

DIVISION 7 PUMP WORKS

SECTION 7000 PUMPING EQUIPMENT

7001 GENERAL

1.1 Standards and Workmanship

(1) General

All materials shall be new, the best of their respective kinds and of such as are usual and suitable for work of like character. All materials shall comply with the latest Japanese Industrial Standards (JIS) or equivalent.

All workmanship shall be of the highest class throughout to ensure smooth and vibration free operation under all possible operating conditions, and the design, dimensions and materials of all parts shall be such that the stresses to which they may be subjected shall not render them liable to distortion, undue wear, or damage under the most severe conditions encountered in service.

All parts shall conform to the dimensions shown and shall be built in accordance with approved drawings. All joints, datum surfaces, and mating components shall be machined and all castings shall be spot faced for nuts. All machined finishes shall be shown on the shop drawings.

(2) Standard to be used

All materials to be furnished under the Contract shall conform to the authorized standard for materials and tests of Japan or United State of America or equivalent. The following standards are referred to and abbreviations shown have been used :

- (a) Japanese Industrial Standards (JIS)
- (b) American Society for Testing and Materials (ASTM).

Other international standards may be accepted, provided that the requirements therein are in the opinion of the Employer equivalent to the issue of the Japanese Industrial Standards (JIS). If the Contractor proposes equivalent standard for such materials, the

Contractor shall state the exact nature of the changes between the proposed standard and the Japanese Industrial Standards and shall submit complete standard, and the information and data on the materials in the English language for the Employer's approval.

If no standard is indicated, then the relevant Japanese Industrial Standards, if any, shall apply.

All electrical equipment and metal or electrical works shall comply with the requirements and latest revisions of the following codes and standard where applicable :

- (a) Japanese Electro-Technical Committee's Standard (JEC)
- (b) Japanese Technical Standard for Electrical Facilities
- (c) Japanese Electric Machine Industry Association Standard (JEM)
- (c) Japanese Cable-makers Association Standard (JCS)
- (e) Local codes, other standards, instructed and/or approved by the Employer.

(3) Material Inspection and Testing

Materials, parts and assemblies thereof, entering into the Work shall be tested, unless otherwise directed, according to the best commercial method for the particular type and class of Work. When the manufacturer desires to use stock material not manufactured specifically for the equipment furnished, satisfactory evidence that such material conforms to the requirements herein stated shall be furnished, in which case tests on these materials may be waived. Certified mill test reports of plates and sections will be acceptable. In addition to the mechanical test required by the Specifications, all materials shall be examined in the shop for laminations and imperfections before incorporating them into the Work and any defective material shall be rejected.

For each castings specimen shall be tested and a certificate to this effect shall be furnished by the manufacturer to the Employer showing the conformity of the materials specified.

The ultimate strength, limit of elasticity, ductility, hardness, etc., will be determined from such test pieces.

The Contractor shall furnish, free of charge, all such test pieces out and machined to the sizes, shapes and dimensions. The testing of the specimens shall be carried out by the Contractor at this own expense.

Two copies of all test reports shall be mailed simultaneously to the Employer. The Contractor shall also supply to the Employer certified test reports giving the chemical analyses and physical properties of materials used.

(4) Shop Assembly

All items of equipment shall be assembled in the shop prior to shipment and tests shall be performed by the Contractor as may be required to demonstrate to the satisfaction of the Employer the adequacy of the equipment and its component parts. All tests should simulate normal operating conditions as closely as possible.

All dismantled parts shall be properly matchmarked and doweled to ensure correct assembly in the field.

(5) Castings

All castings shall be dense, sound and true to pattern, of workmanlike finish and of uniform quality and condition, free from blowholes, porosity, hard spots, shrinkage defects, cracks or other injurious defects, and shall be satisfactorily cleaned for their intended purpose.

Castings shall not be repaired, plugged, or welded without permission of the Employer. Such permission will be given only when the defects are small and do not adversely affect the strength, use, or machinability of the castings. Excessive segregation of impurities or alloys at critical points in a casting will be cause for its rejection.

Surfaces which do not undergo machining and are exposed in the final installation shall be dressed to provide a satisfactory appearance so that they will not require surface smoothing at the Site prior to painting.

(a) Iron Castings

Iron castings shall be in accordance with JIS G 5501, FC 250 or equivalent.

(b) Steel Castings

Steel castings shall be fully annealed and shall be in accordance with JIS G 5101, SC 450 or equivalent.

(c) Bronze Castings

Bronze castings shall be in accordance with JIS H 5111, BC 2 or equivalent.

(d) Phosphor Bronze Castings

Phosphor bronze castings shall be in accordance with JIS H 5113, PBC 2 or equivalent.

(6) Forgings

Forgings shall be in accordance with JIS G 3201, SF 390A or equivalent. The ingots from which the forgings are made shall be cast in metal molds, the workmanship shall be first-class in every respect and the forgings shall be free from all defects affecting their strength and durability, including seams, pipes, flaws, cracks, scales, fins, porosity, hard spots, excessive non-metallic inclusions and segregations.

(7) Mild Steel Plate and Bars

(a) Structural steel and flat bars shall be in accordance with JIS G 3101, SS 400 or equivalent.

(b) Steel bolts, nuts and washers shall be in accordance with JIS G 3123 or equivalent.

(c) Corrosion-resisting steel and bars shall be in accordance with JIS G 4303, G 4304, G 4305, G 4306 and G 4307 or equivalent.

(8) Machine Work

(a) General

All tolerance, allowances and gauges for metal fits between plain cylindrical parts shall conform to Japanese Industrial Standards or other approved equivalent standards for the class of fit as shown or otherwise required. Bearing surfaces shall be true and exact to secure full contact. Journal and sliding surfaces shall be polished and all surfaces shall be finished with sufficient smoothness and accuracy to ensure proper operation when assembled. Parts entering any machine shall be carefully and accurately machined. All drilled holes for bolts shall be accurately located and drilled from templates.

(b) Finished Surfaces

Surface finish shall be indicated on the Contractor's drawings and shall be in accordance with Japanese Industrial Standards or equivalent. Compliance with specified surface will be determined by sense or feel and by visual inspection of the work compared to standard roughness specimens, in accordance with the provisions of the above stated standards.

(c) Unfinished Surfaces

So far as is practicable, all work shall be arranged to obtain proper matching of adjoining unfinished surfaces. When there is a large discrepancy between adjoining unfinished surfaces, they shall be chipped and ground smooth, or machine, to secure proper alignment. Unfinished surfaces shall be true to the lines and dimensions shown on the drawings and shall be chipped or ground free of all projections and rough spots. Depressions or holes not affecting the strength or usefulness of the parts may be filled in an approved manner.

(d) Keys and Keyways

Keys and keyways shall conform to the requirements of Japanese Industrial Standards or other approved equivalent standards, unless otherwise specified or required.

(e) Pins and Pin Holes

Pin holes shall be bored to gauge, smooth and straight, and at right angles to the axis of the member. The boring shall be done after the member is securely fastened in position. Pins shall be of hardened and ground steel and positively held in position.

(f) Lubrication

Before assembly, all bearing and journal surface's grease and oil grooves shall be carefully cleaned and lubricated with an approved oil or grease. After assembly, each lubricating system shall be filled with an approved lubricant. Self-lubricating bearings shall be cleaned with clean rags, and greased with an approved lubricant before assembly. Solvent shall not be used on the self-lubricating bearings. The specification of all approved lubricants will be mentioned in the operating and maintenance instructions.

(g) Balancing

All revolving parts shall be truly balanced both statically and dynamically so that when running at normal speeds and any load up to the maximum, there shall be no vibration due to lack of such balance and the plant shall operate with the least possible amount of noise.

(9) Welding

All welding shall be done either manually by the shielded metallic arc process or automatically by the shielded arc or submerged arc method.

The Contractor shall submit a welding procedure for the approval of the Employer in the same manner as the drawings. After the welding procedure has been approved, the Contractor shall record it on a special drawing which shall thereupon become one of the drawings of the Contract. Weld sizes and types shall be shown on all shop drawings where welding is required.

Plates to be joined by welding shall be accurately cut to size and rolled by pressure to the proper curvature which shall be continuous from the edge. Flattening in the curvature along the edges with correction by blows will not be allowed. The dimensions and shape of the edges to be joined shall be such as to allow thorough fusion and complete penetration as necessary and the edges of plates shall be properly formed to accommodate the various welding conditions. The surfaces of the plates for a distance of 25 mm from the edge to be welded shall be thoroughly cleaned of all rust, grease and scale, to bright metal.

(10) Qualification of Welding Procedure

The technique of welding employed, the appearance and quality of the welds made and the methods used in correcting defective work, shall conform to the American Welding Society (AWS) standard D.I.I., or other approved equivalent standard.

(11) Qualification of Welders and Welding Operators

All welders and welding operators assigned to the works shall have passed a qualification test, within the preceding six months, for welders and welding operators, in accordance with JIS Z 3801 or equivalent. The Contractor shall furnish the Employer with certified copies of report of the results of physical tests of specimens welded in the qualification tests. If, in the opinion of the Employer, the work of any welder at any time appears

questionable he shall be required to pass the appropriate re-qualification test. All costs of qualification tests shall be borne by the Contractor.

(12) Welding Electrodes

The welding electrodes shall conform to JIS Z 3211 or 3212, low hydrogen type covering or equivalent.

Stainless type weld metal, where used in the water passages for protection against pitting, shall be of chromium nickel steel. The type, chemical composition and JIS or approved standard number of welding rods used for this purpose shall meet with the approval of the Employer.

(13) Piping

(a) General

Steel pipe shall be used for water lines. All necessary studs, bolts, screws, nuts, washers, gaskets, packing, supports, etc., required in connection with the field assembly of the piping systems shall be supplied by the Contractor. All gaskets and packing shall be of approved material and of a type that has proved satisfactory for the service to which they will be subjected. Where pipe is embedded in concrete, it shall be carefully set to the required lines and grades and securely braced and held so that no movement shall occur during concrete placement. Pipe supports to be embedded in concrete shall be made of material which will not deteriorate weaken or cause damage to the pipe. The Contractor shall schedule and arrange his work of installing pipes and pipe supports in co-operation with the Employer.

(b) Hangers and Supports

The Contractor shall supply and install all pipe hangers, brackers and supports required for the support of the piping, including the drilling and caulking for expansion anchors and any work incidental to the setting of such embedded anchors or inserts in concrete.

Unless otherwise specified, pipe supports shall be spaced at 2.1 m maximum. Vertical runs shall be supported by means of pipe clamps or collars. Hangers and supports shall be painted.

(c) Installation and workmanship

Piping shall be installed in the locations, elevation and to lines in accordance with the approved drawings. All lines shall be sloped to allow drainage to the low point. Where a branch cannot be drained through fixtures, a drain valve shall be provided in an accessible location. All piping shall be fitted and assembled to introduce the minimum of stressing to the pipe and fittings, and the assembly shall conform to the best piping practice. The Employer shall be the sole judge of the standard of workmanship. All pipes shall be supported and installed to avoid pockets that will not drain completely. All piping to be embedded shall be tested and approved by the Employer prior to being embedded.

Sleeves or check-nuts will be provided where pipes pass through a wall, floor or beam. The space around the pipe should be filled with concrete.

All surfaces of the pipe which come in contact with concrete shall be cleaned prior to placing the concrete in order to secure a satisfactory bond. Pipe unions shall be fitted where necessary to facilitate installation or maintenance of equipment.

(d) Test of Piping Systems

The Contractor shall test all pipe lines as directed by the Employer and shall supply all labor, material, pumps, plugs, gauges, etc., required to make the complete test. Lines shall be tested in convenient sections. In the case of failure due to faulty workmanship on the part of the Contractor, material failure or leaks, he shall repair all damage and leaks, replace the faulty material, and retest the piping at his own cost until the satisfactory results are obtained. Results of all such tests shall be furnished.

Before testing, all anchor blocks, thrust supports, and hangers shall be in place. If piping is tested in section, temporary end caps shall be fitted to the approval of the Employer. Each section shall be slowly filled with the test medium, care being taken to expel all air from the piping if liquid is used. For acceptance, the test pressure shall remain constant for the period without pumping additional water into the section under test. If a drop in pressure occurs, leaks shall be repaired and the pipe line retested until acceptable.

(14) Hydraulic Pressure Tests

All pressure vessels, cooling coils and piping shall be pressure tested, and shall meet the following requirements :

- (a) Part subject to water pressure :
1.5 times the maximum design pressure for 10 minutes
- (b) Parts subject to air pressure :
1.5 times the maximum design pressure for 10 minutes
- (c) All other parts :
Twice the maximum working pressure but not less than 70 lbf/cm² (32.8 kgf/cm²) for 10 minutes.

All pressure is gauge pressure. All leaks and evidence of excessive or permanent deflection shall be repaired to the fullest satisfaction and the test repeated until the test results are satisfactory. Results of all such tests shall be furnished.

1.2 Change to Material and Equipment

The Contractor shall not make any changes to the equipment or in the materials to be incorporated in the Plant that specified or implied by these Specifications without the written approval of the Employer.

Such changes or alterations shall in no way be detrimental to the interests of the Employer and shall not result in any increase to the Contract Price.

1.3 Design and Working Stress

The design, dimension and materials of all parts shall be such that they will not suffer damage under the most adverse conditions nor result in deflections and vibrations which might adversely affect the operation of the equipment. Mechanisms shall be so constructed to avoid sticking due to rust or corrosion.

The Contractor shall design the equipment in careful consideration of the tropical climate and shall also pay attention both to the optimum material selection and to construction in order to ensure their long reliable service life and efficient operation by removing the much amount of garbage, etc. The Contractor shall submit the calculations and drawings of the pumping equipment to the Employer for his approval.

All parts which will have to be dismantled or which might have to be dismantled, for purposes of servicing or replacement shall be fastened with noncorrodible fasteners. The type, material and size of all fasteners shall be selected to safely withstand the maximum superimposed direct, alternating, kinetic and thermal loads and all loads induced by workmen when installing or removing the fasteners during the life of the equipment.

The design shall be such that the installation, replacement and general maintenance may be undertaken with the minimum of time and expense. The tolerances used for dimensions and finishes shall be selected with due consideration to the particular properties and functions of the parts and the corresponding accuracy required to obtain proper operation and tight sealing.

Wherever possible, all similar parts, including spare parts, shall be made to gauge and interchangeable. Such parts shall be of the same materials and workmanship and shall be constructed to such tolerances as to enable substitutions or replacement from spare parts to be made easily and quickly.

Suitable structural steel bases or frames shall be provided where necessary to transmit to the concrete foundations all loads imposed by the various parts of the Plant. Such bases or frames shall be supplied complete with suitable anchor bolts and shall be so proportioned that the bearing loads imposed on the concrete foundations will not exceed 50 kg per square cm.

All Plant shall be designed to minimize the risk of fire and consequential damage, to prevent ingress of vermin, dust and dirt, and accidental contact with electrically energized or moving parts. The Plant shall be capable of continuous operation with the minimum attention and maintenance in the exceptionally severe conditions likely to occur in the Site climate.

1.4 Protection, Clearing and Painting

The following surfaces shall not be painted :

- a. Surface which will be buried in concrete
- b. Parts made of stainless steel, bronze or brass
- c. Surfaces in rolling or sliding contact
- d. Surfaces such as gear teeth
- e. Wire ropes.

All machined parts or bearings surfaces shall be cleaned and protected from corrosion before leaving the manufacturer's shop by the application of an approved rust preventive compound or a peelable plastic film. Where the latter is impracticable such parts shall be heavily covered with high melting point grease or other approved materials. Before commencement of erection such parts shall be cleaned with solvent and lapped or polished bright. The Contractor shall supply the materials necessary for each cleaning.

All parts, other than machined parts, which will be exposed after erection shall be thoroughly cleaned and given at least three coats of best quality approved primer and at least two coats of best quality approved finish paint before leaving the manufacturer's shop. The Contractor will perform to the equipment touching up on the Site after erection, except such apparatus as panels and instruments which will be finish painted under approved procedures before shipment. The Contractor shall supply paint materials and necessary tools, which are used at the Site, with the Plant.

Primer shall be applied to surfaces prepared in accordance with the paint manufacturer's instructions. The surface shall be wiped clean immediately prior to applying the paint. The primer and finish coats of paint shall be applied using the methods and equipment recommended by the manufacturer. The paint system selected shall have a proven life expectancy of not less than five years in the atmosphere prevailing at this Project.

The internal surface of all pipes shall be cleaned out by approved methods before installation and again prior to commissioning, to ensure freedom from dirt, rust, scale, welding slag, etc. All exposed pipes shall be color coded for identification after erection is completed. The code system shall be approved by the Employer.

The final color of all equipment shall be approved by the Employer but the Contractor shall propose a color scheme for the equipment and shall submit color chips or paint samples. A color chip shall be included with the approved color schedule, for each type of finish to be applied at the Site.

1.5 Labels and Plates

All data, name plates, duty labels and instruction plates on cubicles and equipment shall be in English, unless otherwise instructed by the Employer. The Contractor shall submit the schedule of labels and plate for approval of the Employer of which the schedule shall include names, dimension, materials, colors, etc.

1.6 Packing and Marking

Except as may be otherwise approved by the Employer, the whole of the Plant shall be packed or bundled properly so that no damage shall be sustained during transportation to the Site and by rough handling.

Waterproof papers and felt linings shall overlap at seams secured together in adequate manner, but the enclosure shall be provided with screened opening to obtain ventilation.

The method of protection and packing must be suitable to withstand any climate conditions which may be experienced in transit or at the Site. The packing shall be suitable for withstanding rough handling and long periods of storage out of doors in tropical climate.

Each crate, package or bundle shall be marked on the outside to indicate name of consignee, and contain a packing list in a waterproof envelope and copies shall be forwarded to the Employer prior to dispatch. All items of material shall be clearly marked for easy identification against the packing list.

All crates, packages or bundles shall be clearly marked on the outside to indicate the total weight, to show where the weight is bearing and the correct position of the slings and shall bear and identification mark relating them to the appropriate shipping documents.

The Employer shall reserve the right to inspect and approve the equipment and the packing before the items are dispatched. The Contractor shall be entirely responsible for ensuring that the packing is suitable for responsibility for any loss or damage due to faulty packing.

All packing materials shall remain the property of the Contractor and shall be removed from the delivery Site at the earliest opportunity and disposed of to the satisfaction of the Employer.

1.7 Delivery

No part of the Plant shall be delivered to the delivery Site until approval in writing has been obtained from the Employer for such delivery.

Upon shipment of each package or crate, the shipping list shall be attached to the Bill of Lading and an additional copy shall be attached to the package or crate shipped.

The Plants shall be delivered with the complete assembly as far as possible to ensure that the installation or erection may be easily undertaken with the minimum of time and expense.

1.8 Tests

(1) Test at the Manufacturer's Factory

Test at the Manufacturer's Factory shall be carried out in accordance with the requirements of the appropriate section. The results of all tests shall verify the guarantees.

(2) Tests at the Site

(a) Preliminary Test

During and after the installation/erection of each Plant, the Contractor shall perform the following preliminary tests to establish the accuracy of the assembly, to be in sound condition to operate under load and to prove the adequacy of the materials and the workmanships. All tests and test procedures shall be approved by the Employer.

- Insulation tests and drying out of equipment, if required
- Ground continuity tests
- Circuit continuity tests
- Testing and setting up of all relays and other protective equipment
- Hydrostatic tests on all piping, cooling coils and pressure tanks
- Operation tests of auxiliary equipment
- Pump reduction gear and motor/engine shafts alignment and measurement of impeller vane clearance
- Operation of the pump and motor, to check bearing operation, running clearances
- High voltage test
- Any additional tests required by the Employer to ensure the safety of the equipment when operated.

(b) Test on Completion

After the ancillary and control equipment has been installed, tested and approved and each pump unit is fully installed, adjusted and successfully completed its mechanical run, the Contractor shall conduct operation tests in the Employer's presence to demonstrate that the entire work is properly installed, is free from objectionable leakage and is correctly adjusted to operate as specified. The Contractor shall provide and submit the test program including lists of detail test items to the Employer for his approval prior to the testings.

The Contractor shall make all final adjustment to the control and detection devices. The Contractor shall be responsible for the operation of the unit during the test on completion. The pump operation test shall be made when water level in suction pondage is situated at above the stop water level. All the tests shall be carried out by the Contractor at his responsibility and costs including necessary testing equipment and instruments. Required electric power for the test will be supplied by the Employer without charge. The final results of all tests including tests run by the Contractor shall be subject to acceptance by the Employer.

The Contractor shall submit to the Employer two copies of test and inspection report.

1.9 Training of Employer's Staff

The Contractor shall provide the training services by qualified instructor(s) who are fully skilled in operation and maintenance of machines, during the erection and commissioning at the site and during the maintenance period, for the Employer's employees who will subsequently be responsible for the operation and maintenance. The Contractor shall provide twenty (25) copies of operation and maintenance manual and textbooks for the training services.

The training services for the Employer's employees shall be carried out as follows.

(a) During the erection and commissioning at the Site

One (1) mechanical instructor : three (3) months and

One (1) electrical instructor : one (1) month.

(b) During the maintenance period

One (1) mechanical instructor : two (2) months and
one (1) electrical instructor : one (1) month

Payment for training services will be made at the price for the pay item No. 5312. The price shall include the cost of all instructors to be dispatched by the Contractor, operation and maintenance manual, textbooks and all other materials required for successful training services.

1.10 Special Tools

A complete set of all necessary tools other than the Contractor's equipment shall be supplied by the Contractor to enable any dismantling, reassembling or testing to be carried out any part of the equipment, whether of an electrical, mechanical or any other nature during the life of the equipment and shall be subject to approval by the Employer.

7002 MAIN PUMPS

2.1 General

This section covers the design, manufacture, tests before shipment, erection and tests at the Site of:

- 1) Three (3) Motor-driven pumps, each complete with necessary accessories for the satisfactory and efficient operation
- 2) One (1) Engine-driven pump, complete with necessary accessories for the satisfactory and efficient operation.

The complete detail of the various parts of the equipment are not specified in the Specifications. It will be left to the experience and practice of the Contractor to furnish the equipment which will meet in all respects the requirements of the Employer with regard to performance, reliability and satisfactory operation, but subject to the Employer's approval.

The pumping station shall be used for irrigation. The arrangement of the pumps shall be as shown on the respectively attached drawings.

2.2 Design Conditions

(1) Water Requirement

Water requirement : 16.0m³/s
Rated discharge per unit: 4.0m³/s (240m³/min)

The rated discharge per unit shall be the capacity of each pump at the rated total head.

(2) Rated total head

	<u>Motor-driven pump</u>	<u>Engine-driven pump</u>
Rated actual static head	5.40m	5.40m
Rated total head	6.10m	6.20m

(3) Water Levels

a) Intake canal	Maximum	WL + 2.50m
	Normal	WL + 0.70m
	Minimum	WL - 1.30m
b) Suction Sump	Planned	WL - 1.60m
	Minimum	WL - 1.90m (emergency)
c) Discharge reservoir	Planned	WL + 3.80m
	Minimum	WL - 1.39m

2.3 Technical Requirements

The main pumps shall be single-floor type, vertical shaft, mixed-flow pumps and each pump shall be connected with a horizontal shaft induction motor or a diesel engine through a reduction gear.

The principal particular of the pumps shall be as follows :

	<u>Motor-driven pump</u>	<u>Engine-driven pump</u>
Bore of pump	1,350 mm	1,350 mm
Pump speed	Approx. 250 rpm	Approx. 250 rpm
Efficiency at rated point	Not less than 83.5%	Not less than 83.5%
Rated output	350KW	500PS

The Contractor shall pay special attentions to the design of the pumps to avoid any cavitation under full range of the pump operation from the maximum to the minimum actual static head. The hydraulic thrust and the weight of rotating parts of the pump shall be supported by the thrust bearing furnished with the reduction gear. The weight of the pump, the reduction gear and water in the pump casing shall be supported at the pump floor.

2.4 Construction

The pumps shall be able to operate safely and satisfactorily under all specified operating conditions. Corrosion allowance of 2 mm shall be added to the surfaces of the pump parts exposed in water. Adequate provision shall be made for convenient handling of all parts during assembly or disassembly of the pumps.

(1) Suction bell, Casing liner, Casing

The suction bell, casing liner and casing shall be made of gray iron castings equivalent to JIS G 5501, FC 250.

The suction bell shall be designed to minimize the hydraulic entrance losses. The casing shall be flanged and machined and shall be separated from the casing liner. The casing liner facing to the impeller shall be accurately machined. The casing shall be flanged and machined for close fit with the column pipe.

(2) Column pipe, Bearing bracket and Discharge elbow

The column pipe, bearing bracket and discharge elbow shall be made of gray iron casting equivalent to JIS G 5501, FC 250.

The column pipe shall be assembled between the casing and bearing bracket. The column pipe, bearing bracket and discharge elbow shall have smooth inner surfaces so as to allow the effective discharge with the minimum head loss.

The discharge elbow shall be designed to withstand all structure loading, and be provided with adequate curve sections for discharging the water from the column pipe/bearing bracket to the horizontal outlet.

(3) Impeller

The impeller shall be of the open-unbalanced, mixed-flow type and shall be made of steel castings equivalent to JIS G 5101, SC 450.

The impeller shall be designed to withstand the specified heads, and shall be free from noise, cavitation and vibration. The impeller shall be statically balanced by accurate machining and finished to minimize losses arising from hydraulic impulse.

An optimum clearance shall be provided between the blade tip of the impeller and the casing liner so as to minimize the efficiency loss of the pump and minimize the occurrence of cavitation.

(4) Shaft

The shafts shall be made of stainless steel equivalent to JIS G 4303, SUS 304, and shall be accurately machined for precision shafting, and shall have sufficient strength to transmit the required power. The rigidity of the shafts shall be so designed that this first critical speed is at least 130 percent of the normal speed.

(5) Coupling

The coupling between the shaft of the reduction gear and the pump shaft shall be a three piece adjustable flanged type. Adjustment shall be made at this coupling to obtain the correct axial alignment of the impeller in the casing.

Intermediate shaft coupling shall be of suitable rigid type.

(6) Guide Bearings

Ceramic bearings which shall be lubricated directly by the river water shall be provided to support radial load. The bearing sleeves shall be hard metal (special alloy) and shall be provided at the contact surface of the guide bearings.

(7) Stuffing box

Suitable shaft seals not requiring any external sealing water shall be provided.

(8) All bolts and nuts of pump being in contact with the river water shall be made of stainless steel

2.5 Control System

(1) Description of Pump Operation

Each pump, including engine-driven pump, shall be normally sequentially operated on the central control desk in the control house. The control house will be located at the Diversion Dam Site. Operation, instrumentation, indication signal and so on shall be transmitted by transmission line.

(a) Main Pumps (motor-driven and engine-driven)

Operation, "Local / Individual-Local / Sequential-Control House", shall be selected by a change over switch (COS) mounted on a local control panel for each of the main pump.

In case of "Local / Individual" operation, priming pump and open-close operation for discharge valve can be operated by respective control switches (CS) on the local control panel.

The main pump can be operated under several protective interlocks by a CS operation, on the local control panel. Each main pump panel does not have any pump operation switch. It has only an AS for ammeter. In case of "Local / Sequential" operation, concerned a priming pump, a main pump and a discharge valve shall be automatically started by the CS operation, on the local control panel.

In case of "Control House" operation, a priming pump, a main pump and a discharge valve shall be automatically started/stopped by operation signals from the central control desk.

(b) Incoming Power

A VCB for 3KV incoming power shall be operated close/open by a selector switch "Income Panel / Control House", mounted on the incoming panel.

In case of "Control House" operation, close/open operation for the incoming VCB shall be operated by signals from the central control desk.

(c) An automatic transfer switch (ATS)

A selector switch for "Manual-Auto." will be provided on the Low Voltage Panel.

In case of "Manual" operation, commercial or ACG power supply will be selected by a control switch mounted on the LV panel.

In case of "Auto." operation, normally the ATS shall be connected to the commercial line. Once power failure will be occurred, the ATS shall be automatically transferred to the ACG power line.

A few hours later the commercial failure will be recovered. Then the ATS shall be automatically transferred to the commercial power line again.

The low voltage power supply will be momentary cut during ATS operation.

(d) Emergency Generator (Diesel Engine drive ACG)

A selector switch "Auto.-Manu.-Cont.House" shall be mounted on the ACG panel. In case of "Auto.", the ACG unit shall be automatically started by a signal of commercial power failure, and shall be stopped by a signal of the power recovery.

In case of "Manu." the ACG unit shall be started/stopped at ACG panel.

In case of "Cont. House", the ACG unit shall be started/stopped by signals from the central control desk. Because the ACG power will not always be necessary during commercial power failure.

(e) SC Feeder

A control switch "On/Off" for the VCB shall be mounted on the panel. Remote "On/Off" at the central control desk will not be provided.

(2) Operating Sequence for Main Pump

Starting sequence :

- 1) Confirming the water level conditions
- 2) Protective device is not actuated
- 3) Priming pump start
- 4) Start of main pump
- 5) Discharge valve open.

Stopping sequence :

- 1) Closing the discharge valve and stop the main pump.

(3) Fault Indication and Audio-Alarm

The Contractor shall provide in the control system all necessary facilities for operating and stopping pumps and shall give alarms and indications to the operator at central control desk.

Each of troubles and accidents shall be individually light-indicated on the auxiliary relay panels. And those shall be sent to the central control desk for indication and audio alarm.

Major and minor faults for each pump shall be sent to the central control desk as a unit.

(4) Operational Signals

The Contractor shall provide in the control system all necessary facilities for operation, indicating the state and instrumentation on each main pump panel, local control panel and/or auxiliary relay panel.

Major items necessary for indicating of the instrumentation at the central control desk will be as follows :

- 1) Suction water level
- 2) Discharge water level
- 3) Incoming line voltage
- 4) Incoming load current
- 5) KWH at incoming line
- 6) Power factor at incoming line
- 7) Operating hours of diesel engine
- 8) Speed of diesel engine
- 9) Load current of each main motor
- 10) Load current of SC feeder
- 11) Supplied voltage from emergency ACG
- 12) Supplied load current from emergency ACG.

2.6 Accessories

The following accessories shall be provided by the Contractor for each pump :

- 1) One complete set of coupling bolts and nuts
- 2) One complete set of anchor bolts and nuts
- 3) One set of compound gauge
- 4) One set of air vent valve including necessary pipes
- 5) One complete water-tight pump base
- 6) One set of water level switch for safe operation
- 7) Other necessary accessories.

2.7 Tests

(1) Tests at the Manufacturer's shop

Before dispatch from the manufacturer's shop, the all pumps shall be assembled to prove the satisfactory functions. The test shall include dimensional check, material test, painting and packing inspection. If any defect or improper operations are discovered, they shall be corrected.

The performance test of all four (4) main pumps shall be carried out in accordance with the applicable provisions of the latest JIS B 8301 "Testing Methods for Centrifugal

Pumps, Mixed Flow Pumps and Axial Flow Pumps" or equivalent. Measurement shall be taken on not less than four different discharges including the discharge quantity at the rated total head.

The pumps may be rejected for any of the following reasons :

- 1) The shaft power at least one point in the measuring scope exceeds the specified rated output
- 2) Discharge which corresponds to the rated total head is smaller than the specified value
- 3) The pump efficiency which corresponds to the rated total head is smaller than the specified value

(2) Installation and Tests at the Site

The Contractor shall take out the pump from its packing and shall inspect the pump for damage. The Contractor shall repair or replace any damaged portion of the pump, subject to approval of the Employer.

The sole plates for each base assembly shall be installed on the concrete foundation and each base (and beam) shall be assembled and installed on the sole plate. The sole plate shall be aligned and adjusted to keep the pump vertical. After final alignment, the sole plates shall be grouted with a non-shrink grout by the Contractor.

The anchor bolts shall be tightened after alignment of the pump shaft and the reduction gear shaft.

The Contractor shall test all materials, apparatus, equipment and works before the completion date. Before any test is made, the Contractor shall check the work, material, apparatus and equipment for proper connections and adjustments, and place it in satisfactory operating condition.

After the installation has been completed and pumps have been operated for a sufficient period to make all desirable corrections and adjustment, each pumping unit and associated equipment shall be tested to prove that the operation is satisfactory.

Systems shall be tested as deemed necessary by the Employer, to prove that the facilities meet the operational requirements.

Any defect observed during the tests shall be improved by the Contractor.

7003 DISCHARGE PIPES, LOOSE FLANGES AND EXPANSION JOINTS

3.1 General

The Contractor shall provide the necessary discharge pipe from each pump to the discharge side with a loose flange. The pipes shall be designed to minimize the hydraulic losses and for water to flow smoothly.

The loose flange with tension bolts shall be provided for easy assembling and disassembling of the pump and the pipe.

For each main pump discharge pipe, an expansion joint shall be provided between the pump house and the discharge reservoir.

3.2 Discharge Pipes

The design conditions of the discharge pipes shall be as follows :

- 1) Design pressure : 2kgf/cm²
- 2) Corrosion allowance : 2mm
- 3) Size : 1,350 mm dia.

Each discharge pipe shall consist of a pipe proper, a magnifying pipe, seepage rings and other necessary components. Each pipe shall be connected with a flange. The pipes shall be made of mild steel. The following accessories shall be provided by the Contractor for each pipe :

- 1) Bolts and nuts
- 2) Gasket
- 3) Other necessary accessories.

Before dispatch from the manufacturer's shop, the pipe shall be assembled to check the satisfactory manufacturing. The tests shall include material test, dimensional check, painting and packing inspection.

3.3 Loose Flanges

Each loose flange shall consist of a loose flange proper, a short pipe, tension bolts and nuts.

The loose flanges proper shall be made of mild steel. Short pipes shall be designed in accordance with the requirement of Section 3. 2.

3.4 Expansion Joints

The design conditions of the expansion joint shall be as follows :

- 1) Design pressure : 2kgf/cm²
- 2) Settlement : 100mm
- 3) Diameter : 1350mm dia.

The expansion joint shall be rubber type.

7004 VALVES

4.1 General

This section covers the design, manufacture, tests before shipment, erection and tests at the Site of :

Four (4) main pump discharge valves

Four (4) main pump non-return valves.

The complete details of the various parts of the equipment are not specified in the Specifications. It will be left to the experience and practice of the Contractor to furnish equipment which shall meet in all respects the requirements of the Employer in regard to performance reliability and satisfactory operation, but shall be subject to the Employer's approval.

The arrangement of the valves shall be as shown on the attached drawings.

4.2 Discharge valves

Each main pump shall be provided with electrically operated butterfly valve in its discharge pipe. The valves shall be of flanged type and shall be complete with actuating mechanism, bolts, nuts, gaskets, lifting lugs and supporting foot.

The butterfly valves shall be water-tight and shall conform to the following, and shall be installed in horizontal position :

Size	: 1350mm dia.
Design pressure	: 2kgf/cm ²
Maximum differential pressure	: 1.5kgf/cm ²

The materials of construction of the valve shall be as follows :

Body	: Gray iron casting equivalent to JIS G 5501, FC 250
Disc	: Gray iron casting equivalent to JIS G 5501, FC 250
Disc seat	: Rubber
Shaft	: Stainless steel.

The valve shall be connected with the pipe by means of flange connection. Flange standard shall be JIS B 2064 or equivalent.

Provision for manual operation shall be made and the interlock device shall be provided. Each butterfly valve shall have two limit switches to actuate at full open and full closed positions.

4.3 Non-Return Valves

The Contractor shall provide a flap valve, as a non-return valve, at the end of each pump discharge pipe. The flap valve shall be used for preventing back-flow of the water in the discharge reservoir to the pump.

The design conditions of the valves shall be as follows :

Size	: 1650mm dia.
Corrosion allowance	: 2mm.

The valve shall consist of a valve case, flap, spindle and other necessary components. The flap shall be inclined 15 degrees from the vertical axis to smoothly seat itself at the valve case. The valve shall be connected with the discharge pipe by means of a flange connection. The valve case shall be made of mild steel.

4.4 Tests

Before dispatch from the manufacturer's shop, the valve shall be assembled to prove the satisfactory functions. The tests shall include dimensional check, material test, painting and packing inspection. If any defect or improper operations are discovered, they shall be corrected.

After the installation has been completed, the valves shall be tested to prove that the function is satisfactory with the pumping equipment.

7005 SPEED REDUCTION GEARS

5.1 General

The reduction gear shall be of vertical, air-cooled, right-angle type and be sufficient for transmission of the power from the motor or the diesel engine to the main pump. The reduction gear shall be designed to provide efficient, smooth and reasonably quiet running drive under required operating conditions.

5.2 Design Conditions

	Motor-driven	Engine-driven
Rated transmission power	350 KW	500 PS
Input speed	Approx. 1,000 rpm	Approx. 1,000 rpm
Output speed	Approx. 250 rpm	Approx. 250 rpm

5.3 Construction

The reduction gear shall consist of the power input shaft, spiral bevel pinion, spiral bevel gear, power output shaft and other necessary components.

The hydraulic thrust and the weight of rotating parts of the pump shall be supported by the thrust bearing of the reduction gear.

All gears shall be hardened, then hard-cut and shall have no defect on the surface. The materials of the spiral bevel pinion, the spiral bevel gear and the shaft shall be of chromium molybdenum steels and carbon steel respectively, or approved materials.

All the gears and the bearings shall be lubricated by a lubricating unit which shall be provided to each reduction gear, an oil supply pump driven by a separate motor and other necessary components.

The reduction gear shall be designed to bear for 50,000 hours' operation.

5.4 Accessories

The following accessories shall be provided by the Contractor for each reduction gear:

- 1) One set of pressure gauge
- 2) One set of strainer
- 3) One set of oil supply pump driven by a separate motor
- 4) One set of check valve
- 5) One set of oil circulation pump provided in the reduction gear
- 6) One set of radiator
- 7) One lot of oil circulation pipe
- 8) One set of flow sight
- 9) One set of pressure switch
- 10) One complete set of coupling bolts and nuts
- 11) One set of oil level gauge
- 12) One set of oil temperature detector
- 13) One set of thrust bearing temperature detector
- 14) Other necessary accessories.

5.5 Tests

(1) Tests at the Manufacturer's Shop

Before despatch from the manufacturer's shop, the reduction gear shall be assembled and performed to prove specified functions. The tests shall include material test by mill-sheet, dimensional check, painting and packing inspection, and mechanical running test (no-load). If any defect or improper operations are discovered, they shall be corrected.

(2) Tests at the Site

After the installation has been completed, the reduction gears shall be tested to prove that the operation is satisfactory with the pumping equipment.

7006 ELECTRIC MOTORS

6.1 General

This section covers the design, manufacture, tests before shipment, erection and tests at the Site of:

Three (3) main pump motors and accessories.

The complete details of the various parts of the equipment are not specified in the Specifications. It will be left to the experience and practice of the Contractor to furnish equipment which shall meet in all respects the requirements of the Employer in regard to performance reliability and satisfactory operation, but shall be subject to the Employer's approval.

The arrangement of the mortors shall be as shown on the attached drawings.

6.2 Type and Rating

The motors shall be of open, drip-proof, horizontal shaft, three-phase induction motors. The motors for main pumps shall be of squirrel cage type.

The rating of the motor shall be as follows:

- a) Voltage : 3,300 V
- b) Frequency : 50 Hz
- c) Phase : 3 - phase
- d) Output : 350 KW
- e) Speed : 1,000 rpm at the synchronous speed with 6 poles.

The continuous output of the motor shall be ample to drive the pump specified in 2. 2 Design Conditions of Section 7002 MAIN PUMPS under the rated voltage with + 10 percent allowance.

6.3 Technical Requirements

The efficiency of the main pump motor shall be more than 0.92 at the rated load.

The windings of the motors shall be insulated with class F material. The maximum temperature and temperature rise of the motors when operating with the rated output continuously at the rated voltage, power factor and frequency shall not exceed the limits mentioned in JEC 37 or equivalent. Ambient temperature for design purpose shall be 45 deg.C.

The service factor of the motors shall be 1.0.

6.4 Construction

The stator core shall be built up with thin, high grade, non-aging silicon steel lamination, each lamination coated on both sides after punching with an insulating varnish to minimize eddy current losses, if necessary.

There shall be no perceptible buzzing of laminations during operation. The stator frame shall be provided with lifting lugs suitable for applying slings for lifting the complete stator.

Line side terminals of the stator winding shall be suitable for connection of power cables.

The entire rotor shall be designed to safely withstand all mechanical stress to be imposed by the maximum rotating speed of the motor. Assembly of the rotor and shaft shall be dynamically balanced for maximum smoothness of operation with a minimum of vibration and noise.

Special care shall be taken to prevent the end turns of rotor winding from deforming or slipping due to centrifugal stresses on the interconnection. The shaft shall be of ample size to operate safely in combination with the reduction gear at any speed without detrimental vibration or distortion.

The end of the shaft shall be arranged for suitable coupling to the reduction gear. The motor shall be provided with suitable bearings.

The motor shall be equipped with anti-moisture condensation heaters.

6.5 Accessories

The following accessories shall be provided :

- 1) All necessary temperature detectors (Resistor type of 100 Ohms at 32 degrees F (0 degrees C) to be connected to temperature indicator provided on central control desk).
- 2) Lubricating oil and grease for one year operation.
- 3) Other necessary accessories.

6.6 Tests

(1) Tests at the Manufacturer's Shop

Before despatch from the manufacturer's shop, the electric motors shall be assembled and performed to prove specified functions. JEC 37 shall be applied for performances of the motor. The following tests shall be performed for each motor. Reports of all such tests shall be furnished.

- 1) Temperature rise test
- 2) Measurement of winding resistance
- 3) Efficiency test

4) Withstand voltage test.

The test shall include material test, dimensional check, painting and packing inspection. If any defect or improper operations are discovered, they shall be corrected and the entire test shall be repeated.

(2) Test at the Site

After the installation has been completed, the electric motors shall be tested to determine that the operation is satisfactory as the Tests on Completion specified in (b) Test on Completion, (2) Tests at the Site, 1.8 Tests of Section 7001 GENERAL.

7007 DIESEL ENGINE

7.1 General

This section covers the design, manufacture, tests before shipment and at the Site of:
One (1) set of 500 PS Diesel Engine Unit for the diesel driven pump and accessories

7.2 Design Condition

Rated output : 500 PS
Speed : 1,000 rpm

7.3 Technical Requirements

The diesel engine shall be vertical, single acting, solid injection, 4 stroke cycle, cold starting, water cooled, turbo charged, suction air cooled type. Cylinder arrangement shall be 6 cylinders, in line. Starting system shall be compressed air starting, and stopping system shall be fuel cut off system by air piston.

Cooling system shall be forced water cooling by use of in-pipe cooler. Lubricating system shall be forced lubrication by use of gear pump mounted on the engine. Air charging system shall be turbo-charged by means of exhaust gas turbine.

Fuel oil shall be light oil.

Protection system shall be mainly as follows :

Major fault

- 1) Overspeed
- 2) Lube oil low pressure
- 3) Decrease of cooling water
- 4) High temperature of cooling water
- 5) High temperature of exhaust gas

Minor fault

- 1) Starting failure
- 2) Stopping failure
- 3) Expansion tank water low level
- 4) Air tank low pressure
- 5) Fuel tank low level
- 6) Service tank low level.

7.4 Construction

(1) Cylinder Block, Head, Crank Case

The cylinder block, heads and crankcase are made of cast iron. Replaceable wet type cylinder liners are made of high grade cast iron and the bores are honed true and to the proper finish. The cylinder head covers made of special cast iron are manufactured so as to endure heat stress sufficiently and equipped with suction, exhaust and start valves and fuel injection nozzles. The fuel injection nozzles shall be easy to remove for inspection and sweeping.

(2) Crank-shaft

The crank-shaft is of forged, one-piece-type, made of carbon steel. Bearing surfaces shall be of sufficient size to safely sustain all bearing loads imposed, and shall be heat treated to give resistance to shocks and wear. It shall be free of external and internal cracks and shall incorporate drilled passage for lubrication on crank-pin and main bearing journals.

(3) Cam-shaft

The cam-shaft is made of carbon steel, driven by gears from crank-shaft. The hard-wearing surfaces are treated by high frequency induction hardening.

(4) Piston, Piston-pin

Pistons are of trunk type and made of special cast iron and have sufficient resistance against heat and pressure. Piston rings consist of 3 compression rings and two oil scraping rings. The piston-pins are of full floating type and completely carbonized.

(5) Connecting Rods

The connecting rods are made of forged steel and designed for using replaceable and precision insert type crank-pin bearings. A drilled passage for piston-pin lubrication is to be incorporated.

(6) Bearings

Bearings for both main and crank-pin journals are to be of the precision insert bearings (thin copper lead metal) and readily replaceable. The piston-pin metals are of the special phosphorous bronze.

(7) Fuel Oil Pump, Injection Nozzles

Each one set of fuel pump with plunger for adjusting injection volume and timing is provided with each cylinder. The fuel injection nozzles are of the pin-hole type and are designed to adjust the needed injection pressure automatically and to meet with any load condition immediately.

(8) Governor

The governor equipped is of hydraulic type and so sensitive in operation that it is able to adjust the fuel injection volume at any sudden change of loads automatically and immediately. Engine speed variation is calculated not more than 10% (transient) and 5% (permanent). Each one set of governor motor is to be provided in case of parallel operation.

7.5 Accessories

(1) Pumps Mounted on the Engine

- 1) One (1) - cooling water pump
- 2) One (1) - lubrication pump
- 3) One (1) - lub. oil priming pump (motor driven)
- 4) One (1) - fuel oil feeding pump
- 5) One (1) - valve rocker arm lub. oil pump.

(2) Strainer and Coolers

- 1) One (1) - fuel oil strainer
- 2) One (1) - lub. oil strainer
- 3) One (1) - lub. oil cooler
- 4) One (1) - suction air cooler.

(3) Gauges

- 1) One (1) - tachometer
- 2) One (1) - lub. oil pressure gauge
- 3) One (1) - cooling water pressure gauge
- 4) One (1) - suction air pressure gauge
- 5) One (1) - fuel oil pressure gauge
- 6) One (1) - valve rocker arm lub. oil pressure gauge.

(4) Thermometers

- 1) Two (2) - lub. oil (lub. oil cooler inlet and outlet)
- 2) One (1) - boost air (air cooler outlet)
- 3) One (1) - cooling water (turbine outlet)
- 4) Two (2) - cooling water (engine inlet and outlet)
- 5) Six (6) - cooling water (each cylinder)
- 6) Two (2) - cooling water (air inter cooler inlet and outlet)
- 7) Two (2) - exhaust gas (turbine inlet)
- 8) Six (6) - exhaust gas (each cylinder).

(5) Others

- 1) One (1) - exhaust gas turbine (turbo-charger)
- 2) Six (6) - indicator cock (each cylinder)
- 3) One (1) - governor motor

- 4) One (1) - common base
- 5) One (1) - high elastic coupling.

(6) Starting System

- 1) Two (2) - starting air reservoir (150 liter)
- 2) Two (2) - charge air compressor (3.7 KW)
- 3) One (1) - air control panel
- 4) One (1) - piping materials for air system.

(7) Fuel Oil Supply System

- 1) One (1) - fuel oil tank (15,000 liter)
- 2) Two (2) - fuel oil transfer pump (0.4 KW)
- 3) One (1) - fuel oil service tank (390 liter)
- 4) One (1) - piping materials for the system.

(8) Cooling Water System

- 1) One (1) - expansion tank (500 liter)
- 2) One (1) - in-pipe cooler (1,350 mm nominal diameter)
- 3) Two (2) - cooling water pump (0.75 KW)
- 4) One (1) - piping materials for cooling water system.

(9) Exhaust System

- 1) One (1) - silencer
- 2) One (1) - expansion joint for exhaust pipe
- 3) One (1) - piping materials for exhaust system
- 4) One (1) set of special tools for diesel engine.

7.6 Tests

(1) Test at the Manufacturer's Shop

Before despatch from the engine manufacturer's shop, the diesel engine shall be assembled to prove its satisfactory functions. The test shall include dimensional check, starting test, load test, governor test, overspeed test, protection device test and painting and packing inspection. If any defect or improper operations are discovered, they shall be corrected.

(2) Tests at the Site

After the installation has been completed, the diesel engine shall be tested to prove that the operation is satisfactory with the pumping equipment.

7008 AUXILIARY FACILITIES

8.1 Overhead Travelling Crane

One set of low speed overhead traveling crane shall be provided in the pump house of the pumping station as shown on the drawings. The crane shall be electrically operated and be complete with crane girders, main hoist, shafts, gears, complete control equipment, motors, limit switches, trolley electrification, brakes, hoisting ropes, blocks and hooks, ladders, platforms, guard handrails and necessary components for proper and efficient operation of the crane. Materials of crane rails with stoppers and their fittings shall be fabricated.

The crane shall be designed in accordance with the following conditions:

Hoisting capacity	:	Main hoist 20 ton
Span	:	Approx. 13 m
Lifting height	:	Approx. 6.20 m
Travelling length	:	Approx. 24 m
Speed		
Main hoisting	:	Approx. 2.3 m/min
Travelling	:	Approx. 20 m/min
Trolley travelling	:	Approx. 8.3 m/min.

The crane shall be designed such that all movement will take place smoothly and positively. The crane shall be capable of travelling with the full load suspended in any position of the pumping equipment provided in the pump house. Special care shall be taken to guard against oil or grease dripping from the crane.

The crane structure shall be of steel and all-welded construction. The crane girder shall consist of two main girders connected together at each end. Checkered plate walkways and steel handrails shall be provided on each main girder.

All crane motors shall be capable of being controlled from the operating floor level by means of a pendant push button switch. The height of pendant switch shall be vertically adjustable.

The circuits shall be so arranged that when any push button is released the corresponding motor shall stop and the brake applied.

The travel mechanism of the crane girder shall be mounted on the crane girder assembly. The wheels will be driven directly by the motors installed at both ends through the oil bath system gear box. For the wheel bearings, anti-friction bearings will be used to permit easy replacement of the wheels. Provision shall be made to permit access to the travel mechanism for inspection and maintenance.

The crab frame shall be of fabricated steel construction. Wherever possible, crab steel-work shall be arranged to support checkered plate walkways for convenient and safe access to all equipment on the crab.

The crab traverse drive unit shall incorporate a motor driving enclosed gear reducer through flexible coupling to cross-shaft which shall be mounted on ball or roller bearings. Four steel crab wheels shall be double-flanged and shall be fitted with ball or roller bearings on fixed axles. Two of the wheels shall be matched as driving wheels. The brake, mounted on the motor end shaft shall be applied for the travel mechanism of the crane girder and the traverse mechanism of the crab. The main and auxiliary hoist drums shall be fitted with bronze bushings or bearings and shall operate on fixed shafts and shall be mounted in such a way that a drum and shaft can be readily removed together. The hoist drums shall be steel or cast iron and shall have accurately machined grooving to accommodate the hoisting ropes.

All gears shall be enclosed in gearboxes with oil circulation, oil fitting and drain connections, and inspection covers.

All bearings shall be provided with means for lubrication either by automatic circulation, grease gun, or in the case of the final drive gears and hoist ropes, by direct manual application of heavy bodied grease. All load, warning and instruction notices, necessary for the crane, shall be provided by the Contractor.

The Contractor shall provide, on the crane, adequately rated single-phase transformers, suitable for continuous operation for the supply of power to the control circuits, lighting and power outlet circuits, etc.

The electrical power supply to the crane shall be by means of three-phase copper collector wires supported by brackets, attached to the buildings.

A cable carrier system shall be employed for the current collection for crab traversing.

All motors will be of AC motors, and 25% or more ED rated. For hoisting motors, a totally enclosed wound motor type shall be used, and traversing and travelling motors, squirrel cage motor type.

The following accessories shall be provided by the Contractor for the crane:

- i) One lot of trolley wires, insulators and brackets
- ii) Lubricating oil, grease, machine oil with 50 percent spare
- iii) Working light
- iv) Signal horn
- v) Other necessary accessories.

The crane shall be completely assembled at the manufacturer's shop and the following tests shall be carried out:

- 1) Inspection for fabrication and appearance
- 2) Dimensional inspection
- 3) Test working of each drive mechanism

As for test of the travelling device, the girder shall be assembled temporarily on the ground, and idle running test shall be performed.

Any defect observed during the tests shall be improved by the Contractor.

After the complete assembly at the Site, the crane shall pass an operation test including brake system test. These tests shall demonstrate that performances have been met and that the entire equipment meet the requirements specified in the Specification and that it is properly installed and adjusted to operate correctly and safely.

8.2 In-plant Drainage Pump Equipment

In-plant drainage pump equipment such as drainage pumps, drainage pipe, etc. shall be provided in the pump house. The drainage pumps shall be installed in the drainage tank and be used for drainage of the drainage tank to the outside of the pump house.

The drainage pump equipment shall be designed in accordance with the following conditions :

No. of pump	:	Two (2) sets (One (1) set: spare)
Type of pump	:	Submergible type
Rated output	:	Approx. 0.75 KW

The pumps shall be provided with effective lubricating system. The impeller and casing shall be made of cast iron. The design and construction of the motor shall be made to prevent entry of external water, foreign material or contamination into the motor under operating conditions. The cables shall be water proof and be supplied to adequate length.

A check valve shall be provided at the outlet side of the drainage pump to prevent adverse water flow when the pump stops. The check valve shall be swing type. The valve body shall be made of cast iron and the sealing surface of the valve shall be accurately machined for complete water seal when the valve closes.

A hand operating sluice valve shall be provided for changeover of a standby unit and function of the valve. The sluice valve shall be a gate valve. The valve body shall be made of cast iron and the contact surface of seal parts shall be accurately machined for sufficient water seal when the valve closes. Flanges shall be provided for the valves.

The pumps shall be completely assembled at the manufacturer's shop and tested to prove the capacity of them before shipment. After installation at the Site, the operation test for the drainage pump equipment shall be carried out.

SECTION 7100 ELECTRICAL EQUIPMENT

7101 GENERAL

This section covers the design, manufacture, test before shipment, erection and test at the site of:

(1) 3 KV Panels

- One (1) 3 KV incoming panel
- Three (3) Main pump motor panels
- One (1) SC (Static capacitor) feeder panel
- One (1) Station power transformer panel
- Four (4) SC panels

(2) Low Voltage Panels

- One (1) Low voltage distribution panel

(3) Motor control Center

(4) Control Panels

- Instrument panel (TM/TC)
- Auxiliary relay panels
- Engine driven pump control panel
- Local control panels

(5) Battery and Battery Charger

(6) 60 KVA Diesel Engine Generator Unit

The details of the equipment, not specified herein, shall be made by the Contractor upon approval of the Employer. The single line diagram (wiring diagram) is shown on the drawing.

7102 3 KV PANELS

(1) General

The Contractor shall furnish and install self-supporting indoor metal-clad type.

The following equipment shall be mounted inside the panels:

1) For 3 KV Incoming Panel

One (1)	:	Circuit breaker	3.6 KV, 600A, RC25 KA
One (1)	:	Lightning arrester	4.2 KV, 2.5 KA
One (1)	:	Set of GPT	$3.3 \text{ KV} / \sqrt{3}$, $110 \text{ V} / \sqrt{3}$, $190 \text{ V} / 3$
Two (2)	:	CT	3.6 KV, 400/5A
One (1)	:	Power factor control relay for SC	
Two (2)	:	Over current relay	
One (1)	:	Over voltage ground relay	
Two (2)	:	Voltage relay (under voltage, over voltage)	
Three (3)	:	Indicating lamps for ground fault and indicating meters, changeover switches and etc.	

2) For Each Main Pump Motor Panel

Three (3)	:	Current limiting power fuses	3.6 KV, 150A, RC 40 KV
Two (2)	:	Contactors	3.6 KV, 200A
One (1)	:	Three phase starting reactor	
Two (2)	:	CT	3.6 KV, 150/5 A
One (1)	:	Zero phase sequence CT (ZCT)	
Two (2)	:	Over load protection relays for IM load	
One (1)	:	Phase fault detect relay	
One (1)	:	Directional over current ground relay and an ammeter, changeover switch, auxiliary CT and etc.	

3) For SC Feeder Panel

One (1)	:	Circuit breaker	3.3 KV, 600 A, RC 25 KA
Two (2)	:	CT	3.6 KV, 100/5A
One (1)	:	Zero phase sequence CT (ZCT)	
Two (2)	:	Over current relays	
One (1)	:	Directional over current ground relay and an ammeter, changeover switch and etc.	

4) For Station Power Transformer Panel

- One (1) : Load breaker switch with power fuses 3.6 KV, 40A, RC 40 KA
- One (1) : Station power transformer 3-phase 100 KVA,
3.3 KV/380 - 220V
- One (1) : CT for neutral ground circuit
- One (1) : Over current ground relay for neutral circuit

5) For Each SC (Static Capacitor) Panel

- Three (3) : Current limiting power fuses
- One (1) : Contactor
- One (1) : SC (Static capacitor)
- One (1) : Series reactor (SR)
- One (1) : Set of discharge resistor and reactor (L)
and etc.

(2) Three-Phase Bus-Bars

Three-phase copper bus-bars shall be 600 or 1,200 A for horizontal bus-bars, and insulation shall be 45 KV for basic impulse insulation level. The buses shall withstand a short circuit current of 16,000 A for one second without mechanical and thermal failure.

The bus-bar supports shall be non-hygroscopic, frame retardant and crack resistant material.

(3) Circuit Breaker

Type:

Three-pole, single throw, draw-cut, vacuum type with anti-pumping feature, 50 Hz and complete with accessories needed for operation.

Ratings:

Rated voltage	3.6 KV
Basic impulse insulation level	45 KV
Rated continuous current	600 A
Rated breaking current	25 KA
Breaking time	5 cycles
Operating duty cycle	0-1 min, - C.O
Control circuit voltage	110 V, DC.

Operation mechanism:

The circuit breaker shall be provided with electric and local manual controls and shall be stored energy type by 110V DC source.

Accessories:

The following items shall be provided for each circuit breaker:

- (a) Name plate
- (b) Position indicator
- (c) 10-stage auxiliary switch (5a + 5b)
- (d) Counter to record of operation
- (e) One set of maintenance tool for each type.

(4) Medium Voltage Contactor

Three-pole, single throw vacuum type with anti-pumping feature, 50Hz and complete with accessories needed for operation.

Ratings:

Rated voltage	3.6 KV
Basic impulse insulation level	45 KV
Rated continuous current	200 A.

(5) Power Fuse

Single-pole, current limiting type.

Ratings:

Rated voltage	3.6 KV
Rated continuous current	{ for 350 KW, IM 200 A
	{ for SC 40 A
	{ for 100 KVA, TR 40 A
Rated rupturing current	40 KA.

(6) Current Transformer

Type :

Dry molded type for measuring instruments and protective relays.

Ratings :

Highest system voltage 3.45 KV

Rated burden 40 VA.

(except for station service transformer
neutral and low voltage circuit)

Current ratio :

400 / 5A for incoming circuit

150 / 5 A for pump motor circuit

100 / 5 A for SC feeder.

Accuracy class 3.0

Over current strength 16 KA, 1 second

(7) Potential Transformer GPT

Type:

Single-phase, dry molded, type for measuring instruments and protection relays.

Ratings:

Insulation class 3 KV

Primary voltage $3.3 / \sqrt{3}$ KV

Secondary voltage $110 / \sqrt{3}$ V

Tertiary voltage 190 / 3 V.

Rated burden:

For secondary winding 3×200 VA

For tertiary winding 3×200 VA.

Accuracy class:

For secondary winding 1.0

For tertiary winding 3 G.

(8) Cubicle and Termination

The cubicle shall have suitable terminal lugs for power cable. Suitable means shall be provided for supporting the terminals and cables. Enclosure of the cubicle shall be IP-40 (IEC-144) equivalent. The cubicle shall be provided with an access door to facilitate inspection of the equipment.

The door shall be provided with suitable handle, latches and locks. The cubicle shall be provided with necessary power and ground bus-bars, wirings, terminal blocks, indicating lamps, and other accessories.

Space heaters suitable for operation from 200V AC shall be provided inside of the cubicles to prevent moisture condensation while the equipment is being rested. A manual switch for the heater shall be provided in each cubicle.

(9) 100 KVA Station Power Transformer

Type and Ratio:

The transformer shall be three-phase, oil immersed type, self-cooled indoor use service, and no-load ratio of delta-wye connection shall be F3.375 - R3.3 - F3.225 - F3.15 - 3.075KV to 380V of three-phase, neutral ground, three-phase four-wire system.

The transformer shall be mounted in the panel and the primary circuit shall be connected by a Load Breaker Switch.

Output:

The continuous rated output of the transformer shall be 100 KVA at rated tap R.

Core:

The transformer cores shall be built up of thin laminations of the best quality non-aging silicon steel. Lamination shall be coated with an insulating and heat resistant material and held securely by resin bonded glass tape.

Winding and Insulation:

Full insulation shall be applied on both the windings. The windings shall be of high conductivity copper and shall be insulated with class A materials.

Base :

The transformer shall be provided with a flat wheel base suitable to be contained in the cubicle. The transformer shall be locked after positioning with some appropriate devices.

Accessories :

For the above, the following shall be provided for the transformer:

- (a) Dial type thermometer
- (b) Name plate and connection diagram with full details of rating in English
- (c) Other necessary accessories.

Tests :

The following test shall be carried out at the transformer manufacturer's shop:

- (a) Ratio (on all taps)
- (b) Polarity and phase relationship check
- (c) Resistance measurement of windings at each tap
- (d) No-load current and loss
- (e) Load losses at rated current
- (f) Impedance voltage measurement (on rated tap)
- (g) Rated withstand voltage test
- (h) Temperature rise test.

7103 LOW VOLTAGE PANELS

The following equipment shall be mounted inside the panel :

- One (1) : MCCB 3-pole, 460V, 225AF, RC 15KA for station power circuit
- One (1) : Neutral terminal for low voltage power circuit
- One (1) : MCCB 3-pole, 460V, 100AF, RC 15 KA for ACG circuit
- One (1) : Neutral terminal for ACG circuit
- One (1) : Automatic transfer switch, 4-pole larger than 100A
- Two (2) : MCCB 3-pole, 460V, 100AF, RC 15KA for bus-tie circuit
- Two (2) : Neutral terminal for bus-tie circuit
- Two (2) : MCCB 3-pole, 460V, 100AF, RC 10KA for No.1 and No.2 MCC
- Two (2) : MCCB 3-pole, 460V, 50AF, RC 7.5KA for building-A and -B
- Two (2) : Neutral terminal for building-A and -B
- One (1) : MCCB 2-pole, 460V, 50AF, RC 7.5KA for instrumentation
- Two (2) : MCCB 3-pole, 460V, 50AF, RC 7.5KA for spare
- Two (2) : Sets of one (1) voltmeter and a VS
- Two (2) : Sets of three (3) CT, 150/5A, one(1) ammeter and an AS
- Two (2) : Sets of ZCT and earth leakage relay, and indication meters, changeover switches, etc.

7104 MOTOR CONTROL CENTER (MCC)

(1) General

The MCC shall be metal-enclosed free-standing. The enclosure shall be IP-40 (IEC-144) equivalent and fabricated from sheet steel of following thickness :

Main frame	2.3 mm
Enclosure sheet	2.3 mm
Door	1.6 mm
Draw-out unit case	1.6 mm.

The motor control center shall be mounted on steel channel base. The enclosure shall be composed of compartment as follows :

- (a) Bus-bars
- (b) Starter and/or feeder unit compartment with door fitted safety interlocks
- (c) Auxiliary relay compartment, if it is provided

Each compartment for draw-out starter/feeder unit and auxiliary relay shall be provided with a hinged door of pan construction on the front, and the door shall be sufficient size to permit ready removal of any of the equipment in the compartment. Interlocks shall be provided to prevent opening of the compartment door while the circuit breaker (MCCB) is closed.

All vertical section shall have the same structural features with provisions for the additional of similar section of either end. Each compartment shall meet relevant standards for the control equipment installed, and units similar in size shall be interchangeable.

(2) Bus-Bars

The bus-bar shall be copper sufficient current ratings and shall be braced to withstand without damage mechanical stress created by short circuit current of 25,000 A, symmetrical 0.5 sec AC. The bus-bar ratings for AC motor control center shall be 380V 3-phase 50 Hz. The main horizontal bus bars shall be located at the upper side of the structure, and hang vertical bus-bars. The vertical bus-bars are insulated by PVC barriers.

(3) Starter and Feeder Unit

The motor control center shall be a withdrawable unit with individual doors to each compartment. All units smaller than 90 KW starters provide stab-in junction for vertical bus-bars. And outgoing cables shall be connected at terminal blocks.

(4) Starter and Circuit Breaker

The starter unit for AC motor, consists of a 3-pole 460 V AC, molded case circuit breaker (MCCB) fitted with instantaneous magnetic trip, one magnet switch or two magnet switches for reversible drive motor with bimetallic heater elements (ambient temperature compensated thermal relay) for overload protection.

Thermal relay shall be manual reset type. The front mounted operating handle for the breaker shall be lockable at close and open positions of the breaker. And the handle should be padlocked in order to lock the circuit breaker, then the compartment's front door cannot be opened, except space compartment.

These padlocks shall have mechanical interlocks.

The starters and tap-off feeders shall be connected to the vertical bus-bars by means of automatic plug connections. The interrupting capacity of molded case circuit breaker shall not be less than 7,500 A symmetrical at 460 V AC.

(5) Wiring

All wiring in the MCC shall be made of poly-vinyl chloride (PVC) insulated wire. The wire consists of stranded copper conductors. Power circuit wiring shall be black coloured 110 deg.C polyethylene insulated wire (MLFC) and adequate size to carry the rated full load current which conductor is rated.

All control wiring is yellow coloured 2 square mm, poly-vinyl chloride (PVC) insulated wire.

(6) Terminal Blocks

Terminal blocks shall be rated for 600 V. Each terminal shall be numbered in accordance with the wiring requirements. The maximum numbers of wire fitted on one terminal shall be limited to two wires. But inlet wires shall be connected to each terminal.

(7) Phase Discrimination

For phase discrimination of power circuit in motor starter units, coloured PVC tape or caps shall be attached on both ends of the wires near the terminal blocks. For phase discrimination of horizontal and vertical bus-bars, the bus-bars shall be taped by coloured PVC tape at power incoming sides.

(8) Other Requirement

Control circuit voltage	:	200V, AC, 50 Hz
Rated rupturing current	:	7.5 KA (sym.)
Horizontal bus-bar rating	:	800 A
Vertical bus-bar rating	:	200 A
Neutral bus-bar	:	None
Grounding bus-bar	:	75 square mm copper
Internal connection	:	Solderless terminal lug.
Unit connection		
1) Main circuit		
Incoming	:	Terminals
Outgoing	:	Terminals
2) Control circuit	:	Terminals
Mounting of units	:	Single front type
Cable entrance		
1) Incoming	:	Bottom
2) Power circuit for load	:	Bottom
3) Control circuit	:	Bottom
Reset system of thermal over load relay:		Manual reset
Fuse for control circuit	:	3 or 5 A
Indicating lamp at the unit	:	None.

7105 CONTROL PANELS

(1) General

The major items of control cubicles to be supplied are as follows:

- 1) Instrument panel (TM/TC)
- 2) Auxiliary relay panels
- 3) Engine driven pump control panel
- 4) Local control panels.

The control panels shall be furnished complete with instruments, meters control switches, fault indicators, terminal blocks, wiring and other miscellaneous devices as indicated in the Specifications or the drawings.

(2) Instrument Panel (TM/TC) and Auxiliary Relay Panels

The instrument panel (TM/TC) and the auxiliary relay panels shall be metal-enclosed free standing IP-40 (IEC 144) equivalent enclosure. Height is 2,300 mm except channel base and they are fabricated from sheet plate of the following thickness :

Side panel	2.3 mm
Door	2.3 mm.

The auxiliary relays and timers which are required for automatic sequential operation of main pumps and indication shall be provided, mounted on the auxiliary relay panels.

Interface relays and/or some devices which will be provided for noise insulation between auxiliary relay panels and tele-control panel will be mounted on the instrument water level 4 - 20 mA etc. signal convertor or equivalent will be also mounted.

(3) Engine Driven Pump Control Panel

The panel shall be metal-enclosed free standing IP-40 (IEC 144) equivalent enclosure.

Height is 1,900 mm except channel base and it is fabricated from sheet plate of the following thickness.

Side panel	3.2 mm
Door	3.2 mm.

The auxiliary relays and timers which are required for automatic sequential operation of an engine driven pump shall be provided. Changeover switch(es), control switches, indication lamps and etc. which are required for manual operation at the panel shall be provided, mounted on the front door.

(4) Local Control Panels

The local control panels shall be indoor metal-enclosed free standing type. Enclosure is IP-40 (IEC-144) equivalent :

- Three (3) sets for three (3) main pumps
- One (1) set for two (2) drainage pumps
- One (1) set for two (2) fuel pumps
- One (1) set for two (2) cooling water pumps
- One (1) set for two (2) air compressors.

The local control panels shall be mounted parts as follows:

- Changeover switch(es) and control switches
- Lamp indicator or fault indicator
- Ammeter only for main pump motor.

7106 BATTERY AND BATTERY CHARGER CUBICLE

(1) Type and Ratings

One set of storage battery consisting of 54 cells each in sealed plastic transparent container shall be provided to supply 110V DC power coordinating with battery charger.

The battery shall be of lead acid, enclosed type, 110V 40AH (ampere-hour) at 10 hours discharge rate.

One metal-enclosed battery charger, having doors in front of facilitate inspection, shall be supplied. The rectifier element for the battery charger shall be of silicon. Protection fuses shall be provide for individual rectifier diodes.

The battery charger shall be capable of initial charging, floating operation and equalizing charge for 40AH storage battery. The battery charger shall be equipped with adequate characteristics for automatic operation of the above charging.

The battery and battery charger shall be designed for the following requirements :

Type	:	Enclosed
AC input voltage	:	380 V, 3-phase, 50 Hz
Rated DC output voltage	:	110 V
Number of cell	:	54 cells
Rated capacity	:	40 AH/10 Hr.

(2) Construction

The battery shall be of heavy-duty, long-life construction and shall be provided with the following :

- 1) Positive plate of pasted type and negative plate of pasted type
- 2) Separators
- 3) Cells of enclosed explosion proof and sulfuric acid fume proof type, consisting of chemical resisting material, with provisions for measuring the specific gravity of electrolyte from outside. The covers space shall be provided so that the battery will not have to be cleaned out during its normal life
- 4) Supports for cells
- 5) Base structure of steel construction painted with acid resisting.

7107 60 KVA DIESEL ENGINE GENERATOR UNIT

(1) General

This section covers the design, manufacture, tests before shipment, erection and tests at the Site of the diesel engine generator units :

- 1) One (1) Diesel engine with radiator
- 2) One (1) Generator
- 3) Control cubicles
 - a) One (1) generator cubicle

- b) One (1) AVR cubicle
- c) One (1) battery and battery charger cubicle
- 4) Battery and battery charger cubicle for engine starting
- 5) Fuel oil supply system.

The diesel engine generator unit will be used for emergency operation during power failure. Bidders shall state necessary attentions to be taken for maintenance of the related equipment.

The diesel engine generator unit shall be provided with one (1) diesel engine driven electric power generating unit and all its associated components, including starting system, control panel, etc. and all other necessary equipment.

The details of the equipment, not specified herein, shall be made by the Contractor upon approval of the Employer.

The diesel engine generator unit shall meet the following service conditions :

Rated continuous output capacity	: 48KW /60KVA
Power factor	: 0.8
Rated output frequency	: 50Hz
Rated rotating speed	: 3,000 rpm
Rated output voltage	: 380V
Diesel engine continuous power	: 80 PS
Quantity	: 1set.

Diesel engine and generator shall be directly coupled and mounted on a common baseframe of fabrication steel, and one unit cubicle type.

(2) Diesel Engine

Diesel engine shall conform to the following :

- (a) Type : 4 cycle, inline form, compression ignition, water cooled, turbo charged type
- (b) No. of cylinder : 6
- (c) Engine speed : 3,000rpm
- (d) Continuous power : 80PS

The following accessories for the diesel engine shall be provided :

- One (1) set of radiator system
- One (1) mechanical type governor
- One (1) flywheel with cover
- One (1) common base
- One (1) set of bolts, nuts, jack bolts for installation.

The engine shall be equipped with a cell motor starting system of sufficient capacity to start the engine by three starts without recharged. The radiator shall be mounted on the same base as the engine.

The engine exhaust gas shall be discharged through an indoor silencer to the atmosphere.

(3) Generator

The generator shall be synchronous type, single bearing, directly connected to the diesel engine flywheel and housing.

The generator shall conform to the following :

- (a) Type : 3-phase, 4-wire, revolving field type with damper winding, self-excited, self-ventilated open type single bearing synchronous alternator, brushless
- (b) Continuous power : 60KVA (48KW)
- (c) Power factor : 0.8 (lagging)
- (d) Frequency : 50Hz
- (e) Speed : 3,000 rpm
- (f) No. of pole : 2
- (g) Output voltage : 380V
- (h) Class : F (stator winding)
H (rotor winding).

(4) Control Cubicles

The control cubicles shall be of sheet metal dead front, indoor type, and mounted inside the unit.

The control cubicles shall consist of the following :

- One (1) generator cubicle
- One (1) AVR cubicle
- One (1) battery and battery charger cubicle.

i) Generator and Circuit Breaker Cubicle

The following equipment shall be mounted inside the cubicle :

- 1) One (1) circuit breaker
- 2) Two (1) current transformers
- 3) Three (3) single phase potential transformers
- 4) One (1) zero-phase current transformer for supplying with station
- 5) One (1) set of protect relays
- 6) One (1) set of control switches and/or indicators.

ii) AVR Cubicle

The following equipment shall be mounted inside the cubicle :

- 1) One (1) automatic voltage regulator (AVR)
- 2) One (1) set of power circuits for the auxiliary equipment
- 3) One (1) set of auxiliary relays and/or timers
- 4) One (1) set of control switches and/or indicators.

(5) Battery and Battery Charger Cubicle for Engine Starting

One (1) battery and battery charger cubicle for engine starting with the following requirements :

Type	Lead acid
AC input voltage	380V, 3-phase
Rated DC output voltage	24V
Number of cell	12cells
Rated continuous output capacity	120AH / 10hr.

(6) Fuel Oil Supply System

The fuel supply system for the Diesel Engine of the DEG set shall be incorporated into the fuel oil supply system for the Diesel Engine as specified in (7) Fuel Oil Supply System, 7.5 Accessories of Section 7007 DIESEL ENGINE.

(7) Test

After finishing installation, operational tests shall be carried out to check all required functions will be performed satisfactorily.

If not, necessary correction shall be made. Test on completion specified in (b) Test on Completion, (2) Tests at the Site, 1.8 Tests of Section 7001 GENERAL should be applied.

SECTION 7200 MEASUREMENT AND PAYMENT

7201 MEASUREMENT AND PAYMENT

- (1) All the costs required for supply and installation of the pumping equipment indicated in section 7000 "Pumping Equipment" of the Specifications and the drawings shall be included in the unit prices and prices for the pay item Nos. 5301 to 5312 in the Bill of Quantities.

Pumping equipment to be supplied under the pay item Nos. 5301 to 5310 shall include the pumping equipment and accessories indicated in the applicable sections of the Specifications, which are shown in table "A", and all other pumping equipment and accessories necessary to complete the pump works.

Measurement, for payment, will be made of the pumping equipment actually installed. Payment for the pay item Nos. 5301 to 5311 will be made after the Employer's acceptance for the test on completion. The unit prices and price for the pay item Nos. 5301 to 5310 shall include the cost of design, supply, fabrication, manufacture, shop assembly, tests at the manufacturer's shop, delivery, painting and handling of the pumping equipment and accessories to be supplied under the respective pay items, and all other costs required for complying the applicable requirements specified in the Specifications. The cost of special tools shall be deemed to have been included in the unit prices and price for the pay item Nos. 5301 to 5310.

All the costs required for installation and tests at the Site of the pumping equipment and accessories supplied under the pay item Nos. 5301 to 5310 shall be included in the price for the pay item No. 5311. The cost of the test on completion shall also be included in the price for the pay item No. 5311.

After the test on completion, the Contractor shall demolish and remove the water measurement facility shown on the drawings. These costs shall be included in the price for the pay item No. 5101 "Temporary works."

During the test on completion, the slopes and bottom of waste way shall be protected against flow of pumping water. Thy type of the protection shall be plastic net sheeting as shown on the drawings or other means approved by the

Employer. The cost for such protection shall also be included in the pay item No. 5101.

- (2) All the costs required for supply and installation of the electrical equipment for the pump works indicated in section 7100 "Electrical Equipment" of the Specifications and the drawings shall be included in the unit prices and prices for the pay items Nos. 5401 to 5414 in the Bill of Quantities.

Electrical equipment to be supplied under the pay item Nos. 5401 to 5413 shall include the electrical equipment and accessories indicated in the applicable sections of the Specification, which are shown in table "A", and all other electrical equipment and accessories necessary to complete the pump works.

Measurement, for payment, will be made of the electrical equipment actually installed. Payment for the pay item Nos. 5401 to 5414 will be made after the Employer's acceptance for the test at the Site. The unit prices and price for the pay item Nos. 5401 to 5413 shall include the costs of design, supply, manufacture, shop testing, delivery and handling of the electrical equipment and accessories to be supplied under the respective pay items, and all other costs required for complying the applicable requirements specified in the Specifications.

All the costs required for installation and test at the Site of the electrical equipment and accessories supplied under the pay item Nos. 5401 to 5413 shall be included in the price for the pay item No. 5414.

The cost of furnishing and installing the cables and all other materials necessary to complete the mechanical and electrical equipment in the pumping station shall be included in the price for the pay item No. 6401.

TABLE "A" APPLICABLE NO. OF SPECIFICATIONS TO PUMP WORK

(1/2)

Specifications		Bill of Quantities (Part - 1 Main Works)		
Applicable Sec. No.	Pay Item No.	Description of Work	Unit	Quantity
		Section 5. 3 <u>Mechanical Equipment</u>		
7002	5301	Supply of main pump, ϕ 1350 mm	unit	4
7005	5302	Supply of speed reduction gear	unit	4
7006	5303	Supply of prime mover, 350 KW motor	unit	3
7007	5304	Supply of prime mover, 500 PS diesel engine, including starting system, fuel oil supply system, cooling water system, exhaust system, etc.	unit	1
7004 - 4.2	5305	Supply of electrically operated butterfly valve, ϕ 1,350 mm	unit	4
7003 - 3.4	5306	Supply of expansion joint, ϕ 1350 mm, rubber type	set	4
7003 - 4.3	5307	Supply of non-return valve, ϕ 1,650 mm	set	4
7003-3.2, 3.3	5308	Supply of discharge pipes and loose flange, ϕ 1350 ~ ϕ 1650 mm	set	4
7008 - 8.1	5309	Supply of overhead travelling crane, 20 ton	L.S.	1
7008 - 8.2	5310	Supply of in-plant drainage pump equipment	set	2
	5311	Installation of all equipment supplied under Pay Item Nos. 5301 ~ 5310	L.S.	
7001 - 1.9	5312	Staff training	L.S.	
		Section 5. 4 <u>Electrical Equipment</u>		
7102 - (1), 1)	5401	Supply of 3 KV incoming panel	unit	1
7102 - (1), 2)	5402	Supply of main pump motor panel	unit	3
7102 - (1), 3)	5403	Supply of static capacitor feeder panel	unit	1
7102 - (1), 4)	5404	Supply of station power transformer panel	unit	1
7102 - (1), 5)	5405	Supply of static capacitor panel	unit	4
7103	5406	Supply of low voltage distribution panel	unit	1

Specifications		Bill of Quantities (Part - 1 Main Works)		
Application Sec.No.	Pay Item No.	Description of Work	Unit	Quantity
7104	5407	Supply of motor control center	set	1
7105 - (1), 1 & (2)	5408	Supply of instrument panel (TM/TC)	unit	1
7105 - (1), 2 & (2)	5409	Supply of auxiliary relay panel	set	1
7105 - (1), 3 & (3)	5410	Supply of engine driven pump control panel	unit	1
7105 - (1), 4 & (4)	5411	Supply of local control panels, including <ul style="list-style-type: none"> · Three (3) sets for three (3) main pumps · One (1) set for two (2) drainage pumps, · One (1) set for two (2) fuel pumps, · One (1) set for two (2) cooling water pumps and · One (1) set for two (2) air compressors 	L. S.	
7106	5412	Supply of battery and battery charger cubicle	unit	1
7107	5413	Supply of 60 KVA diesel engine generator unit	unit	1
	5414	Installation of all equipment supplied under Pay Item Nos. 5401 ~ 5413	L.S.	

DIVISION 8 GATE WORKS

SECTION 8000 GATE WORKS

8001 GENERAL

(1) General

The work to be done under this Specification shall include the design, supply fabrication, manufacture, shop assembly and testing, delivery, site installation, site testing of tidal gates and related equipment and training of Employer's operation and maintenance staffs specified herein.

(2) Equipment to be Supplied by the Contractor

The supply includes mainly the gate, embedded part, hoist and local control equipment of the following equipment:

- a) Flood Gate (1 - Leaf Gate)
 - 3 sets of Flood Gate
 - 3 sets of embedded part
 - 3 sets of Hoist Device with Local Control panel
 - 3 sets of Electrical works

- b) Regulating Gate (2 - Leaf Gate)
 - 2 sets of Regulating Gate
 - 2 sets of embedded part
 - 2 sets of Hoist Device with Local Control panel
 - 2 sets of Electrical works

- c) Stop Log
 - 1 set of Stop log
 - 5 sets of embedded part
 - 1 set of guide frame
 - 1 set of Lifting beam

(3) Standards

The design, materials, manufacture, installation, test and performance of all equipment shall conform to the following standards or to equivalent applicable standards.

JIS	-	Japanese Industrial Standard
TSGP	-	Technical Standards for Gates and Penstocks
JEM	-	The standard of the Japan Electrical Manufacturer's Association Standards
JEC	-	Standards of the Japanese Electro-Technical Committee
IEC	-	International Electro-Technical Commission

8002 DESIGN REQUIREMENT FOR GATE

(1) General Requirements

This section covers the requirements for gate equipment. The Contractor shall submit the calculations and drawings of gate equipment to the Employer for his approval.

(2) Design Condition

The following design condition shall be applicable to the design of the gates, embedded parts and wire rope hoists. In designing the gate equipment, the load including own weight of gate, hydrostatic load, buoyant force, operating force, hydraulic force, wind force shall be considered where necessary.

Fixed - Wheel Gate

Design Condition			
	1 - LEAF GATE	2 - LEAF GATE	
Gate type	fixed- wheel gate	fixed - wheel gate	
Number	3	2	
Width	30.0 m		
Height	10.0 m		
Hydraulic Conditions		upstream	downstream
	Case 1	WL + 1.800	WL - 1.700
	Case 2	WL - 1.300	WL + 1.800
Sill level	EL - 8.200 m		
Hoist floor level	EL + 17.400 m		
Water tightness	Side and bottom	Side, bottom and middle	
Hoist type	Wire- rope hoist (2 Motor - 2 Drum)		
Operation speed	approx. 0.3 m/min		
Lifting height	approx. 12.100 m		
Gate operation	Local and remote control		

Stop log.

Design Condition			
	STOP LOG		
Gate type	Sluice gate		
Width	30.00 m		
Height	10.00 m (5 pieces of 2.0 m height leaf)		
Hydraulic Conditions		upstream	downstream
	Case 1	WL + 0.700	WL - 1.00
Sill level	EL - 8.200		
Water tight	Side, bottom and middle		

(3) Allowable Stress and Safety Factor

a) General

The allowable stress and safety factor for the gate equipment shall be in accordance with Technical Standards for Gates and Penstocks.

b) Allowable Stress

The allowable stress used for the gate and embedded part shall be as follows.

Structural Steel

Fixed Wheel Gate

(unit : kgf/cm²)

Stress	Steel	SS400, SM400 A, B, C		SM490 A - B	
		Thickness ≤ 40 mm	> 40	Thickness ≤ 40 mm	> 40
1. Axial tensile stress (for net sectional area)		1,200		1,600	
2. Axial compressive stress (for gross sectional area) Compressive member l : buckling length of member (cm) r : radius of gyration of area for the gross section of members (cm)		$\frac{l}{r} \leq 20$: 1,200 $20 < \frac{l}{r} \leq 93$: $1,200 - 7.5 \left(\frac{l}{r} - 20 \right)$ $93 < \frac{l}{r}$: $\frac{10,000,000}{6,700 + \left(\frac{l}{r} \right)^2}$		$\frac{l}{r} \leq 15$: 1,600 $15 < \frac{l}{r} \leq 80$: $1,600 - 11.2 \left(\frac{l}{r} - 15 \right)$ $80 < \frac{l}{r}$: $\frac{10,000,000}{5,000 + \left(\frac{l}{r} \right)^2}$	
Compressive splice plate		1,200	0.92 times the left stress	1,600	0.94 times the left stress
3. Bending stress girder's tensile side (for net sectional area) girder's compressive side (for gross sectional area) Aw : gross sectional area of web plate (cm ²) Ac : gross sectional area of compressive flange (cm ²) l : distance between fixed points of compressive flange (cm) b : width of compressive flange (cm) $K = \sqrt{3 + \frac{A_w}{2A_c}}$ When directly fixed to the skin plate etc.		1,200 $\frac{l}{b} \leq \frac{9}{K}$: 1,200 $\frac{9}{K} < \frac{l}{b} \leq 30$: $1,200 - 11 \left(K \frac{l}{b} - 9 \right)$ But, Say K = 2 with $\frac{A_w}{A_c} < 2$, 1,200		1,600 $\frac{l}{b} \leq \frac{8}{K}$: 1,600 $\frac{8}{K} < \frac{l}{b} \leq 30$: $1,600 - 16 \left(K \frac{l}{b} - 8 \right)$ But, Say K = 2 with $\frac{A_w}{A_c} < 2$, 1,600	
4. Shearing force		700		900	

Steel Casting and Steel Forgings

Fixed - Wheel Gate

(unit : kgf/cm²)

Stress	Steel	SC450	SF440
	1. Axial tensile stress		1,200
2. Axial compressive stress		1,200	1,200
3. Bending stress		1,200	1,200
4. Shearing stress		700	700
5. Bearing stress		1,700	1,700

Note : Axial compressive stress is not considered to be buckling.

Note : The allowable stress of material not specified above shall be with 1/2 the yield point of the materials concerned and shall be determined based on the above provisions.

Steel for Joint

Fixed - Wheel Gate

(unit : kgf/cm²)

Bolt	SS400, S200 C		S345 C	
	1. Shearing stress Finished bolt Anchor bolt	750 500	Same as the left stress	1,000 650
2. Bearing stress Finished bolt Pin	1,700 1,700	0.92 times the left stress	2,300 2,300	0.94 times the left stress

Structural Steel

Stop Log

(unit : kgf/cm²)

Stress	Steel	SS400, SM400 A, B, C	
		Thickness ≤ 40 mm	> 40
1. Axial tensile stress (for net sectional area)		1,350	
2. Axial compressive stress (for gross sectional area) Compressive member l : buckling length of member (cm) r : radius of gyration of area for the gross section of members (cm)		$\frac{l}{r} \leq 20$: 1,350 $20 < \frac{l}{r} \leq 93$: $1,350 - 8.1 \left(\frac{l}{r} - 20\right)$ $93 < \frac{l}{r}$: $\frac{11,600,000}{6,700 + \left(\frac{l}{r}\right)^2}$	0.92 times the left stress
Compressive splice plate		1,350	

Stop Log

(unit : kgf/cm²)

Steel	SS400, SM400 A, B, C	
	Thickness ≤ 40 mm	> 40
3. Bending stress girder's tensile side (for net sectional area) girder's compressive side (for gross sectional area) A _w : gross sectional area of web plate (cm ²) A _c : gross sectional area of compressive flange (cm ²) l : distance between fixed points of compressive b : width of compressive flange (cm) K = $\sqrt{3 + \frac{A_w}{2A_c}}$	1,350 $\frac{l}{b} \leq \frac{9}{K}$ 1,350 $\frac{9}{K} < \frac{l}{b} \leq 30$: 1,350 - 12 (K $\frac{l}{b}$ - 9) But, Say K = 2 with $\frac{A_w}{A_c} < 2$, 1,350	0.92 times the left stress
Compressive splice plate		
4. Shearing force	800	

Steel Casting and Steel Forgings

Stop Log

(unit : kgf/cm²)

Steel	SC450	SF440 A
1. Axial tensile stress	1,350	1,350
2. Axial compressive stress	1,350	1,350
3. Bending stress	1,350	1,350
4. Shearing stress	800	800
5. Bearing stress	1,900	1,900

c) Safety Factor for Hoist

The safety factor for the hoist parts calculated from the rated torque of the motor is as listed below. The stress from the maximum torque of the motor shall be less than 90% of the yield point of used material.

The yield point for ropes shall be 65% of breaking strength.

Safety Factor of Material

Type	Safety factor		
	Tension	Compression	Shearing
Rolled steel for general structures & welded structures (SS, SM)	5	5	8.7
Carbon steel forgings for general use (SF)	5	5	8.7
Carbon steel for machine structural use (S - C)	5	5	8.7
Stainless steel bars (SUS)	5	5	8.7
Carbon steel castings (SC)	5	5	8.7
Gray iron castings (FC)	10	3.5	10
Bronze castings (BC)	8	8	10
Wire rope	8 (For static operating loads)		
Plate link chains	6.5 (For static operating loads)		

d) Allowable Stress for Concrete

Allowable stress for concrete shall be as follows:

(unit : kgf/cm²)

Type	Allowable Stress
compressive stress	60
shear stress	6
bound stress for round bar	6

e) Welded Joint Efficiency

Welded joint efficiency in design shall be as follows:

Welded Joint Efficiency

(Unit : %)

Type of Joint	Work Shop	Field	Remarks
Butt joint	95	90	Checked by radio-graphic inspection
Fillet joint	95	90	Not check by radio-graphic inspection

f) **Minimum Thickness and Deflection**

The minimum thickness of main strength members, including the corrosion allowance shall be more than 6 mm for steel plate and more than 5 mm for steel sections.

Deflection of fixed-wheel gate leaf shall not be more than 1/800 of the span.

Deflection of STOP LOG leaf shall not be more than 1/600 of the span.

g) **Corrosion Allowance**

The corrosion allowance of gate leaf shall be 1.5 mm for structure steel on the downstream side and be 1.0 mm for structure steel on the upstream side for the fixed-wheel gate.

The corrosion allowance of STOP LOG shall not be considered.

(4) **Materials Requirements**

All materials incorporated in the equipment shall be new and be the best available for the purpose.

Unless otherwise specified, materials to be used shall conform to the following or similar.

a) **Fixed-Wheel Gate**

Gate:

Structural steel	JIS G 3101 "Rolled steels for general structure" JIS G 3106 "Rolled steels for welded structure"
Main wheel	JIS G 5111 "High tensile strength carbon steel castings and Low alloy steel castings for structure purposes"
Self-lubricating bearing	JIS H 5102 "High strength brass castings" or similar
Wheel shaft	JIS G 4051 "Carbon steels for machine structural use"
Rubber seals	Synthetic rubber

Embedded part :

Structural steel	JIS G 3101, JIS G 3106
Wheel track	JIS G 4304 "Hot rolled stainless steel plates and sheets"
Seal plate and Cover plate	JIS G 4304

Hoist :

Structural steel	JIS G 3101, JIS G 3106
Drum	JIS G 3106, JIS G 4051
Gear	JIS G 4105 "Chromium molybdenum steels", JIS G 3106, JIS G 4051
Gear shaft	JIS G 4051
Sheave	JIS G 5501 "Gray Iron Castings"
Wire rope	6 × 37 type for flood gate and lower leaf of flood gate, 6 × WS (36) type for upper gate of regulating gate, with fiber core, galvanized.

b) Stop Log

Gate :

Structural steel	JIS G 3101
Rubber seals	Synthetic rubber

Embedded part :

Structural steel	JIS G 3101
Seal plate and Cover plate	JIS G 4304

(5) Requirements for Fixed-Wheel Gate

a) General

Each gate completed with fixed wheel gates, embedded parts and electrical wire-rope hoist shall be installed as shown on the Drawings.

Each gate shall function as shut-off gate for stopping flow from the downstream side, however, upper gate of regulating gate shall also function as flood gate for the flow from the upstream side.

The Contractor shall exercise care and attention in the design of gate equipment to avoid any vibration of gate during operation and in the fabrication of all parts affecting the strength and watertightness.

b) Gate

Each gate shall be designed under hydraulic conditions and shall be adequately satisfied with allowable stress. Gate type shall be shell form fixed wheel gate. Shell form gate consists of skin plate, top plate, bottom plate, diaphragm plates and stiffeners. Each gate shall be provided with main wheels, side rollers and sheaves on each side of the gate. Skin plate of flood gate shall be located on the downstream side and as for regulating gate, skin plate of lower gate leaf shall be located on the downstream side. Each gate shall be provided with seal rubbers at the bottom, both sides and middle of regulating gate. Those seal rubbers shall keep a good sealing performance for hydraulic pressure from the downstream side. The wheels shall be provided with self-lubricating bearing and hard chromium-plated shaft. The clamp bar and bolts, nuts for seal rubber shall be of stainless steel. They shall be easily replaceable and adjustable.

(6) Requirements for Embedded Parts

a) General

Embedded parts shall be installed as shown on the drawings. Embedded parts shall be designed to endure wheel loads of each gate.

b) Embedded Parts

Embedded parts shall be fixed in blockouts, after which they shall be concreted in place. Embedded parts shall consist of sill beam and side guide frame on each side and other necessary components capable of transferring the loads into concrete. Side guide frame shall be provided with stainless steel wheel track and sealing plate. Sill beam shall be provided with sealing plate.

Removable side guides shall be provided more than EL + 3.900, to facilitate maintenance of gates.

Wheel track, seal plate and cover plate shall be of stainless steel for the purpose of resisting corrosion.

(7) Requirement for Wire Rope Hoist

a) General

The construction of the hoist shall be as shown on the drawings. The hoist shall be capable of raising, lowering and sustaining the gate at any position under the specified operating condition.

The hoist equipment shall be designed to endure the rated load with adequate safety factor.

The requirements for electrical equipment and operation shall be as specified in Division 9 of the Specifications.

b) Operating Condition

- Gate can be closed, under Hydraulic Condition Case 2.
- Lowering and raising upper gate of regulating gate shall be under Hydraulic Condition Case 1.
- Raising flood gate shall be under Hydraulic Condition Case 1.
- Raising regulating gate on each gate closed position shall be under Hydraulic Condition Case 1.
- Lowering flood gate and regulating gate shall be under balanced head condition.

c) Wire Rope Hoist

All gate hoists shall be wire rope winch type. Two sets of hoists shall be provided for flood gate and four sets of hoists shall be provided for regulating gate, two for lower gate and the others for upper gate. Each hoist shall be mounted on piers located at the both sides of gate and consists of the following component:

- Electric motor with magnetic brake
- Thruster brake
- Helical gear reducer
- Gear coupling
- Bearings
- Open gear and pinion

- Wire rope drum
- Sheaves
- Machine frame

Gate shall be lifted from two points near both ends of gate leaf. At each point, sufficient number of sheaves shall be provided to reduce tension of rope. Two wire ropes from each lifting point shall be wound on each wire rope drum.

Hoist for each gate shall be equipped with the following accessories:

- Dial type gate position indicator.
- Gate position transducer for remote indication.
- Limit switches to detect gate travel upper and lower limits.
- Gate dogging device.
- Rope adjusting device.

(8) Requirements for STOP LOG

a) General

STOP LOG shall be located as shown in the drawing.

STOP LOG consists of 1 set of gate, 1 set of guide frame, 1 set of lifting beam and 5 sets of embedded parts.

STOP LOG shall function as shut-off gate, when fixed-wheel gate is maintained.

STOP LOG shall be normally stored on the storage area and shall be lowered and raised by truck crane on the bridge under balance head condition.

b) Gate

STOP LOG gate shall be designed under hydraulic condition specified in section 8002 (2).

STOP LOG gate consists of 5 identical sections.

Each section shall be girder form and consists of skinplate, main horizontal beams and stiffeners.

Each section shall be provided with 4 guide shoes and seal rubbers at the bottom and both sides.

c) Embedded parts and guide frame

Embedded parts for STOP LOG shall be installed in blockouts behind of the fixed-wheel gate.

Embedded parts for STOP LOG shall consists of sill beam, side guides and other components.

Surfaces of Embedded parts touching the water shall be of stainless steel.

Guide frame for STOP LOG shall be used for supporting beam and shall be easily replaceable and adjustable.

d) Lifting Beam

Lifting beam shall be semi-automatic type and consists of beam, guide rollers, hooks and other components.

8003 FIXED WHEEL GATE AND RELATED EQUIPMENT

(1) General

This section covers the detailed requirements for gate, embedded parts and wire rope hoist specified in the Specifications.

(2) Gate

The gate shall be of welded construction and shall be fabricated in sections for field assembly. The gate shall be provided with main wheels, shafts, side rollers, rubber seals and other accessories.

Calculation of skinplate shall be due to the DIN 19704 formula.

a) Main Wheel and Shaft

Each main wheel assembly shall be of the cantilevered type equipped with self-lubricating bearing, mounted on the wheel shaft. Wheel shaft shall have a machine eccentricity to facilitate adjustment of roller alignment. The surface of shaft shall be plated with hard chromium of 50 microns. The rolling surface of wheel shall be hardened by heat treating for enduring the loads. Calculation of main wheel shall be due to the Hertz's formula.

b) Side Rollers

Side rollers shall be provided on each end of the gate and shall be equipped with the stainless steel pin and self-lubricating bearing. Side rollers shall be made of the carbon steels or similar.

c) Rubber Seals

The rubber seals of the gate shall be synthetic and have the following physical properties:

Shore hardness	40 - 80
Water absorption	less than 5%
Ultimate tensile strength	more than 150 kgf/cm ²

d) Other accessories

Adequate drain holes shall be provided in the bottom plate of the gate. Manholes for maintenance shall be provided in the shell type gates. Clamp-bar and bolts, nuts for rubber seal shall be of stainless steel.

(3) Embedded Parts

Site guide frame, wheel track, sealing plate and sill beam shall be welded construction. The wheel track shall be hardened to a B.H.N. higher than that used for wheel tread by heat treating. The lower wheel track, side sealing plate shall be machined in order to obtain the watertightness, the tolerances and performance where necessary. Calculation of side guide frame shall be due to Andree's formula.

(4) Wire Rope Hoist

Principal component of wire rope hoist shall be as described below. Each parts shall be designed with the service factor specified in section 8002 (7).

a) Speed Reducer

Speed reducer shall be parallel shaft helical gear type and shall have ample capacity to transmit the rated motor torque. The output shaft shall be connected to the drum pinion directly or through the gear type coupling. The speed reducer shall be provided with auxiliary output shaft for driving position indicator and limit switches, if necessary.

b) Open Gear

The wire rope drum shall be driven with a set of open gear and pinion. The gear shall be attached on one end of the drum with reamer bolts.

c) Drum and Sheave

The wire rope drum shall be of fabricated steel or steel casting and have machined grooves. The drums shall be sized so that there is no overlapping of the wire rope. The diameter of the drum and sheave shall be more than 19 times and 17 times the wire diameter respectively.

d) Wire Rope

The wire ropes for flood gates and lower leaf of regulating gates shall be 6×37 type with fiber core. The wire rope for upper leaf of regulating gate shall be $6 \times WS(36)$ type with fiber core. All ropes consist of galvanized steel wire. The rope shall be stretched by pre-tensioning after manufacturing at shop.

e) Rope Adjusting Device

The one end of the rope shall be attached to the drum in adequate manner. The other end shall be provided with rope socket and fixed to the machinery frame with rope adjusting device. The rope adjusting device shall be capable of adjusting rope length with threaded spindle and detecting rope slacking and over load on the rope.

Provision shall be made to equalize the tensions of two ropes attached on one drum.

f) Gate Position Indicator

A dial type gate position indicator shall be provided on each hoist. The indicator shall be located so that the operator can easily observe it from the operating position in front of the control panel. The indicator shall be driven by auxiliary shaft of speed reducer of pinion gear shape with roller chain and sprockets within two (2) cm graduation in three (3) digits.

For digital indication of gate position on local panel and remote control panel, gate position transmitter shall be provided. The transmitter shall be driven by messenger rope system tensioned by counter weight.

Transmitter for detection of gate filting driven by the same messenger rope system.

g) Dogging Device

The dogging device, which can hold the gate at the fully open position, shall be provided for each gate. The device shall be hook type, hung from the machinery frame and operated manually.

h) Lubrication

Each hoist shall be provided with centerlized lubrication system with hand pump, which shall be capable of applying grease to the components of the hoists except to helical gears of speed reducers.

i) Machinery Frame

The hoist components shall be mounted on the machinery frames, which have ample rigidity against deformation. The bases for components on the frames shall be accurately machined, and components shall be installed with dowel pins.

j) Machinery Cover

The open gears and high speed shafts shall be guarded with adequate covers. The inspection window with lid shall be provided on the cover, if required.

8004 LOCAL CONTROL EQUIPMENT

(1) General

This section covers the requirements for the following equipment to operate and control the wire rope hoist specified in section 8003 of this Specification.

(2) Motors

The motors shall be of horizontal shaft, squirrel cage, induction type, designed for full voltage starting, weatherproof and totally enclosed. The motors insulation system shall be class B or higher in accordance with JIS and continuous or where appropriate, minimum one hour rating at 40°C ambient temperature. The rated capacity of motor shall be more than 100 percent of the calculated based on the maximum hoisting load. The starting and maximum torque of motor shall be more than 200 percent and less than 300 percent of its rated torque respectively.

(3) Brakes

The brakes mounted on motors shall be of spring-applied and AC solenoid released type. The thruster type shall be also provided. The torque rating of these brakes shall be a minimum of 150 percent of the rated full load torque of the motor. The brake shall be arranged to automatically release upon application of power and to automatically set when de-energized.

(4) Limit Switches

The limit switches shall be the heavy duty type, and shall have contacts of 10 amp rating at 250V AC. The limit switches shall be provided for each hoist of the following functions.

- a) Control circuit switches to stop the gate at the "Fully Raised" and "Fully Lowerd" positions : to provide "Dogging Zone" position for interlocking in dogging device operation circuit.

The limit switch shall be driven from machinery through a reduction gear and shall be rotating disk type with snap-action contacts.

For upper leaf of regulating gate, a control circuit switch to stop the gate at the "Fully Closed" position in shall be provided.

- b) A control circuit "Upper Over Hoist" switch to stop the hoisting motion and prevent the gate from coming in contact with any hoist frame component.
- c) A control circuit "Slack Rope" switch to stop the lowering motion when the ropes becomes slack due to a obstruction in the guides or when a gate contacts the sill. The switch shall be actuated by lifting the cover of the rope end device by spring.
- d) A control circuit "Over load" switch to stop the hoisting motion when the over load occur.

The switch shall be actuated by drifting the cover of the rope ends device against spring.

- e) A control circuit "Dogging Caught" and "Dogging Released" switch to stop the dogging device operation when it reaches gate caught or gate released positions.

(5) Position Indicator

One (1) electric gate position transmitter which is installed on the hoist and housed in weatherproof enclosure shall be provided.

The gate position indicator shall be mounted in the remote control panel and be reading exact vertical opening at one (1) cm graduation in three (3) digits.

(6) Local Control Panel

The local control panel shall be installed near the hoist to operate each gate at local place. Regulating gate shall be operated from 1 (one) local control panel which is used in common. The panel enclosure shall be constructed by steel plate and shall be of outdoor self-standing and moisture proof type.

All indicators such as meters and lamps shall be visible from outside of the panel through glass window without opening the front door.

All operation switches such as push buttons and selector switches shall be mounted in the push button station with small door which shall be place on the front door of the control panel.

The following control devices shall be mounted on or within the local control panel, but not be limited to:

- Molded case circuit breaker
- Molded case circuit breaker for hoist room lighting
- Voltmeter
- Ammeter
- Magnetic contactor
- Control relay
- Push button (Open, Close, Stop)
- Door switch (Remote, Local)
- Indicating lamp
- Space heater
- All other necessary transformers and miscellaneous device

8005 GATE OPERATION

(1) General

Each gate shall be raised and lowered individually either from the local control panel and from the remote control panel.

(2) Raising Operation

In raising operation of the gate from the sill or intermediate position, when the "Raise" push button is momentarily pressed and the motor shall be started in the hoisting direction of rotation and the brakes shall be released.

The hoist shall be stopped by the limit switch when the gate reaches the "Fully Raised" position.

The gate shall be raised until the hoist is stopped by either the "Fully Raised" limit switch or by pressing the "Stop" push bottom.

(3) Lower Operation

In lowering operation of the gate from the fully open position or intermediate position, when the "Lower" push button is momentarily pressed and the motor shall be started in the lowering direction of rotation and the brakes shall be released.

The gate shall be stopped by the limit switch which is actuated at a few distance (cm) from the sill, and the timer.

The gate can be stopped in any position by pressing the "Stop" push button momentary.

When the gate contacts the sill, the hoist shall be stopped by the slack rope limit switch to prevent excess rope slack.

8006 MANUFACTURE AND INSTALLATION

(1) General

All works shall be done in a thorough workman like manner and the best modern practice. Unless otherwise specified, manufacture and installation of gate equipment shall conform to the applicable provisions of JIS and TSGP or other equivalent standards.

(2) Material and Instruments

The material and instruments shall be free from defects and shall be of high quality applicable to the work.

(3) Manufacturing

Cutting of steel plate shall be performed with precision, no cracks shall be permitted. Gear wheels shall be heat treated to obtain sufficient hardness mechanically finished.

Casting shall be smooth and free from honey-comb or any defects. All bolt holes shall be mechanically drilled in the shop.

(4) Welding

All welding shall be done manually by the shielded arc method, automatically by submerged arc methods and others. All welding shall conform to the requirements of the JIS. All welders and welding operators assigned to work shall have the welding qualification, which conforms to the JIS or other equivalent standards.

The surfaces of plates to be welded shall be free from rust, grease, an other foreign matter along the edges prepared for welding.

The welding rods shall be suitable for materials, welding methods and welding positions.

The Contractor shall submit welding procedure explaining the edge preparation, welding rod, flux type and welding methods.

(5) Painting

a) General

All equipment for gate work shall be painted as herein specified. No painting is required on bronze or stainless-steel, on rolling or sliding surfaces, on metal surfaces to be embedded in concrete, and metal surfaces to be machined, except side walls of gear rims.

All metal surfaces to be painted shall be cleaned and removed of rust, oil dust, mortar or other foreign matters by sand-blasting or shot-blasting.

In the following cases, no painting work shall be allowed.

- When the temperature is below 5°C or the humidity is above 85%.
- When the atmospheric temperature and humidity are extra ordinarily high.
- When there is fear of wetting before the paint is completely dry.

b) Application of paint

The paint shall be applied for gate equipment as follows.

- External surfaces of gate body an external surfaces of embedded part.

- A. epoxy resin paint : film thickness of 200 microns.
- Internal surfaces of gate body.
- C. Tar-epoxy resin paint : film thickness of 260 microns.
- Hoist equipment
- F. Phtahlic resin paint : film thickness of 135 microns.
- Electrical equipment : due to manufacturer's standard specification

Details of application paint shall be in accordance with the attached coating system.

Coating System

Coating system & symbol	Coating location	Process	Paint	Standard film thickness (μ)	Coating interval (20°C)
					Minimum & Maximum
A Epoxy resin paint system	Steel mill/shop	1st primer	Zinc-rich primer (organic)	20	72H - 6M
	Shop	1st layer (under coat)	Epoxy resin paint	60	
		2nd layer (under coat)	Epoxy resin MIOpaint (Note 4)	60	24H - 7D
	Field	3rd layer (intermediate coat)	Epoxy resin paint	30	24H - 18M
		4th layer (top coat)	Epoxy resin paint	30	24H - 7D
C Tar epoxy resin type	Steel mill/shop	1st primer	Zinc-rich primer (organic)	20	72H - 6M
	Shop	1st layer (under coat)	Tar epoxy resin paint, Class I	80	24H - 7D
		2nd layer (intermediate coat)	Tar epoxy resin paint, Class I	80	24H - 7D
		3rd layer (top coat)	Tar epoxy resin paint, Class I	80	
F Phthalic resin paint system	Steel mill/shop	1st primer	Wash primer	15	4H - 3M
	Shop	1st layer (under coat)	Red-lead or lead-type anticorrosive paint, Class 1	35	24H - 3M
		2nd layer (under coat)	Red-lead or lead-type anticorrosive paint, Class 1	35	
	Field	3rd layer (intermediate coat)	Ready mixed paint for upper coat, Class 2	25	24H - 6M
		4th layer (top coat)	Ready mixed paint for upper coat, Class 2	25	15H - 1M

Remarks : H - Hour
D - Day
M - Month

(6) Installation

a) General

The Contractor shall install, attach, weld, clean and paint the gate equipment at the site under the dry condition. All equipment shall be located properly as indicated on the drawings and shall be secured rigidly in place.

b) Installation work

Prior to the welding, all surfaces to be welded shall be cleaned of loose scale, slag, rust and other matters with a wire brush or other means.

During the welding, the Contractor shall install suitable protective devices against wind, rain and other foreign matters.

Blockouts for 2nd-stage concrete and embedded steel bar in the concrete shall be performed prior to the installation works by others.

The Contractor may use these bars for installation of the equipment, and supplemental anchoring bars shall be prepared, if required.

The Contractor shall supply all anchors, stiffeners except embedded steel bar and any other attachments which shall be required to maintain the gate body, guide frame securely in place during erection.

Exceptional care shall be taken to insure that all gates and guide frames shall be installed in exact position and alignment, that all hoist equipments are in the proper position relative to the gates and which they operate exactly.

Field welding shall be metal arc-welding.

All moving parts shall be carefully and accurately installed, tested for operation, and adjusted so that all parts will move freely and will function properly to secure satisfactory operation.

After each complete unit of the gate has been installed, it shall be serviced and tested. The servicing shall consist of lubricating, adjusting, and cleaning all parts of the gates.

All parts shall be cleaned thoroughly, bearings shall be lubricated properly, and the gear housing shall be filled with suitable gear oil.

(7) Packing and Delivery

Each equipment shall be packed properly or protected for shipment from the manufacture place to the site.

Each crate or package shall contain a packing list in water proof envelope.

All equipments shall be delivered to the site in accordance with installation time schedule.

8007 TEST AND INSPECTION

(1) General

This section covers the test and inspection for shop and field works. The Contractor shall perform and record the following test and inspection. The Contractor shall submit the test and inspection procedure before commencement of works for the approval of the Employer and after works, test and inspection reports shall be submitted to the Employer.

(2) Tolerance

Tolerance shall conform to the applicable provision of TSGP.

a) Flatness, center distance, length of finished parts

$$\epsilon = \frac{\epsilon_0}{2} \left(1 + \frac{L}{10} \right)$$

where : ϵ = dimensional tolerance of the member or part (mm)

ϵ_0 = dimensional tolerance for a length of 10 meters, and is as follows :

For important parts, such as water-tight part, roller tread, etc :

flatness of welded construction ± 3 mm

flatness of machined surface ± 1.5 mm

For ordinary component members :

flatness and center distance ± 6 mm

such ordinary dimensions as width, height, etc. ± 8 mm

L = length of the member of part (m)

(3) Shop Test

a) Material test

Certified mill reports of main materials, including the results of material tests may be submitted to the Employer for his approval instead of performing material test by the Contractor. The characteristic and performance of principal mechanical and electrical equipment shall be also submitted to the Employer for his approval.

b) Welding test

The radiographical test or ultrasonic test for butt welding joints shall be carried out for more than 5 % of total butt welding length. Qualification for welding operator and welder shall be submitted.

c) Shop assembly test

The Contractor shall perform shop assembly test of the gates, embedded parts and hoists. Operational and running test, without load, shall be performed for each hoist. Appearance and measurement inspection shall be made on weld joints and main dimensions by the Contractor. All such assemblies are within acceptable tolerances and function as designed. Acceptable tolerance for gates and embedded parts shall be in accordance with the above tolerance in TSGP standards.

d) Painting test

Painting test shall be carried out and the record shall be submitted to the Employer. Coating thickness shall be in accordance with the coating system specified.

(4) Field Test

a) Field welding test

Application shall be such as specified in (3) hereinabove welding test.

b) Field assembly test

Application shall be such as specified in (3) hereinabove shop assembly test.

c) Field painting in test

Application shall be such as specified in (3) hereinabove painting test.

d) No load operation test

The Contractor shall perform gate operation test by raising and lowering under no load condition. The Contractor shall check the gate speed, electric current and voltage, rotation of motor and the operation of limit switch.

Operation test for 1 set of STOP LOG shall be performed under the dry condition.

(5) Water Operation Test

After completion of all equipment installation at the site, the Contractor shall carry out the water operation test.

The Contractor shall provide and submit the operation test program including detail test items to the Employer for his approval prior to the testings.

All final test records and data which meet the technical provisions in the Specifications and Contract drawings shall be submitted to the Employer for final acceptance.

8008 MAINTENANCE TOOLS

A complete set of all necessary maintenance tools shall be supplied by the Contractor to enable any erection, dismantling or testing to be carried out on any parts of the equipment, whether of an electrical, mechanical or any other nature during the life of the equipment and the list of which shall be submitted to the Employer for approval. The tools shall be supplied in lockable cabinet(s).

The cost of supplying maintenance tools shall be deemed to have been included in the prices for the pay item Nos. 2301 and 2302.

8009 PHOTOGRAPHIC RECORDS

The Contractor shall keep photographic records for progress of work up to completion thereof. Upon completion of the work, the Contractor shall submit them to the Employer on editing in an album with adequate explanation to the Employer's satisfaction. The Contractor shall provide himself necessary access to the work and temporary facilities to photograph any part of the work at any stage of manufacture and construction. The cost of the photographic records shall be included in the price for the pay item No. 1201.

8010 TRAINING OF EMPLOYER'S STAFF

After completion of all equipment installation including remote control system at the site, the Contractor shall instruct and train the Employer's operation staffs relating to adjustment, operation and maintenance of the gate equipments. The Contractor shall dispatch the instructors as shown below.

One (1) mechanical instructor : two (2) months and
One (1) electrical instructor : one (1) month

The Contractor shall submit to the Employer twenty-five (25) sets of operation and maintenance manual for permanent installations, textbooks for training of operation and maintenance staffs of the Employer and three (3) sets of records of results of test operations.

Payment for training the Employer's staff will be made at the price for the pay item No. 2305, which price shall include the cost of instructors, operation and maintenance manual, textbooks and all other materials required for successful training services.

8011 MEASUREMENT AND PAYMENT

(1) The cost of the gate works specified in Division 8 of the Specifications and the drawings shall be included in the prices for the pay item Nos. 2301 to 2305. Gate equipment to be supplied under the pay item Nos. 2301, 2302 and 2304 shall be as follows.

Pay Item No. 2301 Gate equipment indicated in section 8001, (2), a) of the Specifications, and all other equipment and accessories necessary to complete the flood gates.

Pay Item No. 2302 Gate equipment indicated in section 8001, (2), b) of the Specifications, and all other equipment and accessories necessary to complete the regulating gates.

Pay Item No. 2304 Gate equipment indicated in section 8001, (2), c) of the Specifications, and all other equipment and accessories necessary to complete the stop log.

The prices for the pay item Nos. 2301, 2302 and 2304 shall include the cost of design, supply, fabrication, manufacture, shop assembly and testing, delivery, painting and handling of the equipment and accessories to be supplied under the respective pay items, and all other costs required for complying the applicable requirements specified in the Specifications.

Payment for the pay item Nos. 2301, 2302 and 2304 will be made by the progress percentage as specified below based on the respective prices in the Bill of Quantities.

PAYMENT FOR THE PAY ITEM NOS. 2301, 2302 AND 2304

(a) The advance payment which corresponds to thirty (30) percent of the respective prices in the Bill of Quantities will be made within 45 days after the Employer's approval for the calculations and drawings of gate equipment to be supplied under the respective pay items.

- (b) The progress payment which corresponds to fifty (50) percent of the respective prices in the Bill of Quantities will be made within 45 days after the Employer's acceptance for the gate equipment arrived at the designated site.
 - (c) The final payment which corresponds to twenty (20) percent of the respective prices in the Bill of Quantities will be made after the Employer's acceptance for the results of water operation test.
- (2) All the costs required for installation and field tests of the equipment and accessories supplied under the pay item Nos. 2301 and 2302 and the cost of water operation test shall be included in the price for the pay item No. 2303. The cost of field test for the stop log, including operation test under the dry condition, shall be included in the price for the pay item No. 2304.

DIVISION 9 CONTROL SYSTEM AND ELECTRICAL FACILITIES

SECTION 9000 GENERAL

9001 GENERAL

(1) General

The work to be done under this Specification shall include the design, supply fabrication, manufacture, shop assembly and testing, delivery, site installation, site testing of control systems and electrical facilities and training of Employer's operation and maintenance staffs specified herein. The Contractor shall submit the calculations and drawings of the control system and electrical facilities to the Employer for his approval.

(2) Scope of Work

Supply, design and others for control systems and electrical facilities as follows :

- a) Ban Sang station
Water level gauging, VHF
- b) Nakhon Nayok station
Water level gauging, VHF
- c) T/M, T/C and remote control systems
T/M and T/C systems of Pumping Station, T/M, T/C and remote control systems in Control House, observation system, etc.
- d) Monitoring and paging system
- e) Electrical facilities including emergency generator for Diversion Dam area
- f) Incoming cubicle and transformer (No.1 and No.2 substations)
- g) Road lighting
- h) Employer's staff training

9002 AMBIENT CONDITIONS

The equipment shall be suitable for long time operation, and all guaranteed technical data shall be maintained under the following ambient conditions. But particular equipment, for example, printed circuit boards or others using for T/M, T/C and control system, shall be provided their own counterplan for necessary equipments.

Temperature	40 °C
Relative Humidity	Mean year 72 % Mean Max 94 %
Wind velocity	30 m/sec