SECTION 8100 MAIN PUMPS

8101 General

(1) General

- All Sub-Sections under Section 8000 General Technical Specification shall be applied to this section.
- This Section shall covers the particular technical specification of the main pumps and related equipment or devices, which installed in the El Salaam No. 7 Pumping Station.

(2) Scope of Works

The works shall include the designing, manufacturing, testing, transport to the site, erection and tests at the site of the following complete in accordance with this specification.

- Four (4) complete sets of vertical shaft, single-suction, centrifugal-type pumps, each with a capacity of 10.827 cubic meter per second under a total lifting head of 99.60 meter.
- Building and testing a hydraulic model and furnishing approved result of the final model tests, together with acceptable hydraulic designs for the main pumps.

8102 Finish

The type of finish shall be that most suitable for the part to which it applies and shall be defined on the working drawings in micron in accordance with ISO 468 "Surface roughness - Parameters". Unless otherwise specified by the Engineer, surface roughness shall not exceed the following values.

- Surfaces in sliding contact: 63 micron
- Surfaces in permanent contact where a tight joint is required: 125 micron
- Surfaces in contact where a tight joint is not required: 250 micron
- Other machined surfaces: 500 micron

The finish of the following pump parts shall not exceed the following maximum surface roughness in micron.

(a) For Impeller
Outside: 250
Water passages (upstream two thirds): 125
Water passages (downstream one third): 63

(b) For Shaft
Exposed: 63
Journal: 32

Stuffing box sleeve: 16
Bore: 125

(c) For Wearing ring
Clearance surface: 63
All other: 125

(d) For Grooves for O-ring
Stationary parts: 125
Relative motion parts: 63

8103 Equipment Requirements

(1) General

(a) Type and Description

The pump shall be a vertical shaft, single suction, centrifugal type direct connected to a vertical shaft synchronous motor. The casing shall be of the diffuser type construction. The rotation parts and pump casing cover shall pass through inside of the motor stator for pump assembly and disassembly.

The pump shall be the product of a manufacturer experienced in the design and manufacture of the type of pumps required and shall be designed and constructed to meet the general mechanical design requirements as follows.

- The impeller shall be removable without disturbing the suction cover and the entire rotating element shall be able to remove from the casing when the top cover is taken away.
- Provision shall be made to permit vertical movement of the impeller and shaft an amount sufficient both for adjusting and dismantling the thrust bearing, and for clearing the motor shaft when the coupling bolts are removed.
- An oil-lubricated thrust bearing as part of the motor shall be bearable against both the total weight of the rotating parts in pump and maximum unbalanced hydraulic thrust which is occurred in case that clearance between impeller and wearing expands more than two times of design value.
- All parts of the pump shall be designed for safety operation against the stress by the maximum reverse speed in power failure without consideration of unrestricted reverse flow, friction and windage.
- All major parts shall be provided with eye bolts lugs, or lifting devices to facilitate handling with a crane.
- The hydraulic design of the prototype pumps shall be homologous with the pump model approved by the Engineer.

(b) Operating Condition

Normal starting and stopping of the pump unit shall be controlled from a control circuit

specified in later section. The pump will be started with the discharge valve closed. Automatic opening of the discharge valve will be initiated by a contact, which closes when the unit reaches synchronous speed. Under emergency conditions, including power failure, closure of the discharge valve will be initiated simultaneously with power interruption to the motor. Under normal shutdown conditions, the discharge valve will close, and then power to the pump motor will be interrupted. The discharge pipelines shall be filled water by the pipeline fill pumps provided in the pumping station.

(2) Performance (Pump Ratings)

The minimum pump capacity, total head, and speed at rated conditions are shown below. The expected range of total heads and the best efficiency head are also shown below. All pump losses shall be in addition to the specified head and shall be allowed for when computing the pump characteristics.

Rated capacity: 10.827 (m^3/s)
Rated head: 99.6 (m)
Head range: 99.6 to 87 (m)

Suction sump water surface elevation: Maximum 10.7 m.
At upstream of the weed screen: Design 9.9 m (full unit operation)
Minimum 9.7 m (full unit operation)
Minimum 8.8 m (one unit operation)
Discharge tank water surface elevation: Design 92.9 m
Minimum 92.5 m
Pump centerline elevation: 1.60 m

The pumping efficiency of the pump shall be more than 91.0 percent and the best efficiency point shall be selected between 87.0 m head and 99.6 m head by taking account of the submergence condition and operating range.

Following table shows relation of heads.

Head (m)	Discharge tank water surface elevation (m)	Suction sump water surface elevation (m)	Actual head (m)	Friction losses (m)	Rated head (m)
Rated	92.9	9.9	83.0	16.6	99.6
Minimum	92.5	8.8	83.7	3.3	87.0

Regarding the losses of upstream weed screen, the ones are deemed to be 0.2 m for this friction loss.

(3) Performance guarantee

(a) General

The acceptance of the pump performance will be determined by the pump model test as specified in Section 8000.

(b) Pump Efficiency

The guaranteed efficiency of the prototype pump shall be equal or greater than 91.0 percent in accordance with IEC 497, where the K value shall be adopted as 0.5. The Contractor shall guarantee the specified efficiency, but the higher proposed value more than guaranteed value will not be considered.

(c) Pump Head-Capacity Relationship

At the rated head of 99.6 m, the pump capacity shall not less than 10.827 m^3/s.

(d) Pump Submergence Requirement

At the largest anticipated flow (per pump) under the lowest head, the pump shall operate satisfactorily under following conditions.

a. Suction sump water surface elevation at upstream of the weed screen: 8.8 m
b. Pump centerline elevation: 1.6 m

(e) Combined Moment of Inertia

The combined moment of inertia of the pump and motor rotating parts shall not be less than 113 ton-m^2.

(4) Design and Construction

(a) General

The basic materials and methods shall be in accordance with Section 8000. The materials chosen for the different parts of the pumps shall be suitable for quality of water as shown in the chemical analysis given. Equivalent materials according to other specifications or better can be accepted if the contractor shows clearly its chemical analysis and it's mechanical properties.

(b) Impeller

(i) General

The impeller shall be of the enclosed type and shall be made in one piece entirely of stainless steel: ASTM designation, A743M Grade CF-8 or equivalent. Impeller shall be equipped with replaceable wearing rings. The fabricated impeller is not acceptable.

(ii) Design and Fabrication

The impeller shall have sufficient strength to withstand forces due to runaway speed and to support its own weight and the shafts when the latter is disconnected from the motor shaft and the impeller is resting on a ledge or shoulder in the suction cover or suction tube liner.

The impeller shall be provided a bolted flange connection for attaching the impeller to the pump shaft. The bolt holes in the flanged connection shall be reamed together when the impeller and pump shaft are assembled in the shop.

All water-passage surfaces of the impeller shall be ground smooth. Ground surfaces shall be free from hollows, depressions, cracks, or projections. Water passage shall be accurately ground and polished to assure high efficiency. Inlet and outlet edges of the vanes shall be chipped and ground very smooth to the templates in accordance with IEC 497.

The impeller shall be thoroughly inspected by a non-destructive method (liquid penetrate examination). Acceptance of criteria shall be in accordance with ASME, Section Ⅷ, Division 1, Appendix 8. The finished impeller shall be statically and dynamically balanced as required to achieve a balance quality grade of G 6.3 in accordance with ISO-1940.
The Contractor shall warrant each pump against excessive cavitation or pitting for a period of two (2) years from the date the pump is put into service.

Cavitation or pitting will be considered excessive under any of the following conditions. Cavitation will be considered excessive if it exceeds the limit given by one of the methods for cavitation evaluation in the IEC publication No. (IEC/TC4/W615) march 1970 or later. (Draft Recommendations for Cavitation Pitting Evaluation in Turbines and Storage Pumps) The factors to be adopted in cavitation evaluation shall be those for stainless steel storage pumps and pump turbines.

Excessive cavitation including contiguous cavitated areas shall be corrected by modification and repair of the cavitated parts, or by replacement of such parts with an improved design. Erosion or damage caused by suspended matter in the water and corrosion caused by the chemical composition of the water to be covered by the Contractor's warranty.

After such modification and repair or replacement, the warranty period for modified and repaired or replaced part shall be extended for additional two years from date of reputing in operation, after witch the cavitation evaluation shall be within allowable limits. The unit shall not operated under outside of the head range specified or with suction level below the specified except pump manufacturers advance agreement and direction.

(c) Pump Shaft and Intermediate Shaft

(i) General

The pump shaft and intermediate shaft shall be made of forged, open-hearth carbon, entirely of ISO 9327 (correspond to JIS G3201 SF540A or ASTM A668, class D annealed before machining) or alloy steel properly heat-treated. It shall be machined all over and shall be provided with integrally forged flanged couplings for connection to the impeller and to the intermediate shaft or to the pump shaft and to the motor shaft.

(ii) Design and Fabrication

The shafts shall be of ample size to operate at any speed up to full reverse runaway speed without excessive vibration or objectionable distortion. The size of the shaft and the construction of the main bearing support shall be such that any shaft deflection or unbalanced radial thrust on the impeller under any condition of speed up to full runaway speed or under any condition of discharge from maximum capacity to shutoff shall not cause contact between the impeller and casing wearing ring. Total deflection of the shafts shall not exceed two-third (2/3) of the wearing ring clearances under above condition. The Contractor shall submit shaft deflection calculation sheet.

The diameter of the intermediate shafts shall be coordinated with the motor manufacturer. The shafts shall have a hole not less than 75 mm in diameter bored axially throughout its entire length and the machining of this hole shall be sufficiently smooth to permit visual inspection of the metal in the interior of the shaft. The lower flange of the pump shaft shall be provided with a permanent metal plug and lathe center before shipment.

The shafts shall be ultrasonically inspected on a whole length and repaired in accordance with ASTM A388. The shafts will be rejected if examination show one or more discontinuities, which produce indication exceeding in amplitude, the indication from the calibrated notch. The shafts shall be machined accurately all over to the finish specified in this Clause except that the top and bottom coupling bolt holes shall be reamed to size when the shafts are assembled in the shop with the impeller or intermediate shaft and motor shaft respectively. The shafts shall be polished where it passes through the guide bearing.

The pump shaft shall have a removable and renewable sleeve where it passes through the shaft seal in the casing cover. The sleeve shall be made of stainless steel with a minimum Brinell hardness of 400. The sleeve shall be machined to the finish specified in the Section 8000. A water shedder shall be provided above the stuffing box, and an oil deflector shall be provided on the shaft below the guide bearing, if required.

The Contractor shall calculate the shaft critical speed for the combined motor and pump. The calculations shall take into account the rigidity of the pump and motor bearings supports as well as their locations, the motor shaft dimensions and the motor rotating mass. The calculated critical speed shall be a minimum of 25 percent above the runaway speed. The Contractor shall submit critical speed calculation sheet.

The coupling flanges shall basically conform to ANSI/IEEE Standard 810. "IEEE standard for Hydraulic Turbine and Generator integrally Forged shaft Couplings and Shaft Run out Tolerances". The Contractor shall determine the elevation of the face of the couplings. The upper coupling flange of the intermediate shaft shall be a male half coupling for connection to a female half coupling on the motor shaft. The alignment of the shafts shall be checked individually and on combined pump and intermediate shaft respectively at the shop by rotating the shafts. The tolerances for the shaft run out shall be in accordance with ANSI/IEEE Standard 810. The aligned shafts shall be marked with match mark of

permanent stamps, using marks sufficiently different for each set of shafts to prevent interchange of shafts during assembly in the field. Each shaft shall also be designated near the coupling with the pumping unit number.

To ensure the accurate alignment of the pump and motor shafts, the intermediate shaft shall be shipped to the motor contractor where it will be fitted together with the motor shaft and checked carefully for alignment of the assembly while the shafts are rotating. The intermediate shaft shall be shipped to the motor contractor with the bolt holes in the coupling flange drilled undersize. The Contractor may be omitted shaft or coupling mounted nut covers for both coupling of the pump and intermediate shaft, if coupling face is apart 2.5 m from walkway floor within pump pit and intermediate guide bearing floor.

(iii) Coordination with Electric Motor

The motor contractor will be responsible for the following:

- Furnishing to the pump contractor a template or other adequate information for drilling undersize intermediate shaft coupling bolt hole and for machining the recess on the coupling flange, if required, to accommodate the nut guard.
- Fitting the intermediate shaft to the motor shaft and reaming the bolt holes in the coupling flanges of both shafts.
- Furnishing and fitting all coupling bolts, nuts, and nut guards for the coupling between the two shafts.
- Furnishing a bolt jack for inserting and removing the coupling bolts
- Aligning the pump and motor shafts and checking the alignment of the coupled assembly while rotating to ensure that the tolerances for shaft run out are in accordance with ANSI/IEEE Standard 810.
- Match marking the aligned shafts by permanent stamps.
- Storing and protecting the intermediate shafts until shipped to the site with motor shaft.

(d) Casing

(i) General

The pump casing shall be of diffuser type construction and shall be fully embedded in concrete. The casing shall be constructed in radial sections and shall have the least number of sections practicable for shipment and handling. The casing shall be of welded plate steel. The outlet of the casing shall be 1500 mm to suit the casing extension and discharge valve.

(ii) Design and Fabrication

Unless otherwise specified, the pump casing shall be designed and fabricated in accordance with a pressure vessel code approved by the Engineer.

- The diffuser ring shall be designed to resist the bursting stresses in the case when subjected to an internal pressure equal to the design pressure specified in Sub-Section 8009 with no superimposed loads on the top of the diffuser ring or case. The welded portion between upper and lower rings and vane of the diffuser ring shall be 20 % magnetic particle tested.
- Grout and vent holes, tapped for pipe connections shall be provided in the lower sections as required to facilitate the placing of concrete and grout under the diffuser

ring. The steel pipe plugs shall be provided for closing.

- The spiral casing shall be designed for an internal pressure equal to the pressure specified in the Sub-Section 8009. It shall be made of welded plate steel. The wall thickness of the casing shall be not less than 12 mm. The flanges shall be of the full-face type with continuous bearing over the entire flange face.
- The longitudinal welded portion between the casing and diffuser ring or casing including T-joint shall be 100 % radiographic or ultrasonic tested. And circumference welded portion between the casing and casing or flange shall be 20 % radiographic tested.
- The casing shall be provided with a suitable number of pads and connections for the jacks and tie rods required for field erection.
- Two grounding studs shall be provided on the pump casing. The studs shall be welded to the casing and each stud shall be provided for suitable earth system.

(e) Casing Extension

(i) General

The casing extension shall be designed for an internal pressure as same as the casing.

(ii) Design and Fabrication

The casing extension shall be made of the same material as the spiral casing. The connection between the casing and casing extension shall be bolted joint or welding joint. The downstream end of the extension shall be provided with a flange suitable for connecting to the discharge valve. The casing extension shall be drilled, tapped, and provided with four stainless steel plugs for piezometer connections according to IEC 497. The location of the connections shall be as shown on the drawing No. PSM 206. A tap shall be provided for connecting a pressure gauge. The casing extension shall be provided with the flange connections for drain piping and for the installation of an air-vacuum valve. The casing extension shall be provided with a man door 500 mm in diameter for access to the interior. The man door shall be located approximately as shown on the drawing.

The man door shall be equipped with a hinged, stainless steel bolted cover, and the interior surface shall conform to the contour of the inner surface of the water passage. The man door shall be equipped with a handle and jack bolts and with a bronze test petcock.

(f) Pump Guide Bearing and Intermediate Guide Bearing

(i) General

The guide bearing shall be of the babbit-lined oil lubricate type, and shall be self-lubricating. The guide bearing shall be suitable for contiguous operation with the shaft rotating in either direction. The pump guide bearing shall consist of a bearing housing and a removable bearing shell. The bearing shall be located above the stuffing box and as close to the impeller as possible.

The intermediate guide bearing shall consist of a bearing housing, a removable bearing shell and a rotating oil reservoir with the shaft or the Contractor proposed one. The lubricating oil shall have basically a viscosity of 315 to 355 say bolt universal seconds at

38℃. The bearings shall be designed to use this oil.

(ii) Design and Fabrication

The bearing shell shall be lined with high-grade anti-friction metal, accurately bored, and suitably grooved for oil circulation. The anti-friction metal lining shall be securely anchored to the bearing shell and shall be scraped and polished in the shop to fit properly on the shaft.

The bearing housing shall be welded-plate-steal, designed to support the bearing rigidly and transmit the load due to maximum side thrust of the impeller to the pump casing cover. Dowels of sufficient diameter or other suitable means shall be provided between the bearing housing and pump casing cover to resist movement due to this load.

To facilitate dismantling, the bearing housing and bearing shell shall each be split vertically into two sections and shall be doweled securely. Suitable lifting eyes and backing-out studs shall be provided to facilitate removing and installing the bearing. The bearing and bearing housing shall be designed for the installation of the bulbs of the temperature switch and the resistance temperature detector located diametrically opposite each other in the bearing metal with the sensitive portion adjacent to the bearing metal.

The bearing shall be self-lubricated from an oil reservoir around the bearing from which the oil shall be circulated through the bearing. A portion of the bearing shall be continuously immersed to provide initial lubrication when starting the unit. Provisions shall be made to supply oil to the bearing during reverse rotation of the pump. Provisions shall also be made to prevent loss of oil at the top of the bearing by foaming.

The lubrication system shall be so designed that under any condition of normal operation, including reverse rotation, water will not enter the lubricating system. The lubrication system shall be designed so that the temperature of the bearing oil shall not exceed 60℃ under continuous operation in either direction of rotation. Cooling of the lubricating oil shall be accomplished with a heat exchanger through which cold water will be circulated. The heat exchanger may be choosing either of cooling coil type or cooling jacket type.

Water at a temperature of not over 30℃ will be available for cooling purposes. The waterside of the heat exchanger shall be designed for a working pressure of 5 bar and shall be subjected to a hydrostatic test of 7.5 bar in the factory. The Contractor shall furnish all pipe, fittings, valves, and pipe supports adjacent to the pump required for the lubricating system. Provisions shall be made for connections to the plant oil and water supply and return piping systems outside the pump pit. The Contractor shall furnish instruments and control equipment for the lubricating system as specified in this Clause. The Contractor shall also furnish electrical conduits and a terminal box as specified in this Clause.

The Contractor shall supply the required lubricating-oil for the guide bearings (including the intermediate shaft guide bearing) for the guarantee period +1000 hr of running and shall before using them submit the necessary sample for approval of the Engineer, The

lubricants shall be delivered in sealed steel drums. It is necessary that the quality of oil chosen is readily available and can be purchased locally in Egypt.

(g) Casing Cover and Suction Cover

(i) General

The pump casing cover and suction cover shall be made of the same material as the casing. The casing cover shall be in one piece and the suction cover, if not an integral part of the pump casing, shall also be one piece. The casing cover and suction cover shall be provided with replaceable wearing rings as specified in the Section 8103 (4) (i).

(ii) Design and Fabrication

The casing cover shall be capable of supporting the impeller, pump shaft, and associated parts during erection and dismantling so that these parts can be installed and removed as a single unit. The suction cover shall be capable of supporting the impeller, pump shaft, intermediate shaft, and associated parts when the motor shaft is uncoupled and rest on the suction cover.

The portions of the casing cover and suction cover inside the impeller wearing rings shall be designed for design pressure. The portions of the casing cover and suction cover outside of the impeller wearing rings shall be designed for a pressure equal to shutoff head plus maximum suction head. The space inside the wearing rings shall be adequately drained to prevent excessive water pressure under the casing cover or excessive hydraulic trust on top of the impeller. Suitable passages shall be provided for the leakage water from the wearing rings to balance holes in the impeller or to equalizing lines, as applicable, if equalizing lines are required, they shall be fabricated of schedule 40 stainless steel pipe.

Plugged feeler gauge holes shall be provided 90 degree apart for checking the clearances between the upper and lower rotating and stationary wearing rings. If the wearing rings are accessible from inside the casing or suction tube for such measurements, the feeler gauge holes may be omitted.

The contractor shall provide any specialized tools required for measuring lower wearing ring clearances from inside the suction tube. A tap shall be provided in the casing cover for connecting a pressure gauge to indicate the pressure above the impeller. A tap shall be provided in the suction cover for connecting a pressure gauge to indicate the pressure below the impeller. Pressure gauges are specified in this Clause.

The hole in the casing cover for the stuffing box shall be of sufficient diameter to permit passing the pump shaft flanges. A suitable number of dowels of sufficient diameter shall be provided between the casing cover and casing to resist movement due to the maximum radial thrust of the impeller transmitted through the bearing supports. Suitable lifting devices shall be provided with four points of attachment to the casing cover for lifting the above assembly by means of a crane hook.

(h) Stuffing box

(i) General

A stuffing box, designed so that it can be repacked and adjusted without disturbing the pump guide bearing or dismantling any other part of the pump, shall be provided where the shaft passes through the casing cover. The stuffing box shall be constructed to permit minimum seal water flow without excessive pressure on the packing and shall be packed with high-grade, Teflon type, hydraulic packing.

(ii) Design and Fabrication

The packing shall be suitable for use with the shaft rotating in either direction. The stuffing box shall be provided with a bronze lantern ring hold securely to prevent rotation, and with separate connections for water and grease lubrication. Grease will be applied only before starting and during prolonged periods of shut down. The stuffing box gland shall be made of bronze, shall be sectionalized in two parts, and shall have stainless steel bolts. The stuffing box shall be designed for the installation of the bulb of the temperature switch specified in this Clause.

The Contractor shall furnish all fittings. Valves, Y-type strainer and pipe supports within the pump pit for the water supply to the stuffing box. Unions shall be provided as required for dismantling and at all connections to equipment. Insulated couplings shall be provided where the piping connects to the stuffing box for galvanic corrosion protection. Special attention shall be paid to the stuffing box arrangement for the galvanic corrosion protection.

(i) Casing and Impeller Wearing Ring

(i) General

Removable and renewable wearing rings shall be provided where there are close running clearance between the impeller and stationary parts of the pump. To avoid biting each other, one of each pair of wearing rings shall be made of stainless steel specified hardness, Brinell hardness approx. 300. And for the other wearing ring of each pair shall be of approx. 160.

(ii) Design and Fabrication

The stationary wearing rings shall extend over the area on which the leakage between the rotating and stationary rings impinges. Not more than two sets of wearing shall be provided for the impeller, one set above and one set below the impeller discharge.

The radial clearances between the rotating and stationary wearing rings shall be as small as possible consistent with safe operation and with the clearance required in the pump and motor guide bearings. Adaptation of the labyrinth type-wearing ring shall not accept. Provisions shall be made to permit checking the radial clearances between the upper wearing rings and between the lower wearing rings at four approximately equally spaced points on the circumference.

(j) Suction Elbow Liner

(i) General

A steel suction elbow liner extending from the pump suction cover to the point to be connected with the suction pipe shall be provide as shown on drawing. The connection between the suction cover and suction elbow shall be by either field welding or use of a flange. The suction elbow liner shall be provided with a man door.

(ii) Design and Fabrication

The upper conical section of the suction elbow liner shall be not less than 13 mm thick and the remaining elbow section not less than 10 mm thick. The entire liner shall be reinforced on the outside by ribs or structural steel shapes and shall be provided with adequate means for securely anchoring the liner to the surrounding concrete.

The plate, ribbing, and anchorage shall be designed for full external hydrostatic pressure with maximum of water surface elevation of suction sump and with an absolute pressure of one atmosphere inside the suction elbow liner. The interior of the liner shall be smooth and shall have no abrupt changes in directions.

And the connection between the section-elbow liner and suction pipe shall be by the use of a flange. If welded, the connection shall provide for vertical and angular adjustment so that the alignment and level of the diffuser ring can be maintained during installation. Sufficient copper-nickel caulking stripe shall be furnished to close the interior gap in the joint.

If flanged, the liner shall be provided with a loose slip-on flange for connection to the pump suction flange and shall be designed to provide for vertical and angular adjustment so that the alignment and level of the diffuser ring can be maintained during installation. The lower potion of the flange will be seal welded after field bolting. Sufficient copper-nickel caulking strips shall be furnished to close the interior gap in the field-bolted joint.

The suction-elbow liner shall be provided with a suitable number of pads and connections for the application of jacks or leveling screws and tie rods during field erection. The suction elbow liner shall be provided with a man door approximately 600 x 900 mm in size.

The man door shall be equipped with a hinged cover opening outward into the access passage. The liner surface of the man door shall conform to the contour of the inner surface of the suction-elbow liner. The man door shall be equipped with a handle and jack bolts, and with a brass or bronze teat petcock. The suction-elbow liner shall be provided with pipe connections for the pressure-vacuum gauge specified in herein after of this Clause. The top section of the suction-elbow liner, downstream side of the manhole shall be drilled, tapped, and provided with four equally spaced stainless steel plugs for piezometer connections.

(k) Pit Liner

(i) General

The pump shall be equipped with a welded plate steel pit liner extending a minimum 2.2 meters above the centerline of the pump. The pit liner shall be not less than 6 mm thick, and shall be of sufficient diameter to permit removal of the pump casing cover in one piece.

(ii) Design and Fabrication

The pit-liner shall be suitably reinforced on the outside by ribs or structural-steel shapes, and shall be provided with adequate means for anchoring the liner to the surrounding concrete. The pit-liner shall be provided with a bolted flange or field welded connection for attaching the liner to the pump. A steel angle shall be provided at the top of the liner. The pit liner shall be made integral with the equipment alcove, which have opening for conduit and pipe chances as required. Openings for pipe entrance chases shall be provided with a steel angle around the opening.

(l) Walkways and Safety Guards

(i) General

The pump pit and intermediate shaft bearing room shall be provided walkways around the circumference of the guide bearing for convenience in inspection, operation, and maintenance. And safety guards shall be provided around the pump shaft, and intermediate shaft respectively. All parts shall be easily removable to permit dismantling the pump from above

(ii) Walkway

A floor checkered plate walkway should be provided around the circumference of the pump guide bearing and intermediate shaft guide bearing. To facilitate handling, floor plate sections for the walkways shall not weigh more than 20 kg. Handrail shall be provided as required.

(iii) Safety Guard

A safety guard shall be provided around the circumference of the pump shaft and intermediate shaft.

(m) Drain

Adequate drainage of the pump pit shall be provided. Drains shall be connected to the station drainage system and leakage water shall flow by gravity to the station sump pit.

(n) Instrument, Electric Control and Alarm Switches

The pump shall be provided with the instruments and control and alarm switches specified below. The contractor shall determine the proper scale range for the required operating conditions. The contractor shall furnish data for all instrument to be provided with the pump, type, size, scale range, electrical rating (where applicable) and name of manufacturer. Nameplates for each instrument, electrical control device, and alarm switch provided under this subparagraph shall be furnished and installed by the contractor.

The control equipment shall conform to the applicable standards of ANSI, TEEE, NEMA, and IEC. The equipment shall conform to the following requirement unless otherwise specified and any details not specifically covered shall be subject to the approval of the "Engineer". The contractor shall be responsible for the layout design of the equipment. All devices shall be labeled with a suitable identification nameplate.

Pump- motor instrument panel shall be as specified in Section 9500 Central Control System and shall be located adjacent to the motors on floor EL 13.70. The following instruments for the pump shall be supplied:

(i) Central Control System Indicating Instruments:

Item No.	Required number	Description	Location
1	one	casing pressure indication / alarm	Central Control Console
2	one	pump stuffing box pressure indication / alarm	ditto
3	one	temperature indication/alarm for the pump guide bearing metal	ditto
4	one	temperature indication/alarm for the intermediate shaft guide bearing metal	ditto
5	one set	X-Y vibration indication / alarm for the shaft	ditto
6	one set	X-Y vibration indication / alarm for the bearing cover	ditto
7	one	cooling water outlet temperature alarm for the pump guide bearing	ditto
8	one	cooling water outlet temperature alarm for the intermediate shaft guide bearing	ditto
9	one	cooling water flow alarm for the pump guide bearing	ditto
10	one	cooling water flow alarm for the intermediate shaft guide bearing	ditto
11	one	cooling water flow alarm for the pump stuffing box	ditto
12	one	Reservoir oil level alarm for the pump guide bearing	ditto
13	one	Reservoir oil level alarm for the intermediate shaft guide bearing	ditto
14	one	temperature indication/alarm for the pump stuffing box	ditto

(ii) Local Indicating Instruments:

Item No.	Required Number	Description	Location
1	two	pump suction pressure compound gauge	mount near the suction elbow manhole, and PIC
2	two	pump casing and pipeline pressure gauge with 3 way cock	mount near the casing extension manhole, and PIC
3	one	pump casing pressure transmitter(piezometer)	PIC
4	one / 4 units	pipeline pressure transmitter	PIC
5	one	pump casing cover under (above impeller) pressure gauge	PIC
6	one	pump suction pressure transmitter (piezometer)	PIC
7	one	oil level gauge /switch for the pump guide bearing	pump pit, local position and wired to PTC
8	one	oil level gauge /switch for the intermediate shaft guide bearing	pump pit, local position and wired to PTC
9	one	dial thermometer/switch for the pump guide bearing metal	PIC and wired to PTC
10	one	dial thermometer/switch for the intermediate shaft guide bearing metal	IIC and wired to PTC
11	one	temperature RTD (Resistance Temp. Detector Pt 100 ohm) for the pump guide bearing metal	pump pit, local position and wired to PTC
12	one	oil temperature RTD(Resistance Temp. Detector: Pt 100 ohm) for the intermediate shaft guide bearing	local position and wired to PTC
13	one	cooling water inlet temperature gauge for the pump guide bearing	Pump pit, local position
14	one	cooling water outlet temperature gauge / switch for the pump guide bearing	pump pit, local position and wired to PTC
15	one	cooling water flow gauge/switch for the pump guide bearing	pump pit, local position and wired to PTC
16	one	cooling water inlet temperature gauge for the intermediate shaft guide bearing.	Intermediate guide bearing pit, local position
17	one	cooling water outlet temperature gauge / switch for the intermediate shaft guide bearing	Intermediate guide bearing pit, local position and wired to PTC
18	one	cooling water flow gauge / switch for the intermediate shaft guide bearing	Intermediate guide bearing pit, local position and wired to PTC

Item No.	Required Number	Description	Location
19	one	float level switch for pump pit - depth : 0.1 m - accuracy : ±1% full scale	local position and wired to PTC
20	one	cooling water flow gauge / switch for the pump stuffing box	pump pit, local position and wired to PTC
21	one	dial thermometer/switch for the stuffing box	PIC and wired to PTC
22	one	pressure gauge / switch for the pump stuffing box water supply line	pump pit, local position and wired to PTC

Note.

1) PIC means Pump pit instrument cabinet and PTC means Pump terminal cabinet provided terminal block inside. PTC shall provide next to PIC and I IC.
2) I IC means intermediate bearing pit instrument cabinet.
3) Temperature Gauge (Industrial Thermometer) shall be of the mercury-column, V-scale type with removable plate-glass cover. The scale shall be calibrated in degrees Celsius. The scale shall be provided with a brass or bronze separable socket.

(o) Local Instrument Cabinet

The Contractor shall furnish and install cabinets to house the applicable instruments, gages, electrical control devices specified in paragraph (n) the above. The cabinet shall be of the rigid sheet-steel, wall mount type, and be of a size to permit complete accessibility for operation, maintenance, removal, and replacement for all equipment and devices mounted on the cabinet. The surfaces shall be free from depressions and bumps that will throw highlights when painted. The arrangement of cabinet shall be subject to the approval of the Engineer.

(p) Water Level Switches

Item No.	Required Number	Description	Location
1	four	float level switch for suction sump, at upstream side of weed screen - depth of water : 5 m - accuracy : ±1% full scale	Central control room
2	four	float level switch for suction sump, at downstream side of guard screen - depth of water : 5 m - accuracy : ±1% full scale	Central control room
3	one	float level switch for sump pit - depth of water : 5 m - accuracy : ±1% full scale	Central control room

Note.

The float level switches for the suction sump shall be enable to protect from dust, algae, water weeds etc. on the water.

(q) Electric Conduits, Terminal and Wiring

Electric conduits, terminal and wiring shall be as specified in Section 9800.

(r) Name Plate

The Contractor shall provide an identifying nameplate of corrosion resistant metal for each pump and submit it with the mounting details for approval. The nameplate shall include followings as a minimum:

- Type of pump
- Rated capacity in cubic meter per second
- Rated head in meter
- Speed
- Name of manufacturer
- Date of manufacture and serial number

(s) Ultrasonic Flow meters

Three Ultrasonic flow meters shall be provided on 2400 mm diameter pipelines. The specification shall be as follows:

- Pipe inside diameter: 2400 mm
- Pipe thickness: 22 mm
- Pipe material: Steel

The flow meters shall eight path acoustic flow meter O.R.E. Model 7410 Acoustic flow monitoring system, with an analog out put scaled to read in cubic-meter-per second.

(t) Water Supply System

The water supply system shall be as given in Sub-Section 8302, (3), (b).

8104 Tests

(1) Factory Tests

(a) Model Test

(i) General

The contractor shall furnish one pump model for the pumps furnished. The model pump shall be homologous with the prototype, which the contractor proposes to furnish. Computation simulation instead of the model test shall not accepted. The model tests shall be executed by the Contractor in accordance with items specified herein for the purpose of checking the hydraulic design and operating characteristics of the prototype. The Contractor shall make any changes that the model tests indicate will improve the proto type design.

The Contractor shall furnish all materials, equipment, instruments, gauges, and labor required to construct the model and to obtain the test measurements. The model shall remain the property of the contractor. The Contractor shall furnish model drawings and data and test reports as required in paragraph (iii). The tests shall be conducted in

accordance with the applicable provisions of IEC 497 " International Code for Model Acceptance Tests of Storage Pump". The Engineer reserves the right to witness the tests and calibration of the instrumentation, and the Contractor shall notify the Engineer as far in advance as possible of the date the tests to be witnessed are to begin.

The model test instruments and equipment used in the model tests, in addition to meeting requirements of the above code, shall meet the requirements given in this entire subsection. The model discharge shall be measured directly by gravimetric or volumetric equipment of by indirect means permitted by the code and calibrated by gravimetric or volumetric equipment.

(ii) Model requirement

a) Model Pump

The model shall be complete with pump casing, casing extension, casing cover, impeller, suction pipe, and at least six diameters of straight discharge pipe. The model shall utilize the suction-pipe design for the pump. The hydraulic design of the model shall represent the prototype with only seal clearances permitted to deviate within limits in accordance with IEC 497 from the model to prototype. The throat diameter of the model impeller shall be not less than 260 mm. In case of the space limitation of the model facility, the test of the suction pipe will be accepted separately.

Features affecting hydraulic thrust shall be modeled as accurately as practicable, to permit prediction of prototype thrusts. Suitable windows shall be provided to observe cavitation to the upper portion of the suction-tube liner, which of minimum 180 mm in vertical length, or transparent sections. The outline of the suction-pipe shall be as shown on drawing. The Contractor shall provide piezometer taps in the suction elbow piece and in the pump casing extension at the location as shown on drawing to obtain pressure readings and other data.

b) Model Discharge Header.

The model discharge header shall be tested to prove satisfactory operation for any number and combination of the pipelines and pumps. The model shall be homologous with the prototype shown on the drawing. The Contractor may offer alternative, of which the Contractor to furnish. The ratio of the model discharge header shall be 1/10 to 1/15. However, 1/10 is preferable to avoid error of judgment or calculation for surface roughness, accuracy of header shape and it's dimension. The scale will be acceptable. Reynold's number shall kept not be less than 100,000 under all testing. The Contractor shall provide piezometer taps at the locations in the discharge main header and inlet and outlet branch pipes to obtain pressure reading and other data.

Tests shall cover an area involved inlet and outlet pipes extended it's length to 3D (D: pipe inside diameter) respectively, and each inlet and outlet branch pipes shall have a length of 15D, or at least 10D or multiple holed plates to make steady flow. The Contractor shall measure flow distribution, static pressure, differential pressure between the inlet and outlet branch pipes, and noise under 3 units operation (3 inlet pipeline filled

and 1 line closed) and confirm following requirements and modify, if required.

- Pressure losses: Acceptable fluctuation: max. 0.5 meter
- Flow distribution: Acceptable fluctuation: within ±5 % rating flow
- Differential pressure: Acceptable fluctuation: max. 40 %

(iii) Model drawing and test report

a) Drawings

With in 90 calendar days after receipt of notice of award of contract, the contractor shall furnish drawings covering details of the proposed model and test installation for approval and checking of the piezometer tap locations.

b) Test Reports

The contractor shall furnish two copies of preliminary test data and preliminary results as soon as possible after completion of the tests but not later than the time within 240 calendar days after receipt of Notice of Award of contract. The contractor shall furnish two copies of the initial report of the final model tests for approval. Four copies of the final model test report shall be furnished after approval of the initial report. The final test reports shall include the followings.

- Performance curves of the model showing head, efficiency, and horsepower input verses capacity throughout the entire range of total prototype operating heads from minimum pump head to shutoff pump head at minimum plant sigma.
- Derived performance curves for the prototype corresponding to subparagraph a) above. One set of curves shall be furnished with the step up from model to prototype values not corrected for scale effect. A second set of curves shall be furnished showing the manufacturer's expected performance with correction for scale effect. Proto-type pump efficiency shall be derived from the actual model pump efficiency in accordance with IEC497, where the K value shall be adopted as 0.5.
- Sigma curves that shall show the effect of submergence on pump discharge over the full range of prototype operation. They shall extend beyond the range of prototype operation as required to delineate fully the critical sigma or "break point." Sigma curves shall show the range upped one percent head break and one percent efficiency drop.
- Color photographs of blade cavitation.
- Maximum reverse speed of the proto-type, under maximum head.
- Pressure pulsation in the suction pipe immediately below the impeller and velocity distribution at the eye of the impeller at maximum, design, and minimum equivalent prototype heads.
- Pressure pulsation's in the discharge line. Pulsation at frequencies nears the rotational frequency and the vane passing frequencies are of particular interest.
- Pressure resistance coefficients for the branch pipe combination and pulsation in the dishrag header.
- In addition to the data required above, the model test report shall include complete characteristic curves covering the relationship between discharge, speed, head, and torque ratios. Ratios shall be calculated with respect to the pump best-efficiency conditions. These curves shall cover normal pumping, energy dissipation, and turbine zones of operation. The complete curves for constant head and torque ratios

shall be plotted in increments of 10 percent from 0 to 130 percent with the discharge and speed ratios as the axes. All curves shall be continuous lines completely displayed on the figure.

- Unbalanced axial thrust acting on the impeller shall be measured at 0, 20, 40, 90, 100, 110, 120, and 130 percent of rated Q in the pumping and turbining directions. The results shall be scaled up to prototype hydraulic thrusts and reported as a curve of prototype hydraulic thrusts versus prototype discharge.
- The direction and magnitude of radial force acting on the impeller shall be obtained. Tests shall be performed at 0, 10, 20, 40, 90, 100, 110, 120, and 130 percent of rated Q in the pumping direction and at a sufficient number of points in the turbining direction to fully demonstrate the thrust characteristics of the model and prototype.

(iv) Acceptance of Model

Acceptance of the hydraulic design for manufacture of the prototype will be based on the results of the model tests conducted by the contractor. Particular emphasis will be placed on the hydraulic performance of the model and its ability to operate smoothly and quietly throughout all normal operating conditions as well as the following:

The indicated capacity and efficiency of the prototype at rated and design conditions as determined by the model test. Indicated horsepower input for the prototype as well as the efficiencies and discharges over the entire range of heads.

(v) Failure of the Model to meet Specified Requirements

The Contractor shall replace the failure parts or to prepare a new complete model for re-tests, when the model test did not satisfy the specified conditions on the tests or the operation, and/or when the model did not satisfy the specified capacities, efficiencies and other requirements. All expense of replacing the model wholly or in part, as required, and of re-testing shall be borne by the Contractor.

(b) Equipment Test and Inspection

As to general requirements, refer to Section 8000. Following tests and inspections are required.

(i) Mill Sheets

The Contractor shall provide the Engineer with copies of all mill test reports as follows:

- For steel plate: Pump casing, casing extension, diffuser ring, casing cover and suction cover.
- For stainless steel plate: Wearing rings and shaft sleeve.
- For casting: Impeller
- For Forging: pump shaft and intermediate shaft

The specimens for one lots as to the casing, casing extension, discharge ring, casing cover and suction cover having the plate thickness exceeds 12 mm shall be impact tested and satisfied that impact absorbing energy is 27 J (0℃) or more.

(ii) Shop Assembly and Shop Measurements

a) Shop Assembly.

Each pump shall be assembled completely as much as possible at shop and properly match-marked, and doweled in the shop. The Contractor may not assemble components such as the suction-elbow liner, casing, casing extension, and the intermediate shaft. The contractor may provide the dummy diffuser ring in shop assembly, if required.

b) Shop Measurement.

During the shop assembly, or at other appropriate times, the Contractor shall obtain measurements and micrometer readings of the following.

- Concentricity, plane, and clearances for machined surfaces of important parts, such as diffuser ring, the casing cover, suction cover, impeller, and pump guide bearing.
- Stationary and rotating wearing ring concentricity measurements. In the above measurements, the deviation from true diametrical concentricity shall not exceed 1/4 of the radial design clearance between casing and impeller wearing rings.

Drawings showing the measurements and readings obtained shall be furnished to the 30 calendar days before the pump is shipped.

(iii) Shop Hydrostatic Tests.

Each casing extension, casing, casing cover, and suction cover shall be hydrostatic tested in the pump manufacturer's shop. This hydrostatic test may be conducted at site, if parts of the casing welded at site. The hydrostatic test shall be conducted after all repairs to the casing have been made. If defects are discovered during or after the hydrostatic test, they shall be repaired and the repaired items shall be re-hydrostatic tested. The test pressure shall be 150 percent of the design pressure for each component and shall be maintained for a minimum of 2 hours. Throughout the test period, all components shall be free of leaks.

The contractor shall also take micrometer measurements during the test to determine the amount of displacement of machined surfaces on the diffuser ring. The results of the micrometer measurements shall be included as part of the shop test results to be submitted. All details regarding the hydrostatic test shall be as determined by the contractor and approved by the Engineer. The Contractor shall be responsible for providing all labor, materials, and equipment necessary for conducting the test.

(iv) Paint inspection

After completion of finishing coat, coated surface appearance and thickness of coated layer shall be inspected and compared with painting schedules according to Sub-Section 8014.

(2) Site Tests

(a) Operational Tests

The Contractor shall carry the operation tests for each pumping unit before the unit is placed in service operation.

(b) Performance Tests

(i) General

Soon after the operation of each pump has been approved by the Engineer, it shall be tested the Engineer to determine whether the contractor's warranties and performance requirements have been fulfilled in accordance with IEC 198 "International code for the field acceptance tests of storage pumps".

(ii) Capacity and Efficiency Tests

Capacity and efficiency of the pumps will be determined for as many different heads within the range of heads stated in this Section. The capacities and efficiencies at the warranted conditions will be determined from smooth curves drawn through the test points. The efficiency tolerance shall be less than one (1) percent.

(iii) Conduct of the Tests

The tests will be conducted in accordance with IEC 198, and with the following exceptions. It shall confirm that the specified capacity is fulfilled, and consumption of the motor power is within specified one.

1) The total head will be determined as specified in Clause (v) below
2) Power will be determined as specified in this Clause (vi) below

(iv) Determination of Rate of Flow

Rate of flow water through the pump will be determined by the use of both the calibrated current flow meter by the MWRI, Hydraulic Institute and the Contractor's supplied ultrasonic flow meter.

(v) Determination of Total Head on the Pump

Total head on the pump (Ht) will be the difference between the pressure elevation at the pump discharge and the pressure elevation near the entrance to the suction elbow, both corrected for velocity head. All measurements will be converted to meter of water and will be determined as follows.

a. The pressure elevation "a" at the pump discharge will be measured by means of a deadweight-gauge tester connected to four equally spaced piezometers around the discharge line upstream of the discharge valve and converted to meter of water and referenced to the pump centerline.
b. The velocity head "b" at the pump discharge will be based on the mean velocity at the piezometer section. The mean velocity will be determined by dividing the rate of flow by the area at the piezometer section.
c. The pressure elevation "c" at the pump inlet will be measured by means of a deadweight-gauge tester connected to four equally spaced piezometers around the suction elbow piece and converted to meter of water and referenced to the pump centerline.
d. The velocity head "d" at the pump inlet will be based on the mean velocity at the piezometer section. The mean velocity will be determined by dividing the rate of flow by the area of the passage at the piezometer section.
e. The total head on the pump (Ht) will then be equal to (a + b) - (c + d)

(vi) Determination of Power

The electrical input to the motor will be measured by the 2 or 3 wattmeter method as applicable, using calibrated test instruments connected to the permanently installed instrument transformers. The input to the pump will be the measured input to the motor minus the mechanical and electrical losses in the motor and static exciter. The losses in the motor and exciter will be determined by separate tests in accordance with the latest standards and test codes of the IEEE (Institute of Electrical and Electronic Engineers, Inc.), and ANSI (American National Standards Institute).

(vii) Determination of Efficiency Curve

The efficiency curve of the pump will be determined from smooth curves of the input, head, and rate of flow of water, all as determined in accordance with the above Clauses.

(c) Water Hammer Test

The water hammer test shall be conducted for the confirmation of the adjustment of the valve control system and also the soundness of the countermeasure of the water hammer. This test shall included for the following items

- Pressure transient record at pump discharge and manifold.
- Adjustment of the valve closing time schedule
- Water level record of the two surge tanks
- Water flow shall be measured by the Contractor's supplied flow meter.
- Pump rotation shall be recorded during the transient condition.

This test shall be conducted under completely close of the discharge valve. Finally the test result shall be checked with the analysis, which is conducted by the pump manufacture, and the Contractor shall confirm that there are no problems for the water hammer transient condition.

(3) Test Reports

The Contractor shall submit to the Engineer with four certified copies of all reports of the tests. The report shall include any analyses of these tests.

8105 Spare Parts

The Contractor shall state the necessary spare parts to be kept in stock valid for two years normal operation. All spare parts shall be interchangeable for all four pumps. The spare parts as described in below shall be included in the spare parts list.

For Main Pump	Quantity
- Set of babbitt bearing shell for pump guide bearing	4
- Set of sleeve for pump shaft	4
- Set of wearing rings for impeller	4

	Quantity
- Set of wearing rings for stationary (Casing cover and suction cover) with set of screws or bolts	4
- Set of hydraulic packing for stuffing box	4
- Set of lantern ring for stuffing box	4
- Complete impeller	1
- Set of babbitted bearing shell for intermediate guide bearing	4
- Set of flange gaskets (only special one)	4

8106 Appliances and Tools

The Contractor shall furnish one complete set of any special wrenches, tolls, jigs or gauges, which are required for the adjustment or replacement of parts of items.

8107 Data, Descriptive Documents and Drawings

(1) Submittals of Initial Data and Information

a. General drawings and descriptive data, including plan and cross sectional drawings showing the general construction and over-all dimensions for the pumps. The drawings shall show limiting dimensions, including the length, offset and diameter of the pump casing extension the impeller diameter, pit diameter, diameter and elevation at the eye of the pump and the principal dimensions of the suction elbow liner. The drawing shall show the clearances necessary for erection, assembly and dismantling the pumps in the pumping station.
b. General information as to the materials to be used convenience and method of assembling and dismantling principal parts of the equipment and other information as may be needed to show that the equipment proposed meets requirements of these specifications.
c. Pump characteristic curves showing head, efficiency, power, torque input and submergence requirements versus flow throughout the entire range of flow rates from that corresponding to cutoff point to that corresponding to shutoff head.
   - Maximum amount of hydraulic uplift in tons during any phase of pump operation includes start-up and shutdown.

   If standard drawings and standard descriptive data are submitted, any modifications required to meet the requirements of these specifications shall be clearly indicated thereon.

(2) The Drawings for Manufacture

a. Within 120 days after notice of award, drawings showing overall dimensions of the principal parts such as the suction pipe pump casing, pit liner, and embedded parts.
b. Within 180 days after notice of award, all details of foundation requirements, proposed erection procedure, and details of all embedded parts so that design of second stage concrete can be confirmed.
c. Within one year after notice of award, calculation sheets of the pump critical speed and shaft deflection, analysis of water hammer, and instrumentation data prior to start of manufacturing.

8108 Instruction Manuals

a. The Contractor shall submit the operating and maintenance manuals for guidance of the erection and operating personnel. These manuals shall describe in detail the construction and recommended procedure for assembling, dismantling, maintaining and operating the equipment.
b. The Contractor shall submit four (4) copies to the Engineer for inspection and approval, at least three months before the first unit is to be commissioned.

8109 Measurement and Payment

Separate measurement or payment shall not be made for the work required under this section. Only when, all equipment or devices related to the main pump have been installed, connected and completed it is accepted by the Engineer.

All costs in connection with the work specified herein will be considered to be included with the related item of work in the Bill of Quantities.