moisture evaporation for concrete surfaces exceeds 0.75kg/m²/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.

## 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.

## 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



## General

## Scope of Work

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

## 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 the manufacturer.

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.

## 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 ofthe tank supplier's drawings shall be an approval relating only to their general conformity with drawings andspecifications and shall not guarantee detail dimensions and quantities, which remains the contractor’s responsibility.

## Tank Dimensions

1. **Raw Water Storage Tank**

The raw water storage tanks shall be built in RTP and the island wise dimension of the tanks shall be as per **Table 1.5** under section Part 2A.

1. **Treated Water Storage Tank**

The treated water storage tanks shall be built in RTP and the island wise dimension of the tanks shall be as per **Table 1.5** under section Part 2A.

## Tank Design Standards

The materials, design, fabrication and erection of the bolt 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.

## RTP Tank Materials Specification

* + 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.

* + 1. **Rolled Structural Shapes**

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

* + 1. **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.
    2. **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 11/2").
      * 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 torqueing shall not be permitted.

* + 1. **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

## Factory Powder Coat Process

* + 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.
    1. **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.

* + 1. **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.

* + 1. **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.

* + 1. **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.

* + 1. **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.

* + 1. **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.
    2. **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.

## Tank Structure

* + 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.

* + 1. **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.

* + 1. **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.

* + 1. **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.

* + 1. **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.
    2. **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.

## 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.

## Field Testing

After complete erection and cleaning of the tank, the structure shall be tested for liquid tightness by filling tank to it’s 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.

## 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.

## 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 PUMPS

## Pump Design and Layout

References to Standards for pumps: The following standards are referred to in this Clause

* BS 970, (ISO 683) Wrought steels for mechanical and allied engineering purposes
* BS 1400, Copper alloy ingots and copper alloy and high conductivity copper coatings
* BS 1452, (ISO 185) Flake graphite cast iron
* BS 3468, (ISO 2892) Austenitic cast iron
* BS 4504, Circular flanges for pipes, valves and fittings
* BS 4675, (ISO 2372) Part 1, Mechanical vibration in rotating and reciprocating machinery
* BS 4999, General requirements for rotating electrical machines
* BS 5316, (ISO 2548) Acceptance tests for centrifugal mixed flow and axial flow centrifugal pumps Part 1 Class C tests
* BS 5345, Codes of practice for the selection, installation and maintenance of electrical apparatus for use in potentially explosive atmospheres
* BS 5512, (ISO 281) Methods of calculating dynamic load ratings and rating life of rolling bearings
* BS 6007, (IEC 245) Rubber insulated cables for electric power and lighting
* BS 6105, (ISO 3506) Corrosion-resistant stainless steel fasteners
* BS 6861, (ISO 1940) Balance quality of requirements of rigid rotors
* BS 7671, Requirements for electrical installations



## General

All equipment covered by this specification shall be designed to operate in the environmental conditions in the Project area. The suction and discharge of the pump set shall include tapping for pressure gauge requirements.

Pump casings for centrifugal pumps shall be split along the axis of the shaft to permit the removal of the impeller shaft assembly without dismantling the pipework or disturbing the pump motor. Top and bottom half casings shall be doweled where necessary to ensure correct alignment. Jacking screws shall be provided on the casing flanges of larger pumps to facilitate dismantling.

The pump casing shall be fitted with a drainage tapping and, if necessary to ensure satisfactory priming, the pump casing shall be fitted with a manual air release valve, which shall be drained to a collection point on the bed plate.

The pump shall be connected to its driving motor by a flexible coupling, which shall be adequately guarded in accordance with HMSO Health and Safety at Work etc. Act 1974 or equivalent

For maintenance of all pumping system, service shall be available locally, preferably in Male.

## Driving Arrangements

The pumps shall be driven by electric motors and be either directly coupled or mono block. Motors shall provide a power margin of not less than 20% above the maximum power absorbed by the pump in any possible operating condition up to 50 kW.

## Impellers

The impeller shall be designed such that water passages shall be smooth and free from hollows, cracks, pinholes and projections that might encourage cavitation.

Impellers of the shrouded type shall normally be fitted with wearing rings at the impeller to provide hydraulic balancing. The rings shall be renewable.

If the impellers are of the un-shrouded type, means shall be provided for axial adjustment of the impeller at the pump thrust bearing location. Impellers shall be keyed and positively secured to the pump shaft by fasteners fitted with locking devices. Surfaces shall be machined or smooth finished all over.

## Seals, Glands and Sleeves

If pumps are fitted with packed glands, the shafts shall be fitted with replaceable sleeves where they pass through the gland. Packing shall be readily replaceable and adjustable. If packed glands are used, effective means shall be provided for collection of the gland leakage water, which shall be piped into the drainage system.

Pumps may be fitted with mechanical seals in place of packed glands only if the seals have a proven record of satisfactory running when fitted to the pump design in question, and with prior approval. Mechanical seals shall be readily adjustable and replaceable

Flushing facilities shall be provided for mechanical seals or packed glands if the pumped fluid may include abrasive material.

## Bearings

Pump bearings shall have a design running life of not less than 75000 hours. Bearings shall be designed for loadings 20% in excess of calculated maximum loading and shall be suitable for reverse rotation at 150% of rated speed or the maximum reverse speed the pump can reach in installed conditions when driven backwards by reverse flow if this is greater.

Bearing cooling arrangements shall use closed circuits. Open discharge of cooling water into the pumping station drainage system is not permissible. The coolant flow shall be easily visible and local indication of bearing metal temperature shall be provided. Excessive metal temperatures shall result in safe shutdown of the pump.

## Balancing

Rotating assemblies shall be statically and dynamically balanced in accordance with ISO 1940–1. They shall be designed so that the first critical speed of the pump and its drive is at least 50% higher than the maximum operating speed. If rotating assemblies are small and out-of-balance forces are negligible, the Engineer may waive this requirement. For each pump, the manufacturer shall state whether or not balancing has been completed.

## Net Positive Suction Head (NPSH)

The NPSH requirements of pumps, based on the 2% output drop criterion, shall be at least 1 m less than the NPSH available at every working condition at site maximum ambient temperature.

## Velocities in Pump Branches

Unless otherwise specified, the water velocity in the suction branches of a pump shall not exceed 1.5 m/s and in the discharge branch shall not exceed 2.5 m/s when the pump is operating within its specified working range. There shall be no discernible noise due to hydraulic turbulence or cavitation within the pump or its associated pipe work and valves.

If discharge branch velocities exceed 2.5 m/s in the working range, the use of profiled taper pipes will be allowed. Taper pipes shall be designed to reduce velocity progressively to not greater than 2.0 m/s, using profiled internal contours which contain no steps or angles from which turbulence or cavitation can be generated. The taper pipes shall be considered as part of the pump and be included in performance calculations and tests.

## Priming

Unless otherwise approved, pumps shall be set at levels, which ensure they are self-priming or primed automatically at the lowest inlet water level, which is possible in normal operation.

## Base Plates

If pump and motor are mounted on a combined bedplate, the bedplate shall be a substantial fabricated-steel construction or of cast iron. Holes for holding-down bolts shall be included, and all packing for levelling, and all holding-down bolts and the like shall be provided. Steel dowels shall be fitted after final alignment of pump and motor to facilitate dismantling and reassembly.

## Pump Performance

The pump sets shall be designed to meet the performance requirements. Pump performance guarantees shall relate to the flow rate, the total head and the efficiency of the pump when tested at the manufacturer’s works. Verification of factory test results shall form part of the Site Tests on Completion.

Pumps shall operate at design duty within the acceptance tolerances for flow and total head laid down in ISO 3555.

Unless otherwise specified, at the time of tender the contractor shall supply the performance curves for the pumps he is providing. The curves shall show total head, pump efficiency, power absorbed by the pump, and NPSHr plotted against flow rate for the full operating range required. The curves shall be extended to show shut valve conditions, and to show performance at flow rates at least 20% in excess of the maximum flow rate expected in normal operation at site conditions.

Where appropriate, curves shall also be included to show the variations in station losses and internal plant losses plotted against flow rate, to enable the complete pump performance curves to be shown.

If the purchaser’s estimated system curves for head against flow have been provided, the contractor’s pump curves shall be superimposed on the system curves to show conveniently the expected performance in site conditions.

## Submersible Pumps for Open Well

* + 1. Pump details

Submersible pumps shall be of the totally submersible radial-flow or mixed-flow type directly coupled to submersible motors. The complete unit shall be suitable for continuous operation when totally submerged. Pump set speed shall preferably not to exceed 2900 rpm.

Pump bodies shall have separate sections for each stage, which shall have matching faces, machined and spigot to allow accurate location and alignment of the sections during assembly. Fixing nuts, bolts, studs, and washers shall be stainless steel.

To ensure vibration-free operation, all rotating components of each pumping unit shall be statically and dynamically balanced to BS 6861 and shall be free of cavitation, vibration, noise, and oil or water leaks over the range of operation meeting following requirements:

* The mass of the unit and its distribution shall be such that resonance at normal operating speeds is within acceptable limits
* In any case, the amplitude of vibration as measured at any point on the pumping unit shall not exceed the below limits
* At any operating speed, the ratio of rotate speed to the critical speed of a unit, or components thereof, shall be less than 0.8 or more than 1.3

The Contractor shall ensure that the controls and starting equipment are suitable for use with the pump motor, taking into account all requirement including starting current and number furnished with the pump. For the performance curve of the selected pump impeller, the head shall continuously rise as flow decrease throughout the entire curve run out to shutoff head.

Characteristic curves for the pumps to a reasonably large scale shall be supplied with the offer and when tested through their complete range of workable heads the pumps shall give results, which conform to the curves.

The guaranteed duty point shall be as near as possible to the best efficiency point for the pump selected.

The pump sets and cables shall be suitable for indefinite immersion and operation under all conditions.

The minimum life expectancy of the mechanical and electrical installations is to be 15 years.

Load tested stainless steel lifting chains shall be provided in order that the pump can be lifted in stages from the bore well using the lifting gear.

Pump motor starters shall be housed in Factory Built Assemblies (FBAs) and a duplicate pump data plate shall be screw fixed inside the motor starter compartment.

The contractor shall supply, install and commission a complete and permanent indoor and outdoor lighting, small power and cabling system in the whole area.

Cables in existing hazardous areas and air-conditioned areas shall pass through cable transits.

The small power and lighting installation shall be earthed.

All cables terminating at the FBA shall have their earth conductor earthed at the FBA earth bar.

Surface preparation, priming and final painting should be provided to all machinery and steel work within the pumping station.

The contractor shall provide detailed operation manual, drawings wiring diagrams maintenance/overhaul schedules, spare parts catalogue schedules of all lubricants etc. prior to handing over.

* + 1. Design Conditions

Pumps shall be designed and constructed to satisfactorily operate and perform within the designated design conditions and the requirements specified herein. They shall be designed for a life of 100,000 hours with services intervals at 20,000 hours.

Pumps shall be provided with long bearings designed for an L10 life of at least 75000 hours in accordance with BS 5512 to stabilize the shaft and motor shaft and avoid radial thrust on the motor bearing. Bearings shall be water lubricated and, if rubber-type bearings are used, the bearing material shall be securely bonded to the housing. Rubber-type bearings shall be used only where there is sufficient pressure difference through the bearing to provide adequate lubrication and cooling, and where the bearing is submerged under all operating and starting conditions. Natural rubber shall not be used.

Bearings shall be positively retained within the pump body to prevent bearing rotation; a press fit alone is not acceptable.

Pump operating speed of the pump shall be preferably 1470 rpm but shall not exceed 2900 rpm.

Renewable impeller wear rings shall be stainless steel conforming to BS 970, S15 fitted, to the impeller and case, except where not available on a standard production unit.

Vibration levels shall not exceed the levels given in BS 4675 for Class II machines, quality bands A and B.

The pump, motor and associated electrical equipment shall be rated for a minimum 10 starts per hour, unless otherwise designated.

The contractor shall ensure that the pump manufacturer provides certification, which guarantees the following:

1. Flow rate
2. Total head
3. Power input
4. Efficiency

The pump shall be suitable for use in the ambient conditions in which the temperature can reach 510C. At rated duty the velocity in the system should not be more than 2.5 m/s.

The pump casing shall be cast iron, BS 1452 Grade 220 or 260 with a lower renewable wear ring. Any other part liable to wear shall also be renewable. If considered necessary by the manufacturer to give long life, zinc sacrificial anodes shall be provided.

Pump impeller shall be zinc free bronze or stainless steel.

Pump shafts shall be high tensile stainless steel conforming to BS 970 Part 1.

Hydraulic balances holes shall not be provided. Impellers shall be keyed and positively secured to a combined ground duplex stainless steel 410/316 pump/motor shaft and each shall be tested and adjusted for static and dynamic balance.

An oil chamber shall be incorporated between the pump and motor unit to lubricate seal rings. The pump, motor and associated electrical equipment shall be rated for a minimum of 10 starts/hour and suitable for starting from cold three times in succession or from hot twice in succession followed by a maximum of 5 starts over the next half hour.

Local start/stop and emergency stop push buttons shall be provided for each motor.

Power factor correction capacitors to improve PF better than 0.99 shall be provided for each motor, which shall be installed in the related LT cubicle panel board.

* + 1. Submersible motors

Motors shall be 380-430 V, 3 Phase or 230 V Single phase and 50 Hz, rated at 20% above the maximum power requirement.

Motors shall be squirrel cage, induction, air filled, totally sealed to IP 68 suitable for the maximum immersion depth likely to be encountered, rated to BS 5345.

Motor insulation shall be class F, limited to a class B temperature rise.

A watertight cable junction box sealed from the motor shall be provided for the motor power and control wiring.

Cables shall be EPR insulated, flexible 450/750 volts grade, oil and grease resistant, with tinned annealed copper conductors in accordance with BS 6007. The cable shall be brought directly out of the submersible motor without joints, and shall be of sufficient length, minimum 20m to be terminated in an IP67 junction box outside adjacent to the bore well. They shall be sized in accordance with MEW regulations and BS 7671.

Cables shall be supported using a proprietary “sock” arrangement at the top of the bore well.

Where required in the project specification pumps shall be provided with proprietary monitoring and controls units for inclusion in the motor control.

Motors shall be capable of startup and operation in the event of a completely flooded bore well. Motors shall be selected to meet the maximum power required for the selected impeller at all operating conditions.

Motor cooling shall either be by means of the pumping medium. The use of external cooling water is not acceptable.

## Horizontal Split Casing Centrifugal pumps

* 1. 1. Pump details

Pumps shall be horizontally mounted and directly coupled to their motors. Pump and motor shall be mounted on a combined fabricated steel base plate. Rotating assemblies shall be statically and dynamically balanced and shall be designed so that the first critical speed of the pump and its drive is at least 50% greater than the maximum operating speed.

Pump shall not exceed 1500 rpm. However if 1500 rpm is not suitable for selection, pump speed shall not exceed 2950 rpm in case of high head of pumps.

The pumping units shall all be supplied by one manufacturer and shall be complete including pumps, motors, controls and appurtenances such as, but not limited to, couplings, guards and gauges.

Manufacturer's certified rating curves, shall be submitted shall be submitted to satisfy the specified design conditions, showing pump characteristics of discharge, head, brake horsepower, efficiency and guaranteed net positive suction head required (NPSHr). Curves shall show the fully recommended range of performance and include shut‑off head. This information shall be prepared specifically for the pump proposed. Catalog sheets showing a family of curves will not be acceptable.

The pumps, motors, and controls shall be designed and built for 24‑hour continuous service at any and all points within the required range of operation, without overheating, without cavitation and without excessive vibration or strain. All parts shall be so designed and proportioned as to have liberal strength, stability and stiffness and to be especially constructed to meet the specified requirement. Ample room and facilities shall be provided for inspection, repairs, and adjustment.

All necessary foundation bolts, nuts, and washers shall be furnished and shall be Type 316 stainless steel.

Each major piece of equipment shall be furnished with a stainless steel nameplate (with embossed data) securely mounted to the body of the equipment. As a minimum, the nameplate for the pumps shall include the manufacturer's name and model number, serial number, rated flow capacity, head, speed and all other pertinent data. As a minimum, nameplates for motors shall include the manufacturer's name and model number, serial number, horsepower, speed, input voltage, amps, number of cycles and power and service factors.

* + 1. Design Conditions

Casings shall be of cast iron conforming to ASTM A48, Class 30 of sufficient thickness and suitably ribbed to withstand all stresses and strains of service at full operating pressure. Casings shall be of the multiple volute type split on the horizontal centerline with the suction and discharge nozzle cast integrally with the lower half. Removal of the upper half of the casing must allow the rotating element to be removed without disconnecting the suction and discharge flanges. Lifting eyes shall be cast into the upper casing.

Flange and casings shall be designed for a working pressure of 12 bars. The casing shall be provided with tapped and plugged (removable) vent, drain and gauge connections. Suction and discharge connections shall be 300 lbs. ANSI Standard flat‑face flanges positioned as indicated on the Drawings.

Impellers shall be of the enclosed type of cast bronze ASTM B145, (certified analysis of the impeller pour metal required). Impeller shall be cast in one piece and shall be statically and dynamically balanced. Rotation of the impeller shall correspond to the pump discharge orientation as indicated on the Drawings. The impeller shall be keyed to the shaft and firmly held in place. The arrangement shall be such that the impeller cannot be loosened by torque from either forward or reverse rotation.

* + 1. Wearing Rings
  + The pumps shall be provided with removable leaded bronze wearing rings ASTM B584, for both the casing and impeller, with the wearing surfaces parallel to the axis of rotation. The impeller-wearing ring shall be designed to compensate for a minimum of 6 mm wear
  + Wearing rings shall be securely fastened to prevent any relative motion and designed for easy replacement

The pump(s) shall be furnished with a stuffing box cast integrally with the casing that is readily accessible and equipped with a minimum of five rings of packing in addition to a lantern ring. Each stuffing box shall be provided with a removable split bronze gland with Type 316 stainless steel studs, bolts and nuts to facilitate packing replacement. The lantern ring shall be located adjacent to the outboard second packing ring. The stuffing box shall be drilled and tapped for a 19mm water seal connection.

A tag with the following wording must be installed on each seal water drain valve: "The valve on the seal water drain line must be closed when the pump is operating."

The pump bearings shall be of the heavy-duty row anti‑friction type arranged for grease lubrication with pressure device designed in accordance with AFBMA Standards for a minimum B‑10 life of 75,000 hours, without the addition of external cooling. The inboard and outboard bearings shall be interchangeable. Removable bearing housings shall be bolted and doweled to bearing brackets that are cast integral with the pump lower half casing.

Pump shaft(s) shall be of heat-treated alloy steel, rigid‑shaft type and of sufficient size to transmit the full driver horsepower with a liberal safety factor, accurately machined over the entire length and free from harmful and damaging vibrations. The shaft(s) shall be protected from wear in the stuffing box areas by renewable hardened chrome steel shaft sleeves with a minimum 300 to 350 Brinell hardness. The sleeves shall be sealed to prevent leakage between the sleeve and the shaft. Shrink fit shaft sleeves will not be acceptable. Furnish and install tapped holes in the suction and discharge flanges and 6mm copper pipe nipples complete with "T"‑handle cocks for use in connecting pressure gauges. Nipples shall be of such length and provided with elbows if necessary so that a pressure gauge may be easily installed and read.

The pumps shall be provided with two glycerin‑filled suction and discharge pressure gauges with a 6mm NPT inlet and 110 mm dials. The suction gauges shall be of the compound type to indicate both vacuum and pressure and be graduated to read 15 m positive pressures and 750 mm mercury negative pressures. The discharge gauges shall be graduated from 0 to 10 bars. The gauges shall be connected to the pump nozzles. All fittings and cocks shall be red brass.

The pump and driving motor shall be mounted on an extended fabricated steel base plate, with provision to collect leakage and shall be of sufficient size and rigidity to support the unit and prevent harmful or damaging vibration. A 19mm drain tap and copper pipe nipple shall be provided. The steel base shall be anchored to the level surface of a concrete pad with suitably sized Type 316 stainless steel anchor bolts.

## Horizontal Mono Block Centrifugal Pumps

* + 1. Pump details

Pumps shall be radially mounted and directly coupled to their motors on a common shaft. Pump and motor shall be mounted on a combined fabricated steel base plate. Rotating assemblies shall be statically and dynamically balanced and shall be designed so that the first critical speed of the pump and its drive is at least 50% greater than the maximum operating speed.

Pump shall not exceed 1500 rpm. However if 1500 rpm is not suitable for selection, pump speed shall not exceed 2950 rpm in case of high head of pumps.

The pumping units shall all be supplied by one manufacturer and shall be complete including pumps, motors, controls and appurtenances such as, but not limited to, couplings, guards and gauges.

Manufacturer's certified rating curves, shall be submitted shall be submitted to satisfy the specified design conditions, showing pump characteristics of discharge, head, brake horsepower, efficiency and guaranteed net positive suction head required (NPSHr). Curves shall show the fully recommended range of performance and include shut‑off head. This information shall be prepared specifically for the pump proposed. Catalog sheets showing a family of curves will not be acceptable.

The pumps, motors, and controls shall be designed and built for 24‑hour continuous service at any and all points within the required range of operation, without overheating, without cavitation and without excessive vibration or strain. All parts shall be so designed and proportioned as to have liberal strength, stability and stiffness and to be especially constructed to meet the specified requirement. Ample room and facilities shall be provided for inspection, repairs, and adjustment.

All necessary foundation bolts, nuts, and washers shall be furnished and shall be Type 316 stainless steel.

Each major piece of equipment shall be furnished with a stainless steel nameplate (with embossed data) securely mounted to the body of the equipment. As a minimum, the nameplate for the pumps shall include the manufacturer's name and model number, serial number, rated flow capacity, head, speed and all other pertinent data. As a minimum, nameplates for motors shall include the manufacturer's name and model number, serial number, horsepower, speed, input voltage, amps, number of cycles and power and service factors.

* + 1. Design Conditions

Casings shall be of cast iron conforming to ASTM A48, Class 30 of sufficient thickness and suitably ribbed to withstand all stresses and strains of service at full operating pressure. Casings shall be of the multiple volute type split on the horizontal centerline with the suction and discharge nozzle cast integrally with the lower half. Removal of the upper half of the casing must allow the rotating element to be removed without disconnecting the suction and discharge flanges. Lifting eyes shall be cast into the upper casing.

Flange and casings shall be designed for a working pressure of 12 bars. The casing shall be provided with tapped and plugged (removable) vent, drain and gauge connections. Suction and discharge connections shall be 300 lbs. ANSI Standard flat‑face flanges positioned as indicated on the Drawings.

Impellers shall be of the enclosed type of cast bronze ASTM B145, (certified analysis of the impeller pour metal required). Impeller shall be cast in one piece and shall be statically and dynamically balanced. Rotation of the impeller shall correspond to the pump discharge orientation as indicated on the Drawings. The impeller shall be keyed to the shaft and firmly held in place. The arrangement shall be such that the impeller cannot be loosened by torque from either forward or reverse rotation.

* + 1. Wearing Rings
  + The pumps shall be provided with removable leaded bronze wearing rings ASTM B584, for both the casing and impeller, with the wearing surfaces parallel to the axis of rotation. The impeller-wearing ring shall be designed to compensate for a minimum of 6 mm wear
  + Wearing rings shall be securely fastened to prevent any relative motion and designed for easy replacement

The pump(s) shall be furnished with a stuffing box cast integrally with the casing that is readily accessible and equipped with a minimum of five rings of packing in addition to a lantern ring. Each stuffing box shall be provided with a removable split bronze gland with Type 316 stainless steel studs, bolts and nuts to facilitate packing replacement. The lantern ring shall be located adjacent to the outboard second packing ring. The stuffing box shall be drilled and tapped for a 19 mm water seal connection.

A tag with the following wording must be installed on each seal water drain valve: "The valve on the seal water drain line must be closed when the pump is operating."

The pump bearings shall be of the heavy-duty row anti‑friction type arranged for grease lubrication with pressure device designed in accordance with AFBMA Standards for a minimum B‑10 life of 75,000 hours, without the addition of external cooling. The inboard and outboard bearings shall be interchangeable. Removable bearing housings shall be bolted and doweled to bearing brackets that are cast integral with the pump lower half casing.

Pump shaft(s) shall be of heat-treated alloy steel, rigid‑shaft type and of sufficient size to transmit the full driver horse power with a liberal safety factor, accurately machined over the entire length and free from harmful and damaging vibrations. The shaft(s) shall be protected from wear in the stuffing box areas by renewable hardened chrome steel shaft sleeves with a minimum 300 to 350 Brunel hardness. The sleeves shall be sealed to prevent leakage between the sleeve and the shaft. Shrink fit shaft sleeves will not be acceptable. Furnish and install tapped holes in the suction and discharge flanges and 6mm copper pipe nipples complete with "T"‑handle cocks for use in connecting pressure gauges. Nipples shall be of such length and provided with elbows if necessary so that a pressure gauge may be easily installed and read.

The pumps shall be provided with two glycerin‑filled suction and discharge pressure gauges with a 6mm NPT inlet and 110 mm dials. The suction gauges shall be of the compound type to indicate both vacuum and pressure and be graduated to read 15 m positive pressures and 750 mm mercury negative pressures. The discharge gauges shall be graduated from 0 to 10 bars. The gauges shall be connected to the pump nozzles. All fittings and cocks shall be red brass.

The pump and driving motor shall be mounted on an extended fabricated steel base plate, with provision to collect leakage and shall be of sufficient size and rigidity to support the unit and prevent harmful or damaging vibration. A 19 mm drain tap and copper pipe nipple shall be provided. The steel base shall be anchored to the level surface of a concrete pad with suitably sized Type 316 stainless steel anchor bolts.

# CHAPTER 8 ROADWORKS



## 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 type of surfacing:

* Sand-gravel roads and foot paths

Road ways 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.

## 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 9 ELECTRICAL AND CONTROL EQUIPMENT

1. **Scope of Works**
3. General Electrical Requirements

Scope includes Design, Supply, Installation, testing and commissioning of electrical works for proposed Treatment Facility. For all the related electrical works, the contractor shall take approval from MEE approved electrical engineer and all the electrical works shall be completed with National regulations and guidelines.

* 400V Low Voltage Switch boards and other aux. switch boards, if required, with necessary protection and metering (Indoor Type)
* Power and Control Cables & Cabling
* Indoor and Outdoor Lighting System
* Earthing System

2. 1. **Scope of Works**

Supply Voltage proposed is 400V considering the power requirement as well as reliability. Power supply shall be made available by Electric Supply Company at nearest Electric Supply Company Substation or 2 pole structures for each Treatment Facility site separately. Contractor scope starts from point of supply/meter by laying the suitable size of power cable for connecting to Main LT Panel. The works involved are as under:

* 1. **400 V Main LV Panel**
* 1 no. of suitable rating of TPN MCCB as an incomer with required necessary protections/accessories
* 10 nos. of motor feeders with TP MPCB for motors complete with required necessary protections/accessories
* 1 no. of TPN MCB+ELCB as an outgoing feeder for Indoor and Outdoor Lighting System
* 2 nos. of TPN MPCB/MCB/MCCB as an outgoing feeder for Actuators
* 2 nos. of TPN MCB as outgoing spare feeders
* 1 nos. of TPN MCCB as outgoing spare feeder

All motors, actuator, lighting etc. should be control from Main LV Panel only. This panel is of outdoor type. Also a canopy skin roof shall be fitted over the whole assembly to give added protection against direct sunlight/rain/dust etc.

* 1. **L.T Starters**
* DOL (Direct Online) Starter shall be used for motors up to 7.5 kW
* Star Delta Starter shall be used for motors above 7.5 kW
* VFDs shall be used only for Treated Water Pump Motor, as these motors should operate on variable flow
  1. **Motors**

Submersible motor shall be used in Lift Well to lift the rain water. Motor will stop depending on the level of tank.

Squirrel cage induction motors (TEFC outdoor type) shall be used for pumping from raw water storage tank to ultra-filter, ultra filter to treated water storage tank and treated water tank to tap bay points. Motor will stop depending on the level of tank. Canopy should be provided for outdoor motors.

* 1. **Earthing System**

All electrical equipment, metallic bodies etc. should be earthed properly.

* 1. **Lighting System**

2 nos. of 1x36W Industrial Tube lights with required nos. of switches, plug points etc. in electrical panel room.

6 nos. of Street Light Fixtures with 1x150W HPSV mounted on 7.5Mtr height above ground with 5 nos. of 9Mtr steel tubular street light pole. This shall also include all necessary cabling, wiring, with power factor corrected internal control gear, earthing, fuse cut-out boxes, pole bases, etc.

1 no. of Street Light Fixture with 1x36W Tube Light mounted near each centrifugal pump area. This shall also include all necessary cabling, wiring, with power factor corrected internal control gear, earthing, fuse cut-out boxes, pole bases, etc.

* 1. **Local Push Button Stations**

Start/stop buttons with control panel shall be provided for submersible motors.

Outdoor type local push button stations shall be provided near all motors.

* 1. **References**

The following standards are to be adhered to:

* IEC 144/IEEE/BS or any equivalent International Standard - Degrees of protection of enclosures for low-voltage switchgear and control gear
* IEC 439/IEEE/BS or any equivalent International Standard - Factory-built assemblies of low-voltage switchgear and control gear
* IEC 529/IEEE/BS or any equivalent International Standard - Classification of degree of protection provided by enclosures
* IEC 947/IEEE/BS or any equivalent International Standard - Molded Case Circuit Breakers (MCCB)
* IEC 898/IEEE/BS or any equivalent International Standard - Miniature Circuit Breakers (MCB)
* IEC-60502 Part 1/IEEE/BS or any other International Standards – Power Cables
* IEC/BS/IEEE or any other International Standards for Design, Supply, Installation, testing and commissioning of electrical works

1. **Technical Specifications For Electrical Works**
   1. **General Electrical Requirements**

Scope includes Design, Supply, Installation, testing and commissioning of electrical works for proposed Treatment Facility.

* 400V Low Voltage Switch boards and other aux. switch boards with necessary protection and metering (Indoor Type).
* Power and Control Cables & Cabling.
* Indoor and Outdoor Lighting System.
* Earthing System.
  1. **Nominal Power Supply System**

|  |  |  |  |
| --- | --- | --- | --- |
| (a) | Incoming supply | - | 400V, 3 phase, 4 wire, 50 Hz |
| (b) | Plant Power Distribution Voltages |  |  |
|  | i) Low Voltage | - | 400V 3Phase 4 Wire 50Hz |
| (c) | Lighting, Ventilation and space heating | - | 230V, 1 Phase, 2 wire, 50 Hz, AC |
| (d) | A-C Control (wherever specified) | - | 230 V, 1 Phase, 2-wires, 50 Hz |
| (e) | Voltage variation | - | ± 10% |
| (f) | Frequency variation | - | ± 5% |
| (g) | Combined voltage & frequency variation | - | ± 10% |
| (h) | Earthing |

The electrical system for the treatment facility consists of power supply to the pumps, outdoor lighting and other auxiliary load and along with the load requirement of all Treatment Facility.

1. 1. 1. **Scope of Works**

Supply Voltage proposed is 400V considering the power requirement as well as reliability. Power supply shall be made available by Electric Supply Company at nearest Electric Supply Company Substation or 2 pole structures for each Treatment Facility site separately. Contractor scope starts from point of supply/meter by laying the suitable size of power cable for connecting to Main LT Panel. The works involved are as under:

* 400V LT Panels with necessary protection and metering
* Power and Control Cables.
* Indoor and Outdoor Lighting System.
* Earthing System.
  1. **400V Main LV Panel**
     1. **Feeder Details**
* Phases, 4 Wire, 400V, 50Hz Incoming Supply will directly feed to Main LT Panel (Rain Water Pump Panel) from nearest Supply Company point / 2 pole structures through suitable size of cable.
* Main Incomer, MCCB, TPN fixed type with O/C, E/F, other required protections and all necessary accessories.
* 8 nos. of Motor Feeders as mentioned in SLD with TP MPCB for Motors complete with protection relays, CTs, Meters and all necessary accessories.
* 1 no. of TPN MCCB as an outgoing feeder for Ultra Filtration System
* 1 no. of TPN MCB+ELCB as an outgoing feeder for Indoor and Outdoor Lighting System
* Nos. of TPN MPCB/MCB/MCCB as an outgoing feeder for Actuator.
* 2 nos. of TPN MCB as outgoing spare feeder
* High Conductivity Al grade E91E for TPN bus bar, size shall be suitable for continuous current rating as per the detailed design.
* All equipment/panel board should be as per relevant IEC/IEEE/BS or any other international standard.
* Panel should be suitable for Indoor type.
* All motors, actuator, lighting etc. should be control from Main LV Panel only.
  + 1. **References**

The following standards are to be adhered to:

* IEC 144/IEEE/BS or any equivalent International Standard - Degrees of protection of enclosures for low-voltage switchgear and control gear.
* IEC 439/IEEE/BS or any equivalent International Standard - Factory-built assemblies of low-voltage switchgear and control gear
* IEC 529/IEEE/BS or any equivalent International Standard - Classification of degree of protection provided by enclosures
* IEC 947/IEEE/BS or any equivalent International Standard - Moulded Case Circuit Breakers (MCCB)
* IEC 898/IEEE/BS or any equivalent International Standard - Miniature Circuit Breakers (MCB)
* IEC/IEEE/BS or any equivalent International Standard – other required equipment’s such as CT, PT, Meters, construction etc.
  1. **Outdoor Installations**

The enclosures for outdoor locations shall be double skinned and fitted with lockable outside doors, and housing so designated that all controls, instruments and such like are fully enclosed and the whole assembly weatherproof and vandal proof. The internal cubicles shall also be weatherproof to allow operation of the controls when the outside doors are open during inclement weather.

When specified a canopy skin roof shall be fitted over the whole assembly to give added protection against direct sunlight/rain/dust etc.

* 1. **LV Starters** 
     1. **General**

Starters and their components shall provide Type 2 Co-ordination to BS EN 60947-4-1. They shall be so arranged to provide easy access to all components for maintenance purposes. Starter shall be damp-proof and dust-proof with a minimum Ingress Protection (IP) rating of IP 54. Motor starters shall be rated to carry full load current of its rated duty at its most severe load conditions. All starters shall be selected for Utilization Category AC3 duty and be capable of at least 15 starts per hour at 100% full load torque. Contactors shall confirm to standard BS EN 60947-4-1 Utilization Category AC-3, type tested and ASTA-certified to achieve Type 2 Co-ordination.

* + 1. **DOL (Direct Online) Starter**

Direct-on-Line (DOL) Starters shall be used for motors up to 7.5 kW. DOL starters shall be designed to start and accelerate the motor to normal speed and provide overload protection to the motor and its associated power circuit by switching off the motor by disconnection of the supply.

* + 1. **S/D (Star Delta) Starter**

Star/Delta starters shall be designed to start and accelerate a 3-phase motor in such a way that the stator windings are connected in ‘Star’ initially and after a recommended time delay are connected in ‘Delta’ for final running. The S/D starter shall provide suitable overload protection by disconnection of the supply to the motor. The transition from Star to Delta must occur when the motor is approaching full speed in Star.

The transition time between the Star and Delta contactors shall be adjustable to ensure that the Star contactor is opened before the Delta contactor is closed. The motor shall have 6 terminals in the junction box of the motor with a shorting strip to facilitate Star/Delta starting. Resisting torque during starting shall be less than 1/3rd of the maximum rated motor torque. Closed-transition type S/D starters shall include wire-wound porcelain core resistor banks of sufficient thermal rating to allow three consecutive starts of 30 seconds starting period followed by a 15 minutes rest and another 30 seconds starting period. Resistance values shall be chosen to give high starting current with low transients current. Starter compartments incorporating resistor banks shall be ventilated as necessary.

* + 1. **VFD (Variable Frequency Drive)**

The VFD shall be constructed as follows:

* Rating, as per the Key Electrical SLD/as per rated KW of motor.
* Anti- condensation heaters
* Size to fit in the main panel (Outdoor Type) with necessary space.
* Hardwired and Modbus TCP interface for connection to the ICA Panel, if required.
* Protected against short circuit between output phases and ground, analogue outputs and logic circuit.
* Operate at a power factor of >96%. And efficiency >97% at full load
* VFD shall utilize the latest technology to restrict the harmonic distortion limits
* Have a dedicated microprocessor-based comprehensive electronic motor protection system

VFD cubicle shall be considered as a starter with the addition of a VFD with display unit and a keypad. VFD shall be low harmonic complete with ventilation fans and suitably coordinated with the pump motor. The Total Harmonic Distortion (THD) shall be limited to lowest level under 5% as per G5/4-1 and IEE 519

* 1. **Electrical Cables**
     1. **General Requirements**
* Cables shall be supplied by an approved manufacturer and where possible the same manufacturer shall be used for all cables.
* All cables shall be delivered with cable ends effectively sealed. When a cable is cut from a drum both cable ends shall be immediately sealed to prevent ingress or moisture.
* All cable cores shall be color coded throughout their length and shall be so connected between switch board, distribution board, plant and accessories, that the correct sequence or phase colors are preserved throughout the system.

The color coding should be as follows:

* 3 phase red, yellow and blue
* Single phase red and black
* Earth yellow green
* Control white
* Cable joints shall not be permitted for LV cable installations.
* The term cabling shall include all cable, cable tray, conduit fixings etc. necessary for the satisfactory operation of the plant.
* The installation of the cabling shall be of a 'neat' appearance and functional with cable length kept to a practical minimum.
* Cables complying with BS or IEC approved equivalent standards will be accepted provided all cables which are supplied for a specified operating voltage are to the same national standard. Standards specified in the following clauses indicate the type of cables used in the design: if the Contractor wishes to use cables to an alternative standard then details of current carrying capacity, de-rating factors etc., shall be submitted to the Engineer for approval.
* The power and control cabling shall interconnect the entire Plant including but not limited to:
* Main LT Panel to other pump panels, if required.
* Main LT Panel to DB, if required.
* Lighting
* Control wiring
* Cable Laying in conduit, cable trays, trench, soil, underground, water, etc. including all accessories including cable glands, terminations, cable markers, support systems, clips, fittings and fixtures shall be as per standard practice as specified in relevant IEC/BS or any International standards.
  + 1. **Rating**
* The contractor shall ensure that each cable is adequately rated for its duty under normal and possible fault conditions.
* The rated voltage of the cables shall not be less than the operating voltage and when assessing the rating and cross section of each cable the following factors shall be taken into account:
* Maximum voltage drop permissible
* Type and magnitude of load
* Fault level and duration related to circuit protection relays and fuse gear.
* Over current setting of relays and circuit-breakers
* Route length and disposition of cables
* Ambient temperature
* Method of lying
  + 1. **Conductors**

Nominally electrical conductors for all types of cable shall be of high conductivity copper. All cores shall be at least 2.5 sq.mm cross-sections. With the exception of mineral insulated cables all conductors in excess of 2.5sq.mm shall be stranded.

The Contractor may offer cables incorporating aluminum conductors as an alternative to copper providing that the cross section of each cable is adequate to meet its rating requirements and that due provision is made to prevent corrosion at connections between dissimilar metals. Full details of such precautions shall form part of the alternative proposal.

* 1. **LV Power Cables**
     1. **General Clauses**
* All cables shall be sized for continuous operation at full load at maximum ambient temperature and have a 600/1000 voltage rating.
* Main power cabling shall be copper armored.
* Lighting and control cabling shall be PVC insulated 2.5 sq.mm cable minimum and shall run in galvanized steel conduit unless otherwise specified.
  + 1. **Armored Cables**
* Power cables shall be as per IEC-60502 Part 1/IEEE/BS or any other International Standards provided.
* Cables which are laid external to the electrical panels shall be armored as per IEC-60502-5/IEEE/BS or any other International Standards.
* All such cables shall be terminated with mechanical glands which shall be of a type as to provide adequate mechanical support by positively locking on the armored and shall at the same time give a high level of earth continuity.
* Submersible Flat Copper Cables should be considered for Submersible Motors.
  + 1. **Un-armored Cables**
* Un-armored cables shall be used inside each electrical panel for wiring of control circuit.
* Such cables shall be terminated by mechanical glands similar to that specified for copper cable.
* General purpose - PVC insulated stranded copper conductors white PVC shall be sheathed BS 6500 or IEC equivalent
  1. **Earthing System**

All electrical equipment, metallic bodies etc. should be earthed properly.

* 1. **Lighting System**

2 nos. of 1x36W Industrial Tube lights with required nos. of switches, plug points etc. in electrical panel room.

6 nos. of Street Light Fixtures with 1x150W HPSV mounted on 7.5Mtr height above ground with 5 nos. of 9 m steel tubular street light poles. This shall also include all necessary cabling, wiring, with power factor corrected internal control gear, earthing, fuse cut-out boxes, pole bases, etc.

1 no. of Street Light Fixture with 1x36W Tube Light mounted on 5Mtr steel tubular street light pole near each centrifugal pump area. This shall also include all necessary cabling, wiring, earthing, fuse cut-out boxes, pole bases, etc.

* 1. **LV Motors**
     1. **Performance and Characteristics**
* The submersible motor shall conform to BS/IEC/IEEE or any other International Standards and the submersible cable shall conform to BS/IEC/IEEE or any other International Standards. The motor shall be three phase dry induction type with non-overloading characteristics. Motors shall be capable of giving rated output without reduction in the expected life span when operated continuously under the following supply conditions:
* Variation of supply voltage ±10%
* Variation of supply frequency ±5%
* Combined voltage and frequency variation ±10%
* The starting current of motor shall not exceed 200% of rated full load current for star/delta starting and 600% of rated full load current for DOL starting, under any circumstances.
* Motors shall be suitable for full voltage direct-on-line starting or star-delta starting.
* Motors shall be capable of starting and accelerating the load with the applicable method of starting, without exceeding acceptable winding temperatures, when the supply voltage is in the range 85% of the rated motor voltage.
* Motors shall be designed to withstand 120% of rated speed for two minutes without any mechanical damage, in either direction of rotation. The motor vibrations shall be within the limits specified in the relevant standard. Except as mentioned herein, the guaranteed performances of the motor shall be met with tolerances specified in applicable standard, IEC/IEEE/BS or any other International Standards The enclosure for motor shall be IP-68.
* Minimum three number thermistors in series are to be provided to sense the stator winding temperature. Bimetallic thermal switch to trip the motor against increase in temperature shall be provided.
  + 1. **Submersible Cable**

The cable shall be EPR insulated, CPS sheathed, round, multi core, flexible, unarmored, conductors composed of annealed tinned copper, suitable for 650 / 1100 volts grade and conforming to BS/IEC/IEEE or any other International Standards.

The size of the conductor and length of cable should be suitably selected so that the voltage drop at motor terminals does not exceed 3 percent of the rated voltage.

* + 1. **Earthing**

Earthing of the motor shall be done in accordance with the relevant provisions of IEEE-80. For the purpose of earthing these motors, earthing connection may be made to discharge pipe.

* + 1. **Insulation**

The stator winding shall be made from high conductivity annealed copper conductor; winding insulation shall be of class-F insulation, conforming to BS/IEC/IEEE or any other International Standards. The stator winding shall be of high conductivity annealed copper enameled insulated wires conforming to BS/IEC/IEEE or any other International Standards for dry type motors.

* + 1. **Constructional Features**

Construction features shall comply with IEC/BS/IEEE or any other International Standard. The motor will stop depending up on the low level of tank.

* + 1. **Induction Motor Characteristics**

Performance and Characteristics: All motors shall comply with IEC 60034, 60072 including BS/IEEE or any International standards referred to therein.

|  |  |  |
| --- | --- | --- |
| **Description** | **Unit** | **Particulars** |
| Type |  | Squirrel cage Induction motor (Energy efficient with minimum performance characteristics parameters as per IEC 60034, 60072 including BS/IEEE or any International standards |
| Rating | KW | (\*) |
| Rated voltage | kV | 0.400 |
| Synchronous speed | RPM | (\*) |
| Quantity | Nos. | (\*) |
| Type of mounting |  | Horizontal/ Vertical (depending on application and process requirement) |
| Duty type |  | Continuous (S1) |
| Method of starting |  | VFD/ Star-Delta starter/ Direct on line (depending on application and process requirement) (#) |
| Type of system earthing |  | Effectively Earthed. |
| Class of insulation |  | F (with temperature rise limited to class B) |
| Design ambient temperature | o C | 45 |
| Location |  | Indoor/ Outdoor (depending on application and process requirement) |
| Degree of Protection |  | IP55 |
| Cooling designation |  | IC411 |
| Terminal box |  | LHS – looking from NDE end |
| Space heater for motor |  | Required if motor rating is 30kW and  above |

(\*) – To be furnished by Contractor. Contractor should ensure that all the equipment ratings are based on their system requirement and subject to Engineer approval.

(#) – Motors rating up to and including 7.5 KW shall be started by DOL starter, Motor ratings above 7.5KW and up to or equal to 15 KW shall be started by Star-Delta Starter. Motors shall be energy efficient (Category –2 or better) squirrel cage induction motors (TEFC type) with degree of protection for enclosure of IP 55.

* + 1. **Constructional Features**

Construction features shall comply with IEC/BS/IEEE or any other International Standard.

* + 1. **Earthing Pad**

Two independent earthing pads of non-corrodible metal shall be welded or brazed at two locations on opposite sides complete with suitable bolt and washers for earthing. These earthing pads shall be in addition to earthing stud provided in the terminal box.

* + 1. **Rating Plate**

The following details, in addition to those specified in applicable standards shall be included on the rating plate. Rated voltage, kW rating, frequency, efficiency, power factor, temperature rise of windings in degree centigrade at rated load, and ambient conditions.

Type of bearings, recommended lubricant, lubricating interval & re-lubricating quantity

* + 1. **Tests**

Motor shall be subjected to all the type test (one from similar rating of each lot) and routine tests as per applicable standard in the presence of the Engineer. Copies of test certificates for all brought out items shall be furnished at the time of inspection for the Employer’s approval.

The Contractor shall ensure to use calibrated test equipment / instruments having valid calibration test certificates from standard laboratories traceable to International standards. Motor will stop depending up on the low level of tank. Canopy should be provided for outdoor motors.

* 1. **Local Push Button Stations**
* Start/stop buttons with control panel shall be provided for submersible motors.
* Outdoor type local push button stations shall be provided near all motors.

# 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 |
| **Code No.** | **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 EN 12201-2:2003; BS EN 12201-1:2011 | 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): | * 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 cementious 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 |