(vi) NPSHre curve for the pump.

(vii) Record of dimensional inspection.

(viii) Other test data required.

(4) Test Reports and Performance Curves

(a) After the pumps and motors have been tested as required in Paragraph (3) above, the Contractor shall prepare and submit to the Engineer for approval five (5) certified copies of all test reports and performance curves.

(b) No shipment of the pumps and motors shall be allowed until approval of the Engineer for the test reports and performance curves has been given. However such approval shall in no way relieve the Contractor of the full responsibility for furnishing the equipment that shall meet all requirements of the Specifications.

The Engineer shall reserve the right to reject any pump coupled with motor assembly which does not meet the performance guarantees as to shaft power, specified discharge and pump efficiency and so forth.

A.2.14 Tests at Site

The equipment supplied and installed shall be tested at site in accordance with the requirements of Clause GS.11.2 in Part-I General Specifications.

The Contractor shall obtain and record in graphical form the pump characteristics, various discharge including over discharge.

The documents of test results shall be submitted to the Engineer within 30 days after the completion of the tests. The range of test conditions and the test setting shall be approved by the Engineer.

A.3 NON RETURN VALVES

A.3.1 Type and Design Conditions

Each non-return valve shall be of the by-pass system incorporated slow closing type check valve, and provided at the outlet pipe side of main pump, following short pipe and enlarging pipe with loose flange connection. The design conditions thereof shall be as follows :

(1) Size (inner diameter) : 1,000 mm

(2) Internal pressure for design, vide Clause A.2.3

(a) Static pressure : 6.802 kgf/cm^2 (HWL 114.02 m - EL.46.0 m)
(b) Maximum working pressure : 13 kg/cm^2
(c) Test pressure : 1.5 times the max. working pressure

(3) Discharge passing through valve : Approximate 3.2 m^3/sec

(4) Operating method : Self operation by water pressure

(5) Corrosion allowance : 2.0 mm

A.3.2 Structure General

Each valve shall conform to the following requirements.

(1) Each valve shall consist of a valve body, main valve leaf, shaft, by-pass system, and other necessary components, and shall be able to operate safely and satisfactorily under any operating conditions, especially under water hammer phenomena, so as to let the main check valve close fast after starting of back flow to reduce pressure rise due to water hammering action, and then let the by-pass valve close gradually.

(2) Each valve shall have cast iron body. The valve shaft shall be made of stainless steel or equivalent and shall have ample size to resist the torque during valve operation. The valve seal shall be of metal to metal contact and the valve seats to be furnished on the valve body shall be made of Monel metal or equivalent

(3) Each valve shall be located on the concrete foundation with anchors, coupling to enlarging pipe and short pipe in 1.0 m diameter by means of flange and loose flange connection. Anchor strengths shall be sufficient enough to resist the load specified.

(4) The details of structure and operation of the valves not specified herein, will be left to the Contractor, but subject to the approval of the Engineer.

A.3.3 Gratings at Valve Hatches

The gratings with their anchorages shall be designed and supplied by the Contractor to cover the valve hatch openings at motor floor EL.50.000. The opening of valve hatch shall be 2 m by 2 m. The design loads of the grating shall be 500 kgf/m^2. The gratings made of mild steel shall be hot dip galvanized in accordance with JIS H 8641 or equivalent so as to have a thickness of zinc coating of not less than 550 g/m^2. The galvanizing shall be not to affect

the mechanical properties of the treated material. All drilling, punching, cutting and bending of parts shall be completed and all burrs shall be removed before galvanizing.

The Contractor shall supply installing frames, anchors and other necessary components for correct installations of gratings.

A.3.4 Accessories

The following accessories shall be supplied by the Contractor for the non-return valves:

(1) Six (6) sets of anchor bolts and nuts for valves.
(2) Other necessary accessories

A.3.5 Spare Parts

The following spare parts shall be furnished by the Contractor for the non-return valves, according to the Forms of Schedules in Volume-II.

(1) Two (2) sets of spindles with main and by-pass valve leaf.
(2) Three (3) sets of gaskets.
(3) Other necessary spare parts recommended by the manufacturer.

A.3.6 Tests at Contractor's Shop

Before shipping of the goods from the Contractor's shop, an operation test for each valve shall be performed to prove specified functions. The tests shall include dimensional inspection, pressure test for leaks, operating test and other necessary tests. If any defect or improper operations are discovered, they shall be corrected and the entire test shall be repeated.

A.3.7 Tests at Site

The equipment supplied and installed shall be tested at site in accordance with the requirements of Clause GS.11.2 in Part-I General Specifications.

The documents of test results shall be submitted to the Engineer within 30 days after the completion of the test. The test condition and setting shall be approved by the Engineer.

A.4 GUARD VALVES

A.4.1 Type and Design Conditions

Each guard valve shall be of electrically operated, butterfly valve type guard valve, and provided at the downstream side of the non-return valve. The design conditions thereof shall be as follows:

(1)	Size (inner diameter)	:	1,000 mm
(2)	Internal pressure for design, vide Clause A.2.3		
	(a) Static pressure	:	6.802 kg/cm^2 (HWL 114.02 m - EL.46.0 m)
	(b) Maximum pressure	:	13 kg/cm^2
	(c) Test pressure	:	1.5 times the max. working pressure
(3)	Discharge passing through valve	:	Approximate 3.2 m^3/sec
(4)	Operation time	:	Approximate 2 minutes
(5)	Leakage	:	Max. 100 cc for ten (10) minutes under hydrostatic pressure test
(6)	Corrosion allowance	:	2.0 mm

A.4.2 Structure General

The valves shall conform to the following requirements.

(1) The valves shall be used for shutting off water flow when starting or stopping of main pump, along with their inspection and maintenance. No discharge control by the valves will be considered.

(2) Each valve shall consist of a valve body, valve leaf, shaft, electrically driven operating system with manual handle, controls and other necessary components, and shall have the shaft installed in horizontal position.

(3) Each valve shall be of the products suitable for main pump operation, long working life and valve chamber space, etc. The valve body and valve leaf shall be of cast iron or other approved construction, having rubber based seat for watertightness. The valves shall be coupled with short pipes and penstocks by means of flange connections.

(4) A 150 mm diameter bypass pipe with hand operating sluice valve and air valve having ample air opening, shall be provided for each guard valve.

(5) The operating system of the guard valve shall be designed and fabricated to be capable of operating the valve to suit to the pump operation sequence under the fully unbalanced head conditions. The electrical source for the motor shall be A.C. 220/127 volts, 3-phase, 4-wire and 60 Hz.

A.4.3 Accessories

The following accessories shall be supplied by the Contractor for the guard valves:

(1) Six (6) sets of anchor bolts and nuts for valves.

(2) Six (6) sets of valve position indicator.

(3) Six (6) sets of limit switches for fully opened and fully closed valve positions.

(4) Six (6) sets of torque switch.

(5) Six (6) lots of removable type steel overpass structure for routine inspection.

(6) Other necessary accessories.

Indicators for above (2) and other required shall be furnished on the control board of Subsection E.

A.4.4 Spare Parts

The following spare parts shall be furnished by the Contractor for the guard valves, according to the Forms of Schedules in Volume-II.

(1) 100 % of limit switches.

(2) Two (2) sets of torque switch.

(3) Two (2) grease nipples and/or caps of each type and size used.

(4) One (1) set of fixed and moving contact for relays and switches, etc.

(5) One (1) set of seal with clamping and fixing screws and plate for each valve.

(6) Other necessary spare parts recommended by the manufacturer.

A.4.5 Test at Contractor's Shop

Before shipping of the goods from the Contractor's shop, an operation test for guard valve shall be performed to prove specified functions. The test shall include dimensional inspection, pressure test for leaks, operating test and other necessary test. If any defect or improper operations are discovered, they shall be corrected and the entire test shall be repeated.

A.4.6 Tests at Site

The equipment supplied and installed shall be tested at site in accordance with the requirements of Clause GS.11.2 in Part-I General Specifications.

The documents of test results shall be submitted to the Engineer within 30 days after the completion of the test. The test condition and setting shall be approved by the Engineer.

SUBSECTION-B

ELECTRIC MOTORS

B.1 GENERAL

B.1.1 Scope

This Subsection covers the design, manufacture, testing before shipment, transportation to the Site, installation and erection, commissioning and performance tests at the Site of the following:

- Six (6) vertical shaft electric motors directly coupled to the main pump specified in Subsection-A and all associated equipment.

It is not the intention of these Specifications to specify in complete detail of the various parts of motors, that are being left to the experience and practice of the Contractor to furnish the equipment which shall meet in all respects the requirements of the Employer in regard to performance, reliability and satisfactory operation.

The details of the equipment, not specified herein, will be left to the Contractor,but subject to approval of the Engineer.

The general arrangement of the motors and the associated equipment shall be as shown on the Drawings for Tender, Nos. 3-I-003, 3-I-005 and 3-I-007.

B.2 MOTORS

B.2.1 Type and Rating

The motors to be furnished under this Subsection shall be of totally-enclosed, self-ventilating, vertical shaft, three phase wound-rotor type induction motors with water cooled air coolers and continuous rating of each motor shall be as below:

(1)	Voltage	:	4,160 V
(2)	Frequency	:	60 Hz
(3)	Output	:	Not less than 2,400 kW

The continuous output of the motor shall be ample to drive pump specified in the Subsection-A under the rated voltage ±5 per cent allowance. The Tenderer shall state the output of the motor in his tender and guarantee.

Direction of motor rotation shall be clockwise when viewed from top looking down on unit.

B.2.2 Speed

The synchronous speed of motor shall be 600 RPM with 12 poles. The motor shall be directly coupled to the pump.

B.2.3 Efficiency and Power Factor

The efficiency and power factor of the motor shall be more than 0.95 and 0.85 at rated load, respectively.

B.2.4 Insulation

The windings of the motors shall be insulated with Class F materials.

B.2.5 Temperature Rise

(1) The following limits of temperature rise shall apply to the windings of motors when operating with the rated output continuously at rated voltage, power factor and frequency, with cooling water entering the motor coolers at water temperature of not more than 25°C.

Method of measurement	Temperature rise	
	Stator	Rotor
Embedded temperature detectors between coils	100°C	-
Resistance	100°C	100°C
Thermometer	85°C	-

(2) The maximum temperature of each bearing shall be less than the following values:

Method of measurement	Temperature
Thermometer	60°C
Embedded detectors in metal	65°C

(3) Temperature conditions at the Site should be taken for design purpose to be as follows:

Place	Temperature rise	
	Maximum	Minimum
Inside motor room	30°C	15°C
Outside pump station (Shade temperature)	34°C	9°C
Cooling water	25°C	20°C

B.2.6 Structural General

The motor design must include all provisions necessary to prevent damage resulting from 125% reverse rotation which may occur in the event of back flow at the pump trip phenomenon.

The type of the thrust bearing shall be of kings berry type or other suitable type to be approved by the Engineer.

The thrust bearing shall be provided on the motor and the bracket supporting the thrust bearing shall support the weight of the rotor assembly of the motor, together with the pump impeller, shaft and the unbalanced hydraulic downward thrust acting on the pump impeller.

The brush draw-up equipment at the rated speed shall be provided.

Necessary platform, stairways and handrails shall be provided with the motor.

Adequate provision shall be made for convenient handling of all parts during assembly or disassembly of the motor, and for convenient maintenance and inspection of the motor.

The motor bearing shall be designed to stand well for any load under partial opening of guard valve during transition mode in initial pump discharge.

B.2.7 Stator

The stator core shall be built up with thin, high-grade, nonaging-silicon-steel laminations, each lamination coated on both sides after punching with an insulating varnish or other material to minimize eddy current losses.

The inside diameter of the stator core shall be large enough so that the impeller of the pump can be lifted through the stator with overhead traveling crane.

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

Both ends of the stator winding shall be suitable for termination of the power cables.

Three (3) current transformers, rated at 4.16 kV and 600/5 amp. with ANSI accuracy classification C100 for motor differential protection, shall be furnished and mounted at the neutral end of the winding inside the housing.

B.2.8 Rotor and Shaft

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 from deforming or slipping due to the centrifugal stresses on the interconnections.

The shaft shall be made of carbon steel forgings or the other alloy steel forgings properly heat-treated. The shaft shall be of ample size to operate safely in combination with the pump shaft at any speed without detrimental vibration or distortion. The external surface of the shaft shall be accurately and smoothly machined and polished at bearing surfaces.

The lower end of the shaft shall be arranged for suitable direct coupling to the pump shaft.

B.2.9 Bearing

The motor shall be provided with thrust and guide bearings of the babbitt type. The thrust bearing shall be of the self-equalizing type and shall have ample capacity to support the combined weight of the rotating parts of the motor and pump including the maximum unbalanced hydraulic thrust of the pump impeller, and shall be capable of operating under the load at any speed.

The guide bearing shall be capable of withstanding all stresses incident to the pump operation.

The bearing shall be suitable for dismantling without removal of the motor.

The bearings shall be furnished with lubrication oil system with suitable oil cooling system maintaining the oil at proper temperature. The type of oil used shall be of the same specification for lubrication of the pump bearing.

B.2.10 Motor Cooling

The motor shall be provided with water cooled air cooler. The circulation of cooling air shall be made so that all parts of the motor will have effective contact with the air flow. The air cooler shall be of the tube type with finned tubes expanded into corrosion resisting tube sheets. The tubes of the air cooler shall be of copper or copper alloy. The water supply and discharge headers shall be furnished with the coolers, and all connections between the coolers and the headers shall be of the flanged type. A valve shall be provided in the connection between each cooler and supply header so that any cooler can be readily

disconnected and removed for maintenance without interfering with the operation of the remaining coolers.

Provision shall be made for measuring the water temperature at the inlet and outlet of each cooler and for measuring the temperature difference of the air and water passing through the coolers to facilitate balancing the cooling system when the motor is operated under load.

The flow through each cooler shall be controlled by a valve on the discharge side from the coolers.

A flow switch shall be provided in the supply or discharge pipe line to sense cooling water flow and to provide indication at the control board.

Each unit cooler shall be fastened directly to the stator frame or to base frame and furnished with a cooler casing.

Temperature detectors for inlet air and discharge air of coolers shall be provided.

B.2.11 Motor Housing

A steel plate housing sufficient size to cover the motor shall be furnished for the motor.

The outside wall of the motor housing shall be neatly constructed and sufficiently rigid to prevent objectionable vibrations.

Necessary platforms, stairways and handrailing shall be provided for ready access to and for inspection.

The motor housing shall be constructed for easy inspection and maintenance of the motor and its accessories.

B.2.12 Flywheel Effect

The flywheel effect (GD^2) of the rotating parts of the motor and pump shall not be less than 4,240 Kg-m^2.

The Tenderer shall state the flywheel effect in his Tender.

B.2.13 Liquid Rheostat

A liquid rheostat shall be provided for each pump motor unit to reduce the starting current.

Each liquid rheostat shall be capable of starting for the pump motor unit three times in a period of any one hour. Necessary inter-locking shall be provided to prevent the short-circuit starting of liquid rheostat when the pump motor unit is restarted.

The operation time of the motor from switch-on to full load shall be less than 1 (one) minute.

B.3 CONTROL SYSTEM

B.3.1 Description of Pump Operation

The pumps shall be operated in combination with number of pump units and pump operation hours against the seasonal water requirements.

Each of all following pump control shall be performed.

(1) Remote manual Starting and Stopping of Pumps from the Control Room

The pumps shall be started and stopped by an operator from the desk type control switchboard provided in the control room by remote control.

(2) Manual Starting and Stopping of Pumps from Local Control Panel on Motor Floor

The pumps shall be started and stopped from the local control panels provided on the motor floor. Each individual function shall also be operated by independent control switches on the control panel by the change-over of selecting switches when required.

A control selector for the above shall be located on the local control panel on the motor floor. When the control selector positioned to any of them, the other control system shall be electrically locked to prevent trouble caused by misoperation of the pumps.

B.3.2 Operating Sequences for Pumps

(1) Starting Conditions

The pumps shall be started after the following starting conditions are satisfactorily confirmed. The confirmation of the starting conditions shall be interlocked in the control system.

(a) Water level in suction pondage, normal
(b) Guard valve, close
(c) Starting rheostat, starting position

(d) No other pump under starting action

(e) Protection relay, no operation

(2) Starting Sequence

The pump start shall be performed according to the following starting sequence. The starting sequences shall be automatic in normal operation and be changeable to manual operation.

(a) Confirm the starting conditions

(b) Start the pump motor by means of the starting rheostat control, and run up the pump motor to normal operation speed

(c) Open the guard valve to full open

(3) Normal Stopping Sequence

The normal pump stop shall be performed according to the following stopping sequence.

(a) Close the guard valve to full close

(b) Stop the pump motor

(4) Manual Emergency Pump Stopping Sequence

The manual emergency pump stop shall be performed according to the following sequence.

(a) Stop the pump motor

(b) Close the guard valve, by means of emergency closing operation, simultaneously with the pump motor stop. The operation of emergency pump stopping device shall lock out the motor and shall require manual resetting before the pump can be restarted.

B.3.3 Control Facilities Required

The Contractor shall supply local control panel complete with necessary accessories for controlling motors of the equipment supplied under Subsections A, B and Clause E.7 of Subsection E on EL.50.0 m floor in the pump station.

(1) Remote Control from the Control Room

Necessary facilities shall be provided by the Contractor for performing each of the following control.

(a) Normal start of pump
(b) Normal stop of pump
(c) Manual emergency stop of pump under fault conditions
(d) Individual operation of guard valve

(2) Direct Control from the Local Control Panel

Necessary facilities shall be provided by the Contractor for performing the same control stated in Clause B.3.3 (1) and for performing each of the following control.

(a) Individual operation of pump
(b) Individual operation of guard valve

B.3.4 Protection and Alarm

The Contract shall include in the control system all necessary facilities for shutting down the operating pumps and giving alarm and indication to the Operator on the occurrence of each of the following condition:

(a) Excessive temperature rise in pump and motor bearings
(b) Trouble of starting
(c) Excessive temperature rise in liquid rheostat
(d) Extremely low water level at suction pit
(e) Excessive high water level at head tank
(f) Excessive low voltage of electric power
(g) Over load of main motor
(h) Internal ground fault of motor
(i) Internal short circuit fault of motor
(j) Other protections deemed necessary by the Contractor

The Contract shall also include in the control system all necessary facilities for giving alarm and indication to the operator on the occurrence of each of the following condition:

(a) Trouble of guard valve
(b) Low oil level of pump and motor bearing oil tank
(c) Suspension of cooling water supply
(d) Low water level of liquid rheostat
(e) Low water level at suction pit
(f) High water level at head tank
(g) Not designed water level at one-way surge tank

(h) Extraordinary pressure of auto strainer
(i) High water level of sump pit
(j) Emergency stop (only bell alarm)
(k) Other alarms deemed necessary by the Contractor.

B.3.5 Meters and Indicators

The following meters and indicators shall be provided on the semi-graphic control switchboard, desk type control switchboard and the local control panel by the Contractor.

(a) Pump start indicating lamps
(b) Pump running indicating lamps
(c) Pump stop indicating lamps
(d) Pump emergency stop indicating lamps
(e) Pump start action OK preparation indicating lamps
(f) Guard valve opened or closed indicating lamps
(h) Auxiliary equipment driven indicating lamps
(i) Load ampere meters for main motors
(j) Source pilot light
(k) Other necessary meters and indicators

B.4 COOLING WATER SUPPLY FOR PUMP MOTOR UNITS

B.4.1 Description

Each pump-motor unit shall be provided with a cooling water system for supply to and where necessary, discharge from each item of the equipment requiring cooling water while the pump motor unit is operating.

The cooling water shall be supplied from the discharge penstocks through auto-strainer as shown on the Drawings for Tender, No. 3-I-013. The cooling water system shall consist of supply and discharge pipes, pressure reducing valve, strainer, valves and other necessary components, and shall be designed to facilitate easy assembling and dismantling for maintenance and repair of the system.

The items of the equipment to be supplied by this system shall comprise:

(a) Motor air cooler
(b) Motor bearing coolers

(c) Pump bearing cooler

(d) Pump shaft gland for water sealing

(e) Any other item of the equipment requiring a supply of cooling water while the unit is operating.

B.4.2 General Requirements

The cooling water system shall be designed and supplied to conform with the following requirements.

(1) The Contractor shall determine the water head, size of piping, capacity of the strainer and other items required for the cooling water system, subject to the approval of the Engineer.

(2) The cooling water system to the reducing valve shall withstand the water pressure of 13.0 kg/cm^2.

(3) The strainer shall be of auto-strainer and shall be designed enough to exclude any foreign matter to cause damage or blocking in any part of the cooling system.
The strainer screen shall be of corrosion resistant material and interchangeable structure.

B.5 MOTOR CONTROL CENTER

A combined motor control center shall be provided for auxiliary equipment such as cooling water automatic valve, guard valve, rheostat circulating pump, etc. of each pump-motor unit group to allow independent operation of each unit group without affecting the drive of the other. A common control center shall also be provided for the drainage pumps and automatic strainer.

The motor control center shall be completely wired and equipped with starters, instruments, protective relays, switches, lamps, etc. and shall be furnished together with each local pushbutton switch stand.

The motor control centers shall be comply with the following requirements:

(1) The enclosure and structural parts shall be specified in Clause E.6.3 and finished to Clause E.6.10.

(2) At least one spare unit shall be provided for each frame size of motor control unit.

(3) All units in the motor control center shall be completely accessible and removable from the front

(4) Disconnected switches shall be lockable in "OFF" position.

(5) All equipment in the power circuit shall be insulated at 600 volt. The main buses shall be rated for 630 A and withstand 25 kA for two seconds under fault condition without mechanical or thermal damage.

(6) Wiring, phase arrangement and colour codes shall be as specified in Clause E.6.5, E.6.6 and E.6.7.

(7) A grounding bus shall be provided on the back side at the bottom.

(8) All starters shall be combination type with mold case circuit breakers. The magnetic starters shall have two temperature compensated overload relays with single phasing and undervoltage protection. All starters shall be supplied with at least one normally open and one normally closed spare auxiliary contacts. All overload relays shall be manual reset type and field adjustable to rated motor current.

(9) Provision shall be made to allow rush current without tripping of the corresponding molded case circuit breaker or to keep starting current sufficiently low.

B.6 ACCESSORIES

The following accessories shall be provided by the Contractor for the electric motors:

(1) All necessary motor base and anchor bolts and nuts for motors and associated equipment.
(2) All necessary checkered plates, platforms, ladders, guard handrails for completing the floor around the motors and other associated equipment.
(3) All necessary oil level indicators.
(4) All necessary temperature detectors.
(5) All necessary cooling water flow switches.
(6) Anti-condensation heaters for each motor.
(7) Lubricating oil and grease for two years consumption.
(8) Six sets of secondary short-circuit contactors.
(9) Six sets of electrolyte circulating pump with driving motor.
(10) Sodium carbonate of liquid rheostat for two years consumption.
(11) One set of protective plastic cover (shock absorber) for the edge of stator of main pump motor.
(12) Other necessary accessories.

Indicators for above item (3), (4), (5) and other required shall be furnished on the control switchboard of Subsection E.

B.7 SPARE PARTS

The following spare parts shall be furnished by the Contractor for the motors.

(1) Two sets of brush slip rings and holders
(2) Two sets of upper and lower guide bearing metals
(3) Two sets of thrust bearing metals
(4) Two sets of each type of oil level indicator
(5) Two sets of each type of temperature detector
(6) Two sets of each type of cooling water flow switch
(7) Three sets of packings of each type for cooling water pipe
(8) Two sets of limit switches, float switches and relays for liquid rheostat
(9) One set of secondary short-circuit contactor
(10) One set of electrolyte circulating pump
(11) One set of relays and fuses for each of protection system
(12) Other necessary spare parts recommended by the manufacturer.

B.8 TESTS

B.8.1 Test at Contractor's Shop

The following test shall be performed at the Contractor's shop.

(1) Check of the dimensions
(2) Resistance measurements for stator windings
(3) Insulation resistance test
(4) High voltage test for stator and rotor
(5) Other necessary test required by the Engineer.

B.8.2 Special Test

One motor to be shipped first shall be subject to the following tests after assembly at the Contractor's shop in accordance with Contract.

(1) No load losses measurement
(2) Lock test
(3) Temperature rise test
(4) Retardation tests to determine flywheel effect (GD^2) of rotating parts

(5) Determination of characteristics.

B.8.3 Test at Site

The equipment supplied and installed shall be tested at site in accordance with the requirements of Clause GS.11.2 in Part-I General Specification, including measurement of pump starting current and calculation of water head and pump efficiency.

The documents of test results shall be submitted to the Engineer within 30 days after the completion of the tests. The range of test conditions and setting shall be approved by the Engineer.

SUBSECTION - C

TRANSFORMERS

C.1 GENERAL

C.1.1 Scope

This Subsection covers the design, manufacture, testing before shipment, transportation to the Site, installation and erection, commissioning and performance tests at the Site of the following:

(1) Two three-phase main transformers with no-load tap-changer of 10,000 kVA for stepping down the voltage from 138 kV to 4.16 kV, oil immersed, natural-air cooling, outdoor use type.

(2) One three-phase local service transformer of 1,000 kVA for stepping up the voltage from 4.16 kV to 13.8 kV, oil immersed self-cooled, out-door use type.

(3) Two three-phase station service transformer of 300 kVA for stepping down the voltage from 4.16 kV to 220/127 V, dry molded type to be installed in 4.16 kV cubicle supplied under Clause E.4.10.

C.1.2 Temperature Rise

The maximum temperature rise shall not exceed the following value at the rated output.

(1) For Oil Immersed Type:

55°C in oil by thermometer
55°C of winding by resistance thermometer

(2) For Dry Molded Type of Class B Insulation:

80°C of winding by resistance measurement

C.1.3 Insulating Oil

Insulating oil shall be of non-sludging and of medium viscosity. The characteristics of oil to be used shall be equivalent to those available in Ecuador.

Main and local service transformers shall be supplied with the first filling of oil and ten percent extra oil in sealed non-returnable drums.

C.1.4 Frequency

The transformers shall be designed for a frequency of 60 Hz.

C.1.5 Insulation Level

The transformers shall withstand the following voltages:

(1)	138 kV side:	Full wave impulse.....	1.2 x 50 micro-second, 650 kV
		Chopped wave impulse.....	750 kV
		Power frequency	275 kV for one minute
(2)	Neutral of 138 kV	Power frequency	80 kV for one minute
(3)	13.8 kV side:	Full wave impulse.....	1.2 x 50 micro-second, 110 kV
		Chopped wave impulse.....	130 kV
		Power frequency	34 kV for one minute
(4)	4.16 kV side: (for oil immersed type)	Full wave impulse.....	1.2 x 50 micro-second, 75 kV
		Chopped wave impulse.....	88 kV
		Power frequency	19 kV for one minute
(5)	4.16 kV side: (for dry molded type)	Full wave impulse.....	1.2 x 50 micro-second, 50 kV
		Power frequency	24 kV for one minute

C.2 10,000 KVA TRANSFORMERS

C.2.1 Type and Ratio

Each transformer shall be of 3-phase, oil immersed, natural-air-cooling, outdoor use type with no-load tap changer and the no-load rated ratio of star-delta connection shall be 138 kV to 4.16 kV.

The connection shall be arranged in accordance with vector symbol Yd1 of IEC Publication 76, 1967) and neutral of star connected winding shall be brought out for grounding.

C.2.2 Output

The continuous rated output of each transformer shall be 10,000 kVA at any of taps.

C.2.3 Impedance Voltage

Impedance voltage shall be less than 9% on the base of 10,000 kVA output on the rated tapping and shall be guaranteed by the Contractor.

C.2.4 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 material and clamped securely with insulated bolts.

The design of the core and the method of clamping shall be such as to ensure it free from excessive noise and vibration. The clamping frame-work shall be built up of structural steel members.

The cores shall be provided with lifting eyes or other approved arrangements to permit easy and ready dismantling, and so designed that core and windings can be lifted from the tank with as little dismantling as possible.

To ensure efficient cooling, each core shall be provided with oil ducts.

Suitable means shall be adopted to prevent circulating current being set up within the core.

The cores and windings shall be so located within the tank as to prevent movement.

The cores shall be electrically connected to the transformer tank.

C.2.5 Windings and Insulation

Graded insulation may be applied on 138 kV side windings where the neutral point of 138 kV side will be solidly grounded, but 4.16 kV windings shall be fully insulated.

The windings shall be of high conductivity copper.

The amount of insulation shall be determined not merely by normal voltage per turn, but also by due consideration of the line voltage and the service conditions, including impulse phenomena caused by lightning strokes on transmission line and surges during switching and fault conditions.

The insulation of the end turns of each winding adjacent to the transformer terminals shall be reinforced between turns or provided with suitable means to protect the winding against surges and transients.

The primary and secondary windings shall be so designed that they remain electrically balanced with their magnetic centers coincident under all conditions of operation. The windings shall be so arranged and so firmly clamped in position that they will withstand the mechanical stresses to which they might be subject on short circuit.

Provision shall be made for taking up any contraction due to shrinkage to eliminate movement of any coil due to short circuit, vibration or other sources of disturbance.

All windings, after being wound, and all fibrous and hygroscopic material used in the construct of the transformer shall be dried under vacuum and impregnated with hot oil.

Adequate provision shall be made for the circulation of the oil round and between the windings, so that a very low temperature gradient between the conductors and the oil be assured and any danger of excessive local heating be eliminated. Spacing blocks shall be provided between section of the windings to ensure radial circulation of the oil and to ensure that the windings present a sufficient contact surface to the oil.

The general design and construction of the transformer and the bracing of the windings shall be such that no mechanical movement of the coil is possible as a result of the dead short circuit on any side of the transformer. The transformer shall withstand, without injury, the dead short circuit for a duration of at least two seconds.

C.2.6 Bushing

The bushings for 138 kV side shall be of oil filled or condenser type, the bushings for 4.16 kV side and 138 kV neutral shall be of solid type. The colour of bushing shell shall be brown and the glazed surface shall be free from bulges, hair line cracks and other defects. The glaze shall be uniform throughout the surface.

The terminal of following bushing shall be bolted with clamp type terminal for the following conductors:-

138 kV	line side	:	170 sq.mm aluminum conductor steel reinforced wire
	neutral side	:	100 sq.mm copper stranded wire
4.16 kV	side	:	2 x 1C 400 sq.mm CV cable/per phase.

The transformer shall be provided with two bushing current transformers of 100/5A with relay accuracy on each phase, except neutral, of 138 kV side. In addition, one bushing current transformer shall be provided for thermal image type temperature indicator of 138 kV winding.

The neutral terminal of 138 kV side shall be connected with 100 sq.mm copper conductor which shall run down to ground supported by insulators on the transformer tank.

C.2.7 Tank

Cores and windings shall be enclosed and securely held in a tank made of stout steel plates. The tank shall be of welded construction, suitably stiffened by means of channel or angle section welded to the tank, and shall be absolutely water and hot oil tight and suitable for vacuum drying. It shall be designed so as to permit convenient handling. Necessary lugs and shackles shall be provided to enable the whole transformer to be lifted bodily by a crane or other means; they shall be so located that safe clearance be obtained between the slings and transformer bushing without use of a spreader.

The base of transformer shall be provided with jack steps or recesses to permit the use of jacks and shall have pulling eyes on all four sides.

The tank cover shall be designed so that the bushings can be easily removed and connections to the windings easily made.

The inside of the tank and all steel connections shall be sand or shot blasted. All mill scale shall be completely removed from the outside of the tank before painting.

Two suitable grounding pads shall be welded to the base of the tank.

C.2.8 Cooling System

The transformer cooling system shall consist of radiators of sufficient capacity to prevent overheating the transformer when operated continuously at the rated kVA of the transformer.

The radiator shall be divided into several blocks and fitted directly to the tank of the transformer. These shall be provided with radiator valves, lifting eye and necessary accessories.

C.2.9 Oil Conservator

The transformer shall be supplied with a conservator of atmosphere sealed type with oil resistant rubber diaphragm fitted with an oil level indicator and a silicagel breather of suitable size. It must be possible to inspect the silicagel through a glass window or alternately the container shall be made of glass.

C.2.10 Tap Changer

The transformer shall be capable of operation at his rated output without injury on any tapping.

The no-voltage tap changer shall be provided on 138 kV side with taps at 5 steps of 5 % above and below the rated voltage. The tap changer shall be capable of operating under no-voltage condition from the outside of transformer at ground level for easy operation. The position must be clearly indicated and means of locking shall be provided. All taps shall be rated for full output.

C.2.11 Surge Absorber

Each transformer shall be provided with suitable surge absorber at 4.16 kV side, consisting of condensers and lightning arresters.

C.2.12 Protection

The following protection shall be provided:-

(1) Buchholtz relay protection.
(2) Temperature non-trip alarm. (top oil and winding)
(3) Oil level non-trip alarm.

A Buchholtz relay shall be fitted on between the conservator and the tank with alarm and trip contacts suitable for 125V D.C., and isolating valves shall be inserted on the both sides of the Buchholtz relay. The Buchholtz relay shall be equipped with a testing cock and a gas release cock.

A dial type indicating thermometer calibrated in centigrade, equipped with alarm contacts suitable for 125V D.C., shall be supplied for indicating the temperature of top oil. The transformer shall be provided with a temperature detector of 100-ohm at 0°C for connection to 138 kV winding temperature indicator in the control room.

A temperature indicator shall be provided for two main transformers for indication on the main control switchboard specified in Subsection-E.

C.2.13 Skid Base

The transformer shall be provided with skid base, necessary devices for setting, and appropriate devices for locking on the foundation.

C.2.14 Other Accessories

The following accessories shall be provided with the transformer:-

(1) Combined type oil drain, filtering and sampling valves with screwed cap for the main tank. The valves shall have terminals suitable for connecting the oil purifier, specified on Clause F.6.

(2) Explosion vent.

(3) Name plate and connection diagrams with full details of rating in Spanish.

(4) Man hole or hand hole.

(5) A ladder on the side of the tank to provide access for safe inspection. The lower section of the ladder shall be equipped with a barrier and locking device to prevent its use by unauthorized persons.

(6) Terminal box mounted on the tank containing the terminals for connections of all alarm contacts and controls. The space below the control housing shall be kept free of obstructions, which would interfere with conduit connections.

(7) Clamp type ground connectors, two for each transformer.

(8) Other necessary accessories.

C.2.15 Spare Parts

(1) One set of gaskets.
(2) Two bursting plates.
(3) One dial type thermometer.
(4) One oil level gauge.
(5) One set of spares recommended by the manufacturer.

C.2.16 Tests

The following tests shall be carried out at the Contractor's shop in compliance with this Specification:-

(1) Ratio (on all tappings).
(2) Polarity and phase relationship.
(3) Resistance of both windings at each tap.

(4) No-load current and losses.

(5) Load losses at rated current.

(6) Impedance voltages at rated current on the tapping corresponding to the service voltage.

(7) High voltage test.

(8) Impulse tests of full wave and chopped wave.

(9) Operation test of tap changer.

(10) Operation test of cooling system.

(11) Current transformer ratio, polarity and excitation test.

(12) Auxiliary power input measurement.

(13) Temperature rise test.

After completely assembling transformer at site the following commissioning test shall be carried out:-

(1) High voltage test

In order to confirm whether main transformer has any troubles or not, following voltage shall be applied:

4.16 kV side ..... 5.2 kV, 10 minutes
138 kV side ..... 95.6 kV, 10 minutes

(2) Measurement of insulation resistance

(3) Polarity and phase relationship

C.3 1,000 kVA TRANSFORMER

C.3.1 Type and Ratio

The transformer shall be of 3-phase, oil immersed, self-cooled, outdoor use type and the no-load ratio of delta-star connection shall be 4.16 kV to 14.5F-13.8R-13.1 kV.

C.3.2 Output

The continuous rated output of the transformer shall be 1,000 kVA on any of the taps.

C.3.3 Core

The transformer cores shall be designed as specified in Clause C.2.4.

C.3.4 Impedance

Impedance at the rated kVA shall be more than 4.5 percent for the purpose of suppression of short circuit current for the secondary fault.

C.3.5 Windings and Insulation

Windings and insulation shall be designed as specified in Clause C.2.5, except full insulation shall be applied on all windings.

C.3.6 Tank

The tank shall be designed as specified in Clause C.2.7, but no provisions shall be necessary for jack steps or recesses and pulling eyes.

C.3.7 Skid Base

The skid base shall be provided as specified in Clause C.2.13.

C.3.8 Radiator and Oil Conservator

Oil conservator shall be provided as specified in Clause C.2.9.

C.3.9 Protection

The protection shall be provided as specified in Clause C.2.12, but no winding temperature are required.

C.3.10 Accessories

In addition to the above, the following shall be provided for the transformer:-

(1) Oil valves
(2) Name plate and connection diagrams with full details of rating in Spanish
(3) Other necessary accessories

C.3.11 Spare Parts

The following items shall be furnished and quoted as spares:-

(1) One set of gaskets
(2) One set of spare recommended by the manufacturer.

C.3.12 Tests

Clause C.2.16 shall be applied, as far as applicable but requirements for high voltage at site shall be 17.25 kV for 10 minutes for 13.8 kV side.

C.4 300 kVA TRANSFORMER

C.4.1 Type and Ratio

The transformer shall be of 3-phase, dry molded type cubicle-housed, self-cooled, indoor use and the no-load ratio of delta-star connection shall be 4.37F-4.16R-3.95F kV to 220-127 V of three phase four-wire system.

C.4.2 Output

The continuous rated output of the transformer shall be 300 kVA on any of the taps.

C.4.3 Impedance

Impedance at the rated kVA shall be more than 4.5 percent for the purpose of suppression of short circuit current for the secondary fault.

C.4.4 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 resisting material and clamped securely with insulated bolts.

To ensure efficient cooling, each core shall be provided with air ducts, if necessary.

The other requirements shall be in accordance with the Clause C.2.4 as applicable.

C.4.5 Windings and Insulation

Full insulation shall be applied on all windings.

The windings shall be of high conductivity copper and shall be insulated with class B materials and shall be molded with an epoxy or polyester resin.

Adequate provision shall be made for the circulation of the air around and between the windings, so that a very low temperature gradient between the conductors and the air be assured and any danger of excessive local heating be eliminated. Spacing blocks shall be provided between sections of the winding or between windings to ensure radical or axial circulation of the air and ensure that the windings present a sufficient contact surface to the air.

The other requirement shall be in accordance with the Clause C.2.5 as applicable.

C.4.6 Base

The transformer shall be provided with flat wheel base. The transformer shall be locked after positioning in a sheet steel cubicle by means of appropriate devices.

C.4.7 Accessories

In addition to the above, the following shall be provided for the transformer:-

(1) Dial type thermometer.
(2) Name plate and connection diagrams with full details of rating in Spanish.
(3) Other necessary accessories.

C.4.8 Spare Parts

The following item shall be furnished and quoted as spares:-

(1) Necessary spares recommended by the manufacturer.

C.4.9 Tests

Clause C.2.16 and C.3.12 shall be applied as far as applicable, but requirements for high voltage at site shall be 1.5 kV for 10 minutes for 220-127 V side.

SUBSECTION - D

STATIC CONDENSERS

D.1 GENERAL

D.1.1 Scope

This Subsection covers the design, manufacture, testing before shipment, transportation to the Site, installation and erection, commissioning and performance tests at the Site of the following:

Four 800 kVA static condenser banks with series reactors, discharge coils and other necessary accessories.

D.1.2 Insulation Levels

The static condensers unit shall withstand the following voltages:-

Full wave impulse : 1.2 x 50 micro-second, 60 kV
Power frequency : 19 kV for one minutes

D.2 STATIC CONDENSER SET

D.2.1 Static Condensers

(1) Type

Each static condenser shall be outdoor use, oil filled type.

The static condenser shall have suitable mechanical fault detector to protect from any faults. This detector device is installed on the outside of the condenser case. Upon detection, it opens the circuit to prevent case rupture.

(2) Rating

Each static condenser shall have the following ratings:-

(a) Rated normal voltage ..... 4.16 kV
(b) Rated capacity at 4.16 kV ..... 800 kVAR
(c) Rated frequency ..... 60 Hz
(d) Number of phase ..... Three phase

(e) Maximum temperature rise
at rated voltage ..... 25°C when ambient temp. is 40°C

(3) Connection

The connection of condensers shall be of star type, and neutral point shall not be grounded

(4) Construction of Unit

The internal element of the condenser shall be manufactured by winding sheets of kraft paper or mixed film paper as an insulator and the aluminium foil as an electrode.

After congregating several numbers of these elements, the condenser unit shall be thoroughly dried under high temperature and vacuum condition, and impregnated with mineral oil of high purity which has been beforehand completely degassed of harmful impurities not to leave any gas in the tank which may cause deterioration of the dielectrics.

(5) Tank

The tank shall be metal case of robust construction and shall be provided with a suitable oil volume adjusting device to meet with the expansion and contraction of the impregnating oil.

D.2.2 Series Reactors

outdoor type three phase series reactors shall be inserted to the neutral side of bank to protect the condenser from higher harmonic threats.

The reactor shall have a capacity of 6% of condenser capacity.

D.2.3 Discharge Coils

Outdoor type single phase discharge coils shall be provided to discharge residual charge of condenser.

D.2.4 Protective Devices

The following protective devices shall be supplied and mounted on the static condenser control panel specified in Clause E.6.21.(1).

(1) Over voltage (alarm).
(2) Under voltage protection.
(3) Overcurrent protection.

D.2.5 Control System

The static condenser bank shall be capable to be connected or disconnected to the 4.16 kV bus manually and remotely to improve the power factor of the system.

D.2.6 Other Materials

Necessary anchor bolts, nuts, channel steel base (if necessary), and other items shall be provided without extra cost.

D.2.7 Spare Parts

The following spare parts shall be furnished by the Contractor for the static condenser.

(1) Necessary spare parts recommended by the manufacturer.

D.2.8 Tests

The following tests shall be carried out at the Contractor's shop in compliance with this Specification:-

(1) Static condensers

(a) Construction test
(b) Capacity test
(c) Power frequency withstand voltage test
(d) Condenser loss test
(e) Impulse voltage test (Certificate of type test may be acceptable)

(2) Series reactors

(a) Construction test
(b) Insulation resistance measurement
(c) Power frequency withstand voltage test
(d) Winding resistance measurement
(e) Capacity test
(f) Loss test
(g) Impulse voltage test (Certificate of type test may be acceptable)

(3) Discharge coils

(a) Construction test
(b) Insulation resistance measurement
(c) Power frequency withstand voltage test
(d) Discharge capacity test
(e) Winding resistance measurement

SUBSECTION - E

SWITCHGEAR AND CONTROL EQUIPMENT

E.1 GENERAL

E.1.1 Scope

This Subsection covers the design, manufacture, testing before shipment, transportation to the Site, installation and erection, commissioning and performance tests at the Site of the following:

(1) 138 kV switchgear.
(2) 13.8 kV switchgear.
(3) 4.16 kV switchgear.
(4) Low tension switchgear.
(5) Control switchboards.
(6) Water level and water flow indicators.

E.1.2 General Arrangement

The schematic diagrams are shown on the Drawings for Tender, Nos. 3-I-015 and 3-I-016.

The 138 kV and 13.8 kV switchgears shall be arranged on the outdoor 138 kV switchyard and the main transformer yard. The 4.16 kV and low tension switchgears shall be of indoor cubicle type.

The control switchboards shall consist of main control awitchboards, semi-graphic supervisory control switchboard and sub-boards. The main control switchboards shall be of vertical duplex type and have mimic diagram of switchgear layout, meters, relays, indicators, operating and regulating handles and other apparatus. The semi-graphic supervisory control switchboard for pumping system shall be of vertical self-supporting cubicle type with separated desk type control switchboard and shall have mimic diagram of pumping layout, meters, indicators, operating switches and other apparatus. The sub-boards shall be of the vertical cubicle type and have no-fuse-breakers, protective relays, indicating meters, auxiliary relays etc.

The following items of equipment and instruments supplied under other Subsections are also to be installed on the main and semi-graphic supervisory control switchboards. The contractor shall properly mount each item in its designated place and shall provide all wiring thereof, including terminal blocks.

(1) For the Semi-graphic Supervisory Control Switchboards or the Main Control Switchboard

(a) Specified under Subsection-A.

(i) Six (6) indicators of guard valve opening.
(ii) Six (6) pressure gauges for pumps.
(iii) Temperature indicators for 6 units.
(iv) Oil level indicators for 6 units.

(b) Specified under Subsection-B.

(i) Oil level indicators for 6 units
(ii) Temperature indicators for 6 units
(iii) Cooling water flow switches for 6 units

(c) Specified under Subsection-C.

(i) Two (2) temperature indicators for winding of main transformers.

E.1.3 Name Plates and Escutcheon Plates

All duty plates and escutcheon plates shall be in Spanish language.

E.1.4 Electric Supply

Electric supply for controls, drives and lights shall be as follows:-

(1) 220/127-volt, 60 Hz, A.C. three-phase, four-wire system, from station service transformer through A..C. panel.

(2) 125-volt, D.C. from storage battery through DC panel.

E.1.5 Insulating Oil

Insulating oil required for the oil filled electrical equipment to be furnished under this section shall be non-sludging and of medium viscosity. Contractor shall stated the characteristics and standard of the insulating oil in this tender.

Sufficient oil for the initial filling plus ten (10) percent extra oil shall be supplied in sealed non-returnable drums.

E.1.6 Electrical and Mechanical Design

Switchgear equipment shall be designed electrically to avoid local corona formation and discharge likely to cause radio interference, and shall be designed mechanically to endure short circuit current without thermal and mechanical failure for two (2) seconds. All cubicles and enclosures shall be verminproof, dustproof and where required weatherproof. It shall in general comply with the requirements of Clause E.6.3 as applicable.

E.1.7 Instruments and Meters

All instruments and meters shall be of heavy duty switchboard type. The indicating instruments shall have scales of approximately 240 degrees except where specified otherwise.

E.1.8 Wiring

All switchboard wiring shall in general be PVC insulated unless otherwise required due to special application. It shall comply with requirements of Clauses E.6.5, E.6.7 and E.6.8 as applicable.

E.1.9 Indicating Lights

Red indicating lights shall be used for "ON" position and green lights for "OFF" position. For earthing switch for transmission line, white indicating lights shall be used to indicate that a change in switch position has been ordered and shall light up with red or green light indicating the switch position before the change. On completion of the change only red or green light will stay lit.

E.1.10 Insulation Level

The switchgears shall withstand the following voltages:-

(1)	138 kV	Impulse	1.2 x 50 micro-second, 650 kV
		Power frequency	275 kV for one minute
(2)	13.8 kV	Impulse	1.2 x 50 micro-second, 110 kV
		Power frequency	34 kV for one minute
(3)	4.16 kV	Impulse	1.2 x 50 micro-second, 60 kV
		Power frequency	19 kV for one minute

E.1.11 Tests

The tests to be carried out before shipment at the Contractor's shop are stated in the relevant clauses. The commissioning tests and performance test specified in Clause GS.11.2 in Part-I General Specifications, as applicable and as required by the Engineer shall be conducted at site.

E.2 138 kV SWITCHGEAR

E.2.1 Circuits and Equipment

The Contractor shall furnish the 138 kV switchgear equipment in accordance with the following requirement.

(1) Four (4) circuit breakers

- One for incoming circuit at Severino 138 kV switchgear yard
- Two for main transformer circuits at Severino 138 kV switchfear yard.
- One for outgoing line circuit at Daule Peripa 138 kV switchgear yard.

(2) Eight (8) 3-pole disconnecting switches

- One for incoming line circuit at Severino 138 kV switchgear yard.
- Three for outgoing line circuits at Daule Peripa 138 kV switchgear yard.
- Two for main transformer circuits at Severino 138 kV switchgear yard.
- Two for bus circuits at Daule Peripa 138 kV switchgear yard.

(3) Six (6) current transformers

- Three for incoming line circuits at Severino 138 kV switchgear yard.
- Three for outgoing line circuit at Daule Peripa 138 kV switchgear yard.

(4) Four (4) capacitance potential devices

- Two for Severino 138 kV switchgear yard.
- Two for Daule Peripa 138 kV switchgear yard.

(5) Twelve (12) lightning arresters

- Three for incoming line circuit at Severino 138 kV switchgear yard.
- Six for main transformer circuits at Severino main transformer yard.
- Three for outgoing line circuit at Daule Peripa 138 kV switchgear yard.

E.2.2 Circuit Breakers

(1) Type

Three-pole, single-throw, high speed, outdoor, SF6 gas type, trip-free in any position, 60 Hz, complete with piping, conduit, wiring, and any other accessories needed for operation.

(2) Ratings

Rated voltage	145 kV
Basic impulse level	650 kV
Rated continuous current	1,250 A
Rated breaking current	31.5 kA
Breaking time	3 cycles
Operating duty cycle	0-0.35 sec.-CO-1 min.-CO
Control circuit voltage	125 V D.C.

The circuit breaker for incoming line circuit shall be capable of making single-phase reclosing operation.

(3) Operating Mechanism

The circuit breaker shall be provided with remote electric controls and local manual controls driven by pressure oil or compressed air.

(4) Control Cabinet

Control cabinet of the circuit breaker shall be moisture-proof and provided with suitable heaters to prevent moisture condensation. The cabinet shall have a blank, accessible steel door with gasket. The lead wires and cables shall enter the cabinet from the bottom.

(5) Accessories

The following items shall be provided for each circuit breaker:-

(a) Name plate.
(b) Position indicating lamps.
(c) 10-stage auxiliary switch.
(d) Oil valve, oil pressure gauge and piping.
(e) Counter to record the frequency of operation.

(f) Necessary terminal connections with clamp type terminals.
(g) Grounding terminal(s).
(h) Supporting structure.
(i) One set of maintenance tools.
(j) Other necessary accessories.

(6) Spare Parts

The following parts shall be supplied:-

(a) One (1) set of closing coil.
(b) One (1) set of tripping coil
(c) One (1) set of gasket of each type.
(d) 300% of actual use of signal lamps and fuses.
(e) One (1) set of small components consisting of contacts, coils, relays, etc. for control gear recommended by the manufacturer.

(7) Tests

The following tests shall be carried out at the Contractor's shop.

(a) Construction test.
(b) Power frequency withstand voltage test.
(c) Operation test.
(d) Temperature rise test. (Certificate of type test may be acceptable.)
(e) Millivolt drop test. (Certificate of type test may be acceptable.)
(f) Impulse voltage test.
(g) Rupturing capacity test. (Certificate of type test may be acceptable.)

E.2.3 Three-pole Disconnecting Switches

(1) Type

Pneumatically remote operated disconnecting switches shall be of three-pole, single throw, outdoor, gang-operated, horizontal-break, rotating insulator type. Line side disconnecting switches for incoming line circuit and outgoing line shall have manually operated grounding device.

(2) Ratings:

Rated voltage	145 kV
Rated continuous current	800 A
Basic impulse level	650 kv

(3) Accessories

The following items shall be provided for each disconnecting switch:-

(a) Name plate.
(b) Pneumatic driving device.
(c) 3-stage auxiliary switch for position indication and interlock.
(d) Hand operating set.
(e) Necessary terminal connections with clamp type terminals.
(f) Grounding terminal(s).
(g) Two (2) handles for all disconnecting switches.
(h) Other necessary accessories.

(4) Spare Parts

The following items shall be supplied:-

(a) 300% of actual use of lamps.

(5) Tests:

The following tests shall be carried out at the Contractor's plant:-

(a) Construction test.
(b) Operation test.
(c) Power frequency withstand voltage test.
(d) Measurement of resistance.
(e) Temperature rise test. (Certificate of type test may be acceptable)
(f) Impulse voltage test.
(g) Short-time current test. (Certificate of type test may be acceptable)

E.2.4 Current Transformers

(1) Type

Oil immersed, outdoor double core type for measuring instruments and protective relays.

(2) Ratings

Highest system voltage	145 kV
Rated burden	40 VA
Current ratio	100/5 A x 2
Accuracy class	0.6B2 for measuring, C 200 for protection
Overcurrent strength	40 times for 1 sec.

(3) Accessories

The following items shall be provided for each current transformer:-

(a) Name plate.
(b) Oil level gauge or window.
(c) Oil valves or plugs.
(d) Necessary terminal connections with clamp type terminals.
(e) Grounding terminal.
(f) Other necessary accessories.

(4) Tests

The following tests shall be carried out at the Contractor's Plant:-

(a) Construction test.
(b) Ratio and phase error.
(c) Polarity test.
(d) Power frequency withstand voltage test.
(e) Impulse voltage test.
(f) Opening test of the secondary circuit.
(g) Over voltage inter-turn tests.
(h) Short-time current test. (Certificate of type test may be acceptable.)
(i) Temperature rise test.

E.2.5 Capacitance Potential Devices

(1) Type

Single phase, oil-immersed, outdoor type.

(2) Ratings

Primary voltage	138 kV/$\sqrt{3}$
Secondary voltage	115 V/$\sqrt{3}$
Rated burden	200 VA
Accuracy class	0.6Z class
Basic impulse level	650 kV

(3) Accessories

The following items shall be provided for each capacitance potential device:-

(a) Name plate.
(b) Oil level gauge or window.
(c) Oil valves or plugs.
(d) Necessary terminal connections.
(e) Grounding terminal.
(f) Other necessary accessories.

(4) Tests

The following tests shall be carried out at the Contractor's shop:-

(a) Construction test.
(b) Ratio and phase error test.
(c) Polarity test.
(d) Power frequency withstand voltage test.
(e) Impulse voltage test.
(f) Induced voltage withstand test. (transformer only)
(g) Temperature rise test.

E.2.6 Lightning Arresters

(1) Type

Outdoor type.

(2) Ratings

Rated voltage	120 kV
Normal discharge current	10 kA
Impulse withstand voltage	550 kV
Min. power frequency sparkover voltage	168 kV
Impulse sparkover voltage (100%)	282 kV (peak)
Maximum discharge voltage	309 kV (peak) at 10 kA

(3) Accessories:

The following accessories shall be provided for each lightning arrester:-

(a) Name plate.
(b) Operation frequency counter.
(c) Discharge current recorder.
(d) Necessary terminal connections with clamp type terminals.
(e) Other necessary accessories.

(4) Tests

The following tests shall be carried out at the Contractor's shop:-

(a) Construction test.
(b) Power frequency sparkover voltage test.
(c) Impulse sparkover voltage tests.
(d) Insulation resistance measurement.
(e) Leakage current test.

E.3 13.8 kV SWITCHGEAR

E.3.1 Circuits and Equipment

The Contractor shall furnish and install a self-supporting outdoor type metal-enclosed cubicle assembly for the local service feeder circuits to be located on the main transformer yard.

The following equipment shall be mounted inside the cubicles:-

(1) One (1) set of 3-phase bus.
(2) Two (2) circuit breakers for 13.8 kV feeders.
(3) Six (6) current transformers for 13.8 kV feeders.
(4) Two (2) zero-phase current transformers for 13.8 kV feeders.
(5) One (1) ground potential transformer.
(6) Other necessary accessories.

The following equipment to be installed on the ground shall also be provided.

(1) One (1) set of neutral grounding resistor

E.3.2 Three-phase Bus

Three-phase copper bus shall be of 600 amp. and be insulated at 13.8 kV and basic impulse level 95 kV. The bus shall withstand 25 kA current for one second under fault conditions without mechanical and thermal failure.

Oil or compound filled bus will not be acceptable. All bolted joints shall be silver plated. The bus bar supports shall be of non-hygroscopic, flame retardant, crack resistant material.

E.3.3 Circuit Breakers

(1) Type

Three-pole, single throw, draw out, vacuum or minimum oil type, trip free in any position with antipumping feature, 60-Hz, complete with conduit, wiring, and any other accessories needed for operation.

(2) Ratings

Rated voltage ..... 15 kV
Basic impulse level ..... 95 kV

Rated continuous current	600 A
Rated breaking current	25 kA
Breaking time	5 cycles
Operating duty cycle	0-1 min.-CO-3 min.-CO
Control circuit voltage	125 V D.C.

(3) Operating Mechanism

The circuit breaker shall be provided with remote electric controls and local manual controls and shall be of 125 V D.C. motor-operated spring charge type.

(4) Other Requirement

Other requirements such as accessories and tests shall be in accordance with the Clause E.2.2 as applicable.

(5) Auxiliary Switches

Breaker auxiliary switches shall have sufficient contacts for all controls and interlocks plus two sets of spare contacts, one for normally open and the other one for normally closed.

(6) Control Supply Protection

Fuses and knife switches or molded case circuit breakers shall be provided in the D.C. supply to each unit of the switchgear.

(7) Wiring

Secondary wiring in high voltage compartment shall be protected as far as practical with grounded metal covers, conduit or sheath.

(8) Spares

(a) One (1) set of moving and fixed contacts for 3-phase of each rating.
(b) One (1) set of closing coil.
(c) One (1) set of tripping coil.
(d) One (1) set of spares recommended by the manufacturer.

(9) Tests

Applicable tests listed in Clause E.2.2 (7) shall be conducted at the Contractor's shop.

E.3.4 Current Transformers

(1) Type

Dry moulded type for measuring instruments and protective relays.

(2) Ratings

Highest system voltage	15 kV
Rated burden	15 VA
Current ratio	2 x 50/5 A
Accuracy class	0.6B 0.5 for measuring
	C 100 for protection
Overcurrent strength	40 times for 1 sec.

(3) Tests

Applicable tests listed in Clause E.2.4 (4) shall be conducted at the Contractor's shop.

E.3.5 Zero-phase Current Transformers

(1) Type

Dry moulded, penetration type for cable with testing lead wire for protective relay.

(2) Ratings

Highest system voltage	15 kV
Rated burden	0.5 ohm
Rated primary current	50 A
Zero phase current ratio	200/1.5 mA
Accuracy class	C 100

(3) Test

Applicable tests similar with Clause E.3.4 (3) shall be conducted at the Contractor's shop.

E.3.6 Potential Transformer

(1) Type

Three-phase, dry moulded type.

(2) Ratings

Insulation class ..... 15 kV
Primary voltage ..... 13.8 kV
Secondary voltage ..... 115/3 V
Tertiary voltage ..... $115/\sqrt{3}$ V
Rated burden:
75 VA (for secondary winding)
25 VA (for tertiary winding)
Accuracy class:
0.6 Y class (for secondary winding)
0.6 X (for tertiary winding)

(3) Tests

Applicable test listed in Clause E.2.5 (4) shall be conducted at the manufacturer's shop.

E.3.7 Neutral Grounding Resistor

(1) Type

Cast iron, grid resistor, complete with supporting insulator bushings and other necessary accessories housed in outdoor cubicle.

(2) Ratings

Rated voltage ..... $13.8/\sqrt{3}$ kV
Rated current ..... 50 amp.
Rated resistance ..... 159 ohm
Time rating ..... 10 sec.
Maximum temperature rise ..... 760°C

(3) Accessories

The following items shall be provided for the neutral grounding resistance.

(a) Name plate.
(b) Necessary terminal connection.
(c) Grounding terminal(s).
(d) Other necessary accessories.

(4) Tests

The following test shall be carried out at the Contractor's shop:-

(a) Withstand voltage test.
(b) Measurement of resistance.

E.3.8 Cubicles and Terminations

The cubicles shall have the suitable cable terminal compartments for cross-linked polyethylene insulated, shielded, polyvinyl chloride sheathed power cable stated below:-

35 sq.mm three-core for local service transformer and 13.8 kV feeder circuits.

The following test shall be carried out on cubicle assembly at the Contractor's shops:-

(a) Inspection of construction.
(b) High voltage test.
(c) Measurement of insulation resistance.
(d) Checking of sequence and wiring.

E.4 4.16 kV SWITCHGEAR

E.4.1 Circuits and Equipment

The Contractor shall furnish and install a self-supporting indoor type metal-enclosed cubicle assembly for each motor circuit, main transformer, local service transformer, station service transformer, static condenser and bus tie circuits to be located on the floor of high tension switchgear room.

The following equipment shall be mounted inside the cubicles:-

(1) One (1) set of 3-phase buses.

(2) Ten (10) circuit breakers

- Two for main transformer circuits.
- Six for pump motor circuits.
- Two for static condenser circuits.

(3) Four (4) load break switches

- Two for local transformer circuits
- Two for station service transformer circuits

(4) Twelve (12) power fuses

- Six (6) for local transformer circuits
- Six (6) for station service transformer circuits

(5) Eighty-four (84) current transformers

Twelve for main transformer circuits.
Fifty-four for main motor circuits.
Six for static condenser circuits.
Six for local transformer circuits.
Six for station service transformer circuits.

(6) Six (6) zero-phase current transformers for main motors.

(7) Four (4) ground potential transformers.

(8) One (1) disconnecting switch for bus connection between the group of cubicle.

(9) One (1) set of 3-phase metal-enclosed buses for connection between the group of cubicle.

(10) Two (2) cubicles for station service transformers supplied under Clause C.4.

(11) Other necessary accessories.

The following equipment shall be installed on the outdoor main transformer yard:-

(1) Four (4) 3-pole, outdoor use disconnecting switches for static condenser circuits.

E.4.2 Three-phase Bus

Three-phase copper buses shall be of 2,000 amp. for main circuit, and 600 map. for main motor, local service transformer, station service transformer and static condenser circuits, and be insulated at 4.16 kV and basic impulse level 60 kV. The bus shall withstand 25 kA current for one second under fault conditions without mechanical and thermal failure. Oil or compound filled bus will not be acceptable. All bolted joints shall be silver plated. The bus bar supports shall be non-hygroscopic, flame retardant, crack resistant material.

E.4.3 Circuit Breakers

(1) Type

Three-pole, single throw, draw out, vacuum or minimum oil type, trip free in any position with antipumping feature, 60-Hz, complete with conduit, wiring, and any other accessories needed for operation.

(2) Ratings

Rated voltage	4.76 kV
Basic impulse level	60 kV
Rated continuous current	1,600 A for main transformer circuits 600 A for other circuits
Rated breaking current	25 kA
Breaking time	5 cycles
Operating duty cycle	0-1 min.-CO-3 min.-CO
Control circuit voltage	125 V D.C.

(3) Operating Mechanism

The circuit breaker shall be provided with remote electric and local manual controls and shall be of 125 V D.C. motor-operated spring charge type.

(4) Other Requirement

Other requirements such as accessories and tests shall be in accordance with the Clause E.2.2 as applicable.

(5) Auxiliary Switches

Breaker auxiliary switches shall have sufficient contacts for all controls and interlocks plus two sets of spare contacts, one normally open and one normally closed.

(6) Control Supply Protection

Fuses and knife switches or molded case circuit breakers shall be provided in the D.C. supply to each unit of the switchgear.

(7) Wiring

Secondary wiring in high voltage compartments shall be protected as far as practical with grounded metal covers, conduit or sheath.

(8) Spares

(a) One (1) set of moving and fixed contacts for 3-phases of each rating.
(b) On (1) set of closing coil.
(c) One (1) set of tripping coil.
(d) Other necessary spares recommended by the manufacturer.

(9) Tests

Applicable tests listed in Clause E.2.2 (7) shall be conducted at the Contractor's shop.

E.4.4 Load Break Switch

(1) Type

Mechanically hand operated, three-pole, single-throw, indoor, gang-operated, vertical-break type.

(2) Ratings

Rated voltage	4.76 kV
Rated current	600 A
Rated breaking current	600 A for load current 10 A for exciting current

(3) Accessory

The following items shall be provided for the load break switch.

(a) Name plate.
(b) Order lamp.

(c) 3-stage auxiliary switch.
(d) Hand operated set.
(e) Necessary terminal connection.
(f) Grounding terminal(s).
(g) One handle
(h) Other necessary accessories.

(4) Spare Parts

300% of ordering lamps.

(5) Tests

The tests shall be in accordance with the Clause E.2.4.

E.4.5 Power Fuses

(1) Type

Hook stick operated, single-pole, single-throw, indoor type.

(2) Ratings

Rated voltage	4.76 kV
Rated current	64 - 160 A
Rated interrupting capacity	200 MVA

(3) Accessory

The following item shall be provided for all power fuses:-

- One insulated hook stick.

(4) Spare parts

300% of fuse elements.

(5) Tests

The following tests shall be carried out at the Contractor's shop:-

(a) Construction test
(b) Withstand voltage test

(c) Operation test
(d) Fusing test (sample test)
(e) Insulation resistance test

E.4.6 Current Transformers

(1) Type

Dry type for measuring instruments and protective relays.

(2) Ratings

Highest system voltage ..... 4.16 kV
Rated burden ..... 45 VA
Current ratio:

- 2,000/5 A for main transformer circuits.
- 600/5 A for main motor circuits.
- 200/5 A for static condenser circuits.
- 200/5 A for local transformer circuits.
- 100/5 A for station service transformer circuits.

Accuracy class

- 0.6B 0.5 for measuring.
- C 100 for protection.

Overcurrent strength: for 1 sec.

- 40 times for main transformer circuit.
- 75 times for main motor circuits.
- 150 times for local service transformer, station service transformer and static condenser circuits.

(3) Tests

Applicable tests listed in Clause E.2.4 (4) shall be conducted at the Contractor's shop.

E.4.7 Zero-phase Current Transformers

(1) Type

Dry moulded, penetration type for cable with testing lead wire for protective relay.

(2) Ratings

Highest system voltage	4.76 kV
Rated burden	0.5 ohm
Rated primary current	400 A for main motor circuits
Zero phase current ratio	200/1.5 mA
Accuracy class	C 100

(3) Test

applicable tests similar with Clause E.4.6 (3) shall be conducted at the Contractor's shop.

E.4.8 Ground Potential transformers

(1) Type

Three phase, dry moulded type.

(2) Ratings

Insulation class	5.0 kV
Primary voltage	4.16 kV
Secondary voltage	115 V
Tertiary voltage	$115/\sqrt{3}$ V

Rated burden:

- 75 VA for secondary winding
- 25 VA for tertiary winding

Accuracy class

- 0.6 Y for secondary winding
- 0.6 X for tertiary winding

(3) Tests

Applicable test listed in Clause E.2.5 (4) shall be conducted at the Contractor's shop.

E.4.9 Three-pole Disconnecting Switches

(1) Type

(a) For static condenser circuits

The disconnecting switches shall be of 125 V D.C. motor operated, three-pole, single-throw, outdoor, gang-operated, horizontal-break, rotating insulator type, and be of electrically remote controlled motor-driven type and be locally manual operated type.

(b) For bus connection circuit

The disconnecting switch shall be of 125 V D.C. motor operated, three-pole, single throw, indoor, gang-operated type and be locally manual operated type.

(2) Ratings:

Rated voltage	4.76 kV
Rated current	600 A for static condenser circuits
	1,600 A for bus connection circuit

(3) Accessory:

The following items shall be provided for each disconnecting switch.

(a) Name plate.
(b) Motor operating device.
(c) 3-stage auxiliary switch.
(d) Hand operated set.
(e) Necessary terminal connection.
(f) Grounding terminal(s).
(g) One handle.
(h) Other necessary accessories.

(4) Tests

The tests shall be in accordance with the Clause E.2.3.

E.4.10 Cubicles and Terminations

The cubicles shall have the suitable cable terminal compartments for the cross linked polyethylene insulated, shielded, polyvinyl chloride sheathed power cables stated below:-

- 2 x 400 sq.mm single core per each phase for main transformer circuit.
- 300 sq.mm three core for pump motor circuits.
- 50 sq.mm three core for local transformer, station service transformer and static condenser circuits.

The power cables shall be furnished under Subsection-G. Suitable means shall be provided for supporting the terminals and cable. The cubicles shall be provided with access doors to facilitate inspection of the equipment. The door shall be provided with dust proof and verminproof gaskets, suitable handles, latches and flush locks, and shall be complete with necessary wiring, terminal blocks, ground bus and terminals, indicating lamps, handles and other accessories. Space heaters suitable for operation at 127 V or 220 V A.C. shall be provided inside the cubicles to minimize moisture condensation. A manual switch to control the heaters shall be provided on the cubicle.

The test specified in Clause E.3.8 shall be conducted at the Contractor's shop.

E.4.11 Three-phase Metal-enclosed Buses

(1) Type

Metal-enclosed, segregated 3-phase, copper bus, indoor type, complete with necessary accessories.

(2) Ratings

Rated voltage	4.76 kV
Basic impulse level	60 kV
Rated current	2,000 A
Short circuit withstand current	25 kA for 1 sec.

(3) Test

The following test shall be carried out at the Contractor's shop:-

(a) Withstand voltage test.

E.5 LOW TENSION SWITCHGEAR

E.5.1 Circuits and Equipment

The Contractor shall furnish a self-supporting type metal-enclosed cubicle assembly for low tension switchgear for 300 kVA station service transformer secondary circuits.

The cubicle shall be installed in the low tension switchgear room.

The following equipment shall be mounted in the cubicles:-

(1) One (1) set of 3-phase 4-wire bus.
(2) Seven (7) air circuit breakers.
(3) Two (2) mould case circuit breakers
(4) Nine (9) current transformers.
(5) Two (2) potential transformers.

E.5.2 Three-phase Bus

Three-phase, four copper bus shall be of 1,000 amp. and be insulated at 600 V. The bus shall withstand 25 kA current for one second under fault conditions without mechanical and thermal failure.

The neutral bus shall be grounded inside the cubicle in one point.

Oil or compound filled bus will not be acceptable. All bolted joints shall be silver plated. The bus supports shall be of non-hygroscopic, flame retardant, crack resistant material.

E.5.3 Air Circuit Breakers

(1) Type

Three-pole, single throw, draw-out type, trip-free in any position, with antipumping feature, 60 Hz complete with controls and wirings and other accessories needed for operation.

(2) Ratings

Rated voltage ..... 600 V

Rated continuous current:

1,000 A for station service transformer circuit.

630 A for diesel generator and bus section circuits.

Rated breaking current ..... 25 kA
Control circuit voltage ..... 125 V D.C.

(3) Operating Mechanism

The circuit breakers shall be controlled locally by manual control. The circuit breaker shall open automatically in cases of overcurrent and undervoltage.

(4) Tests

Applicable tests listed in Clause E.2.2 (7) shall be conducted at the Contractor's shop.

E.5.4 Mould Case Circuit Breaker

The moulded case circuit breaker shall be of three -pole, 600 volts. The rated frame current shall be 225 AF. The rated breaking current shall be 25 KA.

E.5.5 Current Transformers

(1) Type

Dry moulded type for measuring instruments.

(2) Ratings

Highest system voltage ..... 220 V
Rated burden ..... 22.5 VA
Current ratio ..... 1,000/5 A
Accuracy class 0.6B 0.9
Overcurrent strength ..... 40 times for 1 sec.

(3) Tests

Applicable tests listed in Clause E.2.4 (4) shall be conducted at the Contractor's shop.

E.5.6 Potential Transformers

(1) Type

Single-phase, dry molded type.

(2) Ratings

Primary voltage	220 V
Secondary voltage	120 V
Rated burden	25 VA
Accuracy class	0.6 X

(3) Tests

Applicable tests listed in Clause E.2.5 (4) shall be conducted at the Contractor's shop.

E.5.7 Cubicles and Terminations

The following apparatuses shall be mounted on the front side of the low tension switchgear cubicles:-

- One (1) voltmeter with selector switch.
- Two (2) ammeter with selector switch

The cubicles shall have the suitable cable terminal compartments for cross-linked polyethylene insulated polyvinyl chloride sheathed power cables stated below:-

- 600 sq.mm three-core and 100 sq.mm one-core for station service transformer circuits.

- 300 sq.mm three-core and 100 sq.mm-one core for diesel generator and other circuit except that D.C. circuit is only 300 sq.mm 3-core

The power cables shall be furnished under Subsection-G. Suitable means shall be provided for supporting the terminal and cable. Other requirements shall be in accordance with the Clause E.3.8. The secondary circuits of instrument transformers shall be brought out to the terminal blocks for the connection of control cables to the measuring instruments on the main control switchboards.

The test specified in Clause E.3.8 shall be conducted at the Contractor's shop.

E.5.8 Spare Parts

(1) One (1) set of fixed and moving contacts of circuit breakers of each rating.
(2) One (1) set of closing coil of circuit breaker.
(3) One (1) set of tripping coil of circuit breaker.
(4) One (1) set of gaskets of circuit breaker.
(5) 300% of indicating lamps.
(6) 200% of control and other fuses.
(7) One (1) set of other spares recommended by the manufacturer.

E.6 CONTROL SWITCHBOARDS

E.6.1 General

The major items of control switchboards and appurtenant equipment to be supplied are as follows:-

For Severino Pumping Station

(1) Seven (7) panel of main control switchboards, duplex type.
(2) One (1) set of semi-graphic supervisory control switchboard.
(3) Three (3) panel of sub-control switchboards.
(4) One (1) panel of battery charger panel.
(5) One (1) panel of repair shop panel.

For Daule Peripa Power Station

(6) One (1) panel of main control switchboard, duplex.

For Both Station

(7) One (1) lot of accessories and spare parts for switchboards.

The control switchboards shall be furnished complete with instruments, meters, control switches, annunciators, protection relays, test blocks, terminal blocks, wiring and other miscellaneous devices as indicated in the specification or on the drawings. The switchboards shall include all required auxiliary and accessory devices, such as auxiliary current and potential transformers, protective devices, fuses, and resistors, whether or not expressly specified or indicated on the

drawings. All instrument scales, coils, relay, contacts and similar features shall be suitable for the apparatus controlled or the purpose intended.

Equipment details are given under Clause E.6.21.

E.6.2 Control, Metering and Relaying Requirement

(1) Control

Operation of the pump and motor units shall be remote manual from the control room with provision for manual control for adjustment purpose or use in an emergency. Starting and stopping shall include liquid resistors, guard valves and other auxiliary equipment and devices. Interlocks as required shall be provided to prevent maloperation in starting.

(2) Metering

Instruments shall be provided on each control switchboard to indicate the following.

138 kV transmission line:

(a) Line current.
(b) kW power received.
(c) 138 kV line voltage.
(d) System frequency.
(e) kWh energy.
(f) kVar meter
(g) Power factor meter.

4.16 kV circuits:

(a) Main transformer current.
(b) Main transformer kW output.
(c) Power factor.
(d) 4.16 kV bus voltage.
(e) 4.16 kV bus ground voltage.
(f) Static condenser line current.
(g) Pump motor line current.
(h) Pump motor kW input.
(i) Main motor kWh energy.
(j) Local transformer line current.
(k) Station service transformer line current.

13.8 kV circuits:

(a) 13.8 kV bus voltage.
(b) 13.8 kV ground voltage.
(c) 13.8 kV feeder current.
(d) 13.8 kV feeder kW output.
(e) 13.8 kV feeder kWh energy.

Low tension circuit:

(a) Station service transformer current.
(b) 220/127 V bus voltage.

(3) Relaying

Relaying panels shall be provided for each machine and equipment incorporating the following protective and alarm features, but the Contractor shall ensure that the protective and alarm schemes are in every way suitable for machines and method of starting.

Protection for pump-motor units:

Emergency stop by manual control switch energizing an independent trip relay to shutdown in case of the normal trip relay failure shall be line breaker tripped and guard valve closed.
simultaneously.

(i) Differential protection on the motor.
(ii) Overcurrent protection on the motor.
(iii) Ground fault protection on the motor.
(iv) Bearing temperature, extremely high (2nd stage).
(v) Other necessary protection.

Protection for main transformer:

(i) Differential protection on the main transformer.
(ii) Overcurrent protection on the main transformer.
(iii) Buchholtz relay operating (2nd stage).
(iv) Other necessary protection.

Protection for local transformer:

(i) Overcurrent protection on the local transformer.

(ii) Buchholtz relay operating (2nd stage).

Protection for static condenser:

(i) Overcurrent protection on the static condenser.
(ii) Mechanical fault detector.

Protection for 4.16 kV circuit:

(i) Undervoltage protection.
(ii) Overvoltage protection.
(iii) Ground protection on 4.16 kV bus section.

Protection for 138 kV transmission line:

(i) Distance protection both phase and earth faults
(ii) Overcurrent protection.
(iii) Under voltage protection

Protection for 13.8 kV circuits:

(i) Overcurrent protection on the 13.8 kV feeders.
(ii) Ground fault protection on the 13.8 kV circuit.
(iii) Directional ground fault protection on the 13.8 kV feeders.
(iv) Undervoltage protection on the 13.8 kV feeders.

Protection for station services:

(i) Undervoltage protection on 220/127 V bus.

Alarm for pump motor units:

(i) Bearing temperature high (1st stage).
(ii) Cooling air temperature high.
(iii) Cooling water flow stopped for motor air cooler, motor bearing, pump bearing.
(iv) Pump and motor bearing oil level low.
(v) Other necessary alarms.

Alarm for main transformers:

(i) Oil temperature high.

(ii) Oil level low.
(iii) Buchholtz relay operating (1st stage).
(iv) Winding temperature high.
(v) Gas press low for circuit breakers.
(vi) Unhealth of disconnecting switches..
(vii) Other necessary alarm.

Alarm for 138 kV transmission line:

(i) Gas pressure low for circuit breaker.
(ii) Unhealthy of disconnecting switches.
(iii) Other necessary alarm.

Alarm for local and station service transformers:

(i) Oil temperature high for local transformers.
(ii) Buchholtz relay operating for local transformers (1st stage).
(iii) Other necessary alarm.

Alarm for station services:

(i) Ground fault on 125 volt, D.C. bus.
(ii) Water level high, in the drainage sump pits.
(iii) Other necessary alarm.

E.6,3 Switchboard Construction

Each switchboards shall be verminproof, dustproof and completely enclosed, by smooth sheet steel panels not less than 2.6 mm thick, with angle or channel edges bent to 7.0 mm radius, seamwelded at corners, and ground smooth. Panels shall be bolted at the bottom to suitable steel channel sills which with necessary framing will hold the structure rigidly together to form a self-supporting dead-front type of structure. Outside panels shall not be drilled or welded for attaching wires, resistors, or switchboard devices. Vertical edges of panels shall be so formed and bolted together that no gaps exposed to view will pass a 0.8 mm filler gauge.

The main control switchboard shall be of vertical duplex type with access door at both ends.

The semi-graphic supervisory control switchboard shall be of vertical type with access door at rear side and with separated control desk board.

The sub-board shall be of vertical type with access doors at rear side.

The repair shop panel shall be wall mounted with front door.

E.6.4 Arrangement

The indicating, integrating instruments, control switches, mimic diagram of bus bars, motors, transformers, switchgears, etc. with indicators showing the position of circuit breaker and disconnecting switches shall be mounted on the front panels and protective relays on the rear panels as shown on the Drawings for Tender, No. 3-I-011. The arrangement of equipment and apparatus shall be submitted for approval.

E.6.5 Wiring and Terminal Marking

All switchboard wiring shall be done with PVC insulated wire more than 2.0 sq.mm in sectional area. A suitable wiring duct system shall be installed for all interpanel and front-to-rear panel wiring which will provide easy access for inspection and replacement. As far as possible all wiring shall be installed in wiring channels and ducts. All wiring from hinged door panels to the fixed panels shall be done with flexible conductor of equivalent size.

Wiring between terminals of the various devices shall be point to point. Splices or tee connection will not be acceptable. Wire runs shall be neatly trunked or clamped.

Exposed wiring shall be kept to a minimum but where used shall be formed into compact groups suitably bond together and properly supported. Instrument transformer secondary circuits shall be grounded only at the first switchboard entered, and not be grounded at any point outside the switchboards.

Fuse blocks shall be provided in the first switchboard entered for all potential transformer secondary circuits. Terminal blocks shall be mounted inside each switchboard to terminate all cables to the switchboard and to provide at least 10 percent spare terminals. Cable supports and clamp type terminal lugs shall be provided for all incoming power wiring terminating at each switchboard. All switchboard wire shall be marked near each terminal end with circuit or wire designation. These markers shall be of an approved type and permanently attached to the conductor insulation. All wiring shall also be coloured as specified in Clause E.6.7 and E.6.8 and any deviation from this standard shall be made on prior approval of the Engineers.

E.6.6 Phase Arrangement

The standard phase arrangement when facing the front of the switchboard shall be A-B-C from left to right, from top to bottom, and front to back. All relays, instruments, other devices, buses and equipment involving three-phase circuit shall be arranged and connected in accordance with the standard phase arrangement where possible.

E.6.7 Wiring Colour Code

The switchboard wire shall be coloured yellow, except the wire for grounding circuit shall be green.

E.6.8 Phase and Polarity Colour Codes

The colour codes for phase and polarity shall be as follows:-

Phase and Polarity		Colour
A.C. three-phase,	first phase	Red
	second phase	White
	third phase	Blue
A.C. single-phase,	first line	Red
	second line	Blue
Neutral, grounded		Black
D.C.,	positive	Red
	negative	Blue

E.6.9 Lighting

One 20-watt fluorescent lamp fixture with door switch shall be provided inside each panel section of control switchboard. One duplex 120-volt convenience outlet shall be provided for each switchboard at convenient location.

E.6.10 Painting

All outside panel surfaces shall be primed, filed where necessary, and given not less than two coats of synthetic undercoat. The finishing coat shall be a semigloss paint. The colour for the outside finish shall be Munsell Notation 5Y7/1. The inside surface of the switchboards shall have two prime coats and one finish coat of light cream colour.

E.6.11 Meters and Instruments

All indicating instruments shall be of the flush-mounted back-connected, dustproof and heavy duty switchboard type. Each indicating meter and instrument shall have a removable cover, either transparent or with a transparent window. Each meter and instrument shall be

suitable for operation with the instrument transformers shown on the drawings under both normal and short circuit conditions.

Scale plates shall have a permanent white circular or rectangular finish with black pointer and markings. The scale ranges shall be determined from the current transformer and potential transformer ratios.

Each wattmeter, and, watthour meter shall be of 2-element, 3-phase, 3-wire type except wattmeter and watthour meter on the station service transformer circuit which shall be of 3-element, 3-phase, 4-wire type.

All indicating instruments shall be approximately 110 mm with a scale are of approximately 240 degrees. The maximum error shall be not more than one and a half (1.5) percent of full scale range.

Shunts for use with D.C. ammeter with calibrated shunt leads of required length shall be provided by the contractor.

Temperature indicator shall be supplied to indicate temperatures measured by 100 ohm at 0°C copper resistance temperature detectors furnished with transformers.

Temperature indicator selector switch for each pump-motor unit to be equipped on the semi-graphic supervisory control switchboard shall be provided with points to indicate the temperature of the following temperature detectors:-

Point No.	Location
1.	Thrust bearing
2.	Motor bearing oil
3.	Motor lower guide bearing metal
4.	Pump guide bearing metal
5.	Pump guide bearing oil
6. - 11.	Motor stator winding
12.	Cooling air inlet
13.	Cooling air outlet
14., 15.	Spare
16.	Test

E.6.12 Protective Relays

Each protective relay shall be of the flush-mounted, back-connected, dustproof, switchboard type, with rectangular case. Each relay shall have a removable transparent cover or a cover with a transparent window, with provision for sealing. Each relay shall be, to the maximum possible degree, of a drawout type from the front of the panel with sliding contacts, without opening the current transformer secondary circuits, disturbing external circuits, or requiring

disconnection of leads on the rear of the panels. Each relay shall be equipped with an operation indicator and contacts for operation on 125 volt D.C. for each phase, with an external, front operated resetting device. Each relay shall be suitable for operation with instrument transformer ratios and connections shown on single line diagrams under both normal and short circuit conditions. Each overcurrent and differential relay shall be suitable for continuous operation at current coil tap rating with 60 Hz alternating current.

(1) Motor Differential Relays

Motor differential relays for short circuit protection shall be single-phase high-speed variable percentage differential type.

(2) Transformer Differential Relays

Transformer differential relays shall be single phase high speed variable percentage differential type. The relays shall be suitable for protection of 3-phase 2-winding transformer and shall provide positive protection against tripping on magnetizing in-rush current.

(3) Overcurrent Relays

Induction overcurrent relays shall have minimum inverse or definite minimum time delay characteristics. Phase relay shall have pick-up current adjustable from 4.0 to 12-amp.

(4) Directional Ground Relay

Motor directional ground relays shall be of induction type and shall have a suitable pick-up current taps or fixed pick-up current tap with external resister having suitable resistance taps.

(5) Overvoltage Relay

4.16 kV bus A.C. overvoltage relay shall be three-phase induction type 110-140 volt range.

(6) Overvoltage Ground Relays

Each overvoltage ground relay shall be of induction type and shall have a suitable variable range of pick-up voltage.

(7) Undervoltage Relay

4.16 kV bus and station service A.C. undervoltage relays shall be of three phase induction type 60-90 volt range.

(8) Transmission Line Protection Relays

Each relay shall be of the mho or compensator impedance, single-zone 0.25-2.5 ohms,high speed, directional distance type. Each relay shall have a continuous rating of 5 amp. 125 volt, 50 Hz alternating current. Each set of relays shall provide short circuit and ground protection faults with directional control on the 138 kV transmission line. Auxiliary current and potential transformers shall be furnished if necessary.

(9) Lockout Relays

Lockout relays shall be electrical trip manual reset type.

(10) Auxiliary Relays

The necessary auxiliary relays required to permit proper operation of the relays listed above and equipment controls and supervision shall be provided, mounted and wired in the switchboards.

E.6.13 Annunciator System

The group annunciator system shall provide automatic visual and audible alarms to indicate abnormal conditions in the pump station and switchyard. The system shall consist of visual annunciators and audible alarm mounted on the semi-graphic supervisory control switchboard and each main control switchboard in the control room. Each annunciator shall have white nameplate showing device number of the corresponding relay with black letter. Resetting of the annunciators after operation shall be conducted manually by the push button provided on the front. All annunciator equipment shall be suitable for operation on 125-volt D.C. and shall operate satisfactorily within a range of 95-135 volts D.C.

At least 25% spare annunciators shall be provided for addition at site. In addition to the above spares, one annunciator shall be allocated for drainage sump high level alarm.

E.6.14 Group Sequence Indicator

The group sequence indicator shall be of lamp type mounted on the desk type control switchboard. The indicator shall have a lamp inside a window which lights up to give indication by the letters on the window. The wordings indicate the operation sequence.

E.6.15 Indicating Lamp Assembles

Indicating lamp assemblies for the main control boards shall be of the switchboard type, insulated for 125-volt D.C. service, with appropriate coloured caps and integrally mounted resistor for 125-volt service. Lamps shall be made of material which will not be softened by the heat from the lamps.

E.6.16 Terminal Blocks

Terminal blocks for switchboard control wiring shall be moulded type with barriers, rated not less than 600-volt with covers. White or other light-coloured marking strips, fastened by screws to the moulded sections at each block, shall be provided for circuit designation.

E.6.17 Control and Instrument Switches

All control and instrument switches shall be of the rotary switchboard type with handle or push button type on the front and the operating contact mechanisms on the rear of the panel. All contacts shall be enclosed in a cover or covers which can be easily removed when installed on the switchboards to afford complete accessibility to contacts and terminals. Each contact shall be readily renewable, and shall have adequate insulation and contact surface.

Each control and instrument switch shall be provided with an escutcheon clearly marked to show each operating position. The switch identifications shall be engraved on the escutcheon plates or on separate name plates. The escutcheon and name plate markings shall be subject to approval.

Control switches for circuit breakers and disconnecting switches shall be provided with the required number of positions and shall be momentary contact type, with spring return to normal position.

The control switches shall have pistol grip handles, mechanical operation indicator to show the last manual operation of switches.

Ordering switch for manual-operated disconnecting switch shall be two position maintained contact type and shall have a flat knob of the same width as mimic bus to show an ordered position of switch.

Instrument and meter selective switches shall be maintained contact type with the required number of positions, and shall have round notched handles.

Emergency shut down switch shall be momentary contact type with spring return to normal position, and shall have red oval handle to be pulled out before they can be turned to operate the switches.

E.6.18 Mimic Buses and Equipment Symbols

Mimic buses and equipment symbols shall be provided on the switchboard to form single line diagrams which will simulate actual electrical connections. Mimic disconnecting switch symbols specified shall be operable. The mimic buses and symbols shall be made of anodized aluminum or other approved material finished in colour. The buses shall be at least

10 mm wide and mounting bolts shall be concealed. Colours of the mimic bus shall be as follows:-

138 kV	Silver
13.8 kV	Brass
4.16 kV	Copper
220/127 V	Dark green

E.6.19 Name Plate

Each board, each panel, each switchboard, device and each power and control circuit shall be provided with an engraved name plate or with other suitable means of identification approved by the Engineer. The name plates shall be made of laminated sheet plastic or of anodized aluminum approximately 2 mm thick engraved to black letters on a white background. The language of all boards, buttons panels etc. shall be Spanish.

E.6.20 Test Blocks

Test blocks shall be provided on the switchboard as required. The test block shall be of the back-connected semi-flush mounted, switchboard type with removable covers. All test blocks shall be provided with suitable circuit identification and shall be arranged to isolate completely the instrument from the instrument transformers and other external circuits so that no other device will be affected, and means shall be provided for testing either from an external source of energy or from the instrument transformers by means of multiple test plugs. The test blocks and plugs shall be arranged so that the current transformer secondary circuits cannot be open-circuited in any position while the test plugs or cover plugs are in place, being inserted, or being removed. Three test plugs for each type of block furnished shall be supplied with the switchboards.

E.6.21 Equipment Details

(1) Main Control Switchboards

The panel-mounted equipment and devices shall include but not be limited to the following:-

(a) Motors panels A and B (for each panel)

Front Side

One - Fault annunciator group.
Three - A.C. ammeters 0-400 amp.
Three - Wattmeters 0-3 MW.

Three - Watthour meters.
Three - A.C. ammeter selector switches.
One - Mimic bus.
Three - Control switch with green and red indication for circuit breaker
One - Reset switch for annunciator
One - Power source switch for A.C.
One - Power source switch for D.C.
One - Set of test terminal

Back Side

Nine - Motor differential relays.
Nine - Overcurrent relays for motor circuits.
Three - Directional ground relays for motor circuits.
One - Complete set of auxiliary relays and lockout relays as required.
One - Set of test terminal

(b) Transmission line panel for Severino Pumping Station

Front Side

One - Fault annunciator group.
One - A.C. voltmeter 0-200 kV.
One - A.C. ammeter 0-100 A.
One - Frequency meter 54-60-66 Hz
One - Power factor meter
One - Wattmeter 0-20 MW.
One - Var meter
One - Watthour meter.
One - A.C. voltmeter selector switch.
One - A.C. ammeter selector switch
One - Mimic bus
One - Orderingl switches with green and red lamps for 138 kV disconnecting switches.
One - Ordering switches with green, red and white lamps for 138 kV earthing switches
One - Control switch with green and red indicating lamp for 138 kV circuit breaker
One - Ordering switch with green and red indicating lamps for 4.16 kV bus connection disconnection switch.
One - Reset switch for annunciator

One - Audible alarm stop switch
One - Lamp test switch for annunciator
One - Power source switch for A.C.
One - Power source switch for D.C.
One - Set of test terminal

Back Side

One - Distance relay
One - Distance ground relay
Two - Overcurrent relay
One - Under voltage relay
One - Complete set of auxiliary relays and lock-out relays as required.
One - Set of test terminal.

(c) Main transformer and static condenser circuit panels A and B (for each panel)

Front Side

One - Fault annunciator group.
One - A.C. voltmeter 0-6 kV for 4.16 kV bus.
One - A.C. ground voltmeter 0-6 kV for 4.16 kV bus.
One - Power factor meter
One - A.C. ammeter 0-1,500 amp. for main transformer.
One - Wattmeter for main transformer
One - A.C. ammeter 0-200 amp. for static condenser.
One - A.C. voltmeter selector switch
Two - A.C. ammeter selector switch
One - Main transformer winding temperature supplied in Subsection 6C.
One - Mimic bus
Two - Control switches with green and red indicating lamps for 4.76 kV circuit breakers on main transformer and static condenser circuits.
One - Control switch with green and red indicating lamps for 138 kV circuit breaker on main transformer 1ry circuit.
One - Ordering switch with green and red indicating lamps for 138 kV disconnecting switch.
Two - Control switches with green and red lamps for 4.76 kV disconnecting switches on static condenser circuits.
One - Reset switch for annunciator
One - Power source switch for A.C.
One - Power source switch for D.C.

One - Set of test terminal
Back Side
Three - Transformer differential relays.
Five - Overcurrent relays for transformer and condenser circuits.
One - Overvoltage relay for 4.16 kV circuit.
One - Undervoltage relay for 4.16 kV circuit.
One - Overvoltage ground relay for 4.16 kV circuit.
One - Complete set of auxiliary relays and lockout relays as required.
One - Set of test blocks.

(d) Local transformer, and station service transformer circuit panel (for two panels)

Two - Fault annunciator group. (for annunciation items on 13.8 KV local line, 220/127 V station service, battery, battery charge and emergency diesel generator circuit, shall be included on this group.)
Four - A.C. ammeter, 0-200 A for 1ry circuits of local transformer.
Four - A.C. ammeters, 0-50 A for 1ry circuits of station service transformer.
Four - A.C.ammeter selector switch
Two - Mimic bus
Two - Control switch with green and red indicating lamps for 4.76 kV load break switch on local transformer 1ry circuits.
Two - Control switches with green and red indicating lamps for 4.16 kV load break switcg on station service transformer 1ry circuits.
Two - Reset switch for annunciator
Two - Power source switch for A.C.
Two - Power source switch for D.C.
Two - Sets of test terminal
Back Side
Eight - Overcurrent relays.
Two - Complete set of auxiliary relays and lock-out relays as required.
Two - Reset switch for lock-out relay
Two - Set of test blocks.

(e) Transmission line panel for Daule Peripa Power Station

Front Side
One - Fault annunciator group.

One - A.C. voltmeter 0-200 kV.
One - A.C. ammeter 0-100 A.
One - Frequency meter 54-60-66 Hz
One - Power factor meter
One - Wattmeter 0-20 MW.
One - Var meter
One - Watthour meter.
One - A.C. voltmeter selector switch.
One - A.C. ammeter selector switch
One - Mimic bus
Five - Orderingl switches with green and red lamps for 138 kV disconnecting switches.
One - Ordering switches with green, red and white lamps for 138 kV earthing switches
One - Control switch with green and red indicating lamp for 138 kV circuit breaker
One - Reset switch for annunciator
One - Audible alarm stop switch
One - Lamp test switch for annunciator
One - Power source switch for A.C.
One - Power source switch for D.C.
One - Set of test terminal
Back Side
One - Distance relay
One - Distance ground relay
Two - Overcurrent relay
One - Under voltage relay
One - Complete set of auxiliary relays and lock-out relays as required.
One - Set of test terminal.

(2) Semi-graphic Supervisory Control Switchboard

The panel-mounted equipment and devices shall include but not be limited to the following:-

One - Complete set of graphic pumping system including suction pondage, pumping equipment, penstock lines and head tank.
Six - Sequence lamp indicators for pump units.

One - Complete set of fault lamp indicator.
Six - Temperature indicators for pumps and motors as specified on Clause E.6.11.
Six - Guard valve opening indicators supplied in Subsection 6A.
Three - Water level indicators for suction pondage and two head tank.
Two - Water flow indicators for discharge pipe lines.
Two - Digital integrating water flow meters for discharge pipelines.
Six - Master control switches for start-stop of pump units.
Six - Control switches for manual shutdown for emergency case.
Six - Selector switches for temperature indicators.
Two - Control power source switches for A.C. and D.C.
One - audible alarm stop switch.
One - Complete set of auxiliary relays and lockout relays as required.
One - Set of test terminal.

(3) Sub-Control Switchboards

The sub-control switchboards shall be provided to feed AC 220-127 V three phase, four wire and DC 125 V power to pumping station common use facilities, and is installed in the low tension switchgear room (EL.60.0 m).

The panel mounted equipment and devices shall include but not be limited to the followings:

(a) A.C. panels - 1 and panel - 2 (for each panel)

One - A.C. ammeter, 0-300 A.
Twelve - No fuse-breakers.for AC - 1.
Sixteen - No-fuse breakers for AC - 2.
One - A.C. ammeter selector switch.
One - Set of terminal block.

Note: No-fuse circuit breakers shall be three-pole, 127 volts. The rated frame currents shall be referred to single line diagram of station service.

(b) D.C. panels

Sixten - No-fuse-breakers.
Two - Magnetic contactor for D.C. emergency lighting circuits.

One - Terminal block..

Note: The rated frame current for no-fuse circuit breakers shall be referred to r single line diagram.of station service.

(4) Battery Charger Panel

One metal enclosed battery charger, having doors in front to facilitate inspection, shall be supplied. The rectifier element for the battery charger shall be of silicon. (Selenium and mercury type not acceptable.) Fuse protection shall be provided for individual rectifier diodes.

The battery charger shall be capable of initial charging, floating operation and equalizing charging for 200 AH storage battery supplied under Subsection 6F.5. The battery charger shall be equipped with an automatic voltage regulator to maintain D.C. output voltage within ±2% under operating condition.

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

A.C. input voltage	220 volt, 3-phase
Rated D.C. output voltage	125 volt
Rated D.C. output current	200 amp.
D.C. voltage regulating range	102 - 159 volt

Following instruments shall be mounted on the panel.

One - A.C. ammeter, 0-100 A.
One - D.C. ammeter, 200-0-100 A.
One - D.C. voltmeter, 0-200 V.
One - Change over switch for D.C. voltmeter.
Five - Magnet circuit breaker..
One - D.C. undervoltage relay.
One - D.C. ground detecting relay.
Two - Lamp indicators with contactor for ground polarity indication.

The Contractor shall supply all other necessary accessories for the battery charger.

(5) Repair shop Panel

One - Set of 220/127 volt, 3-phase, 4-wire bus.
One - No-fuse-breaker, 3-pole, 150 AF, 150 AT.
Ten - No-fuse-breakers, 3-pole 100 AF, 100 AT.

Two - No-fuse-breakers, 2-pole, 100 AF, 50 AT.

The repair shop panel shall be mounted on the wall in the repair shop room (EL.55.0 m).

E.6.22 Spare Parts for Control Switchboards

The following items shall be supplied as spare parts:-

300%	- Switchboard indicating lamps of each type.
10 pcs	- Colour caps of each colour for indicating lamps.
200%	- Fuses of each type and rating used.
1 set	- No-fuse-breakers of each rating.
20 pcs	- Resistors for indicating lamps.
1 lot	- Complete assembly of each type of switches, timers, rheostats, rectifiers and other special devices.
1 lot	- Other necessary spares recommended by the manufacturer for protection relays and other devices if not covered above.

E.6.23 Test

The following test shall be carried out at the Contractor's shop.

(1) Inspection of construction.
(2) High voltage test.
(3) Measurement of insulation resistance.
(4) Calibration test for meters.
(5) Characteristic test for relay.
(6) Checking of sequence and wiring.
(7) Temperature rise test of charger (Certificate of type test may be acceptable)
(8) Floating charge function test
(9) Automatic equalizing test
(10) Efficiency test (Certificate of type test may be acceptable)

E.7 WATER LEVEL AND FLOW INDICATORS

E.7.1 General

To indicate the water levels, the water flow and the digital integrating water flow at the semi-graphic supervisory control switchboard in the control room, selsyn type water level transmitting equipment with floats and indicators and ultrasonic water flow measuring equipment complete with detector, flow meter, digital integrating flow meter and necessary accessories shall be supplied. The control cables for the water level equipment shall be supplied under Subsection G, but the coaxial cables for the water flow measuring equipment shall be supplied under this Subsection.

E.7.2 Water Level Indicator for Suction Pondage

The water level indicator for the suction pondage shall be in accordance with the following requirement.

(1) Transmitting distance ..... 50 meters approximately
(2) Water level fluctuation ..... from El. 47.000 to El. 69.000

The water level transmitting equipment shall provide a contact for pump stop to be closed at the water level of El. 46.500.

E.7.3 Water Level Indicator for Head Tank

Two (2) water level indicators for head tanks shall be in accordance with the following requirement.

(1) Transmitting distance .....220 meters approximately
(2) Water level fluctuation .....from El. 113.300 to El. 114.060

The water level transmitting equipment shall provide the contacts for alarm to be closed at H.W.L 114.060.

E.7.4 Water Level Switches for One-way Surge Tanks

Two (2) water level switches, electrode type, for W.L 101.0 m in two one-way surge tanks shall be provided with two alarm contacts for leakage and overflow of the surge tank.

The water level switch shall be in aaaordance with the following requirement.

(1) Transmitting distance ..... 140 meters approximately
(2) Water level for alarm ..... EL. 100.000 for leakage
EL. 101.200 for overflow

E.7.5 Water Flow Indicators and Integrator for Discharge Pipe Line

Two (2) sets of the water flow measuring equipment provided on the discharge penstocks line shall be in accordance with the following requirement.

(1)	Type:	Ultrasonic type complete with detector, flow meter, digital integrating flow meter and necessary accessories including co-axial cables.
(2)	Transmitting distance:	150 meters approximately.
(3)	Measuring range of water flow:	0 m^3/s - 11 m^3/s.
(4)	Measuring error:	Less than 2.0% at full scale.
(5)	Discharge penstock:	2.0 m in diameter.

E.7.6 Spare Parts

The following item shall be supplied as spare parts:-

(1) One (1) set of spares recommended by the manufacturer.

E.8 ERECTION

The framework for the equipment except steel supporting structure for 138 kV circuit breaker shall be provided under Subsection G.

The channel bases for cubicles and control swichboards shall also be supplied under this Contract.

The erection work shall be done by the Contractor in accordance with the finally approved drawings and instruction manual for erection.

SUBSECTION - F

ANCILLARY EQUIPMENT

F.1 GENERAL

This Subsection covers the design, manufacture, testing before shipment, transportation to the Site, installation and erection, commissioning and performance tests at the Site of the following:

(1) Two (2) overhead travelling cranes.
(2) Two (2) drainage pumping systems.
(3) One lot of machines and tools for repair shop and others.
(4) One (1) set of storage battery.
(5) One (1) oil handling and purifying equipment.
(6) One (1) diesel engine generator set.

The details of the equipment, not specified herein, will be left to the Contractor, but subject to the approval of the Engineer.

F. 2 OVERHEAD TRAVELLING CRANES

F.2.1 Description

Two (2) sets of the low speed overhead travelling crane shall be provided in the pumping station as shown on the Drawings for Tender, Nos. 3-1-005 and 3-1-006. One shall be installed at the platform to use mainly for unloading and loading of the pumping equipment. The other shall be installed at the erection and machine bays to use mainly for installing and maintaining of the pumping equipment.

Each crane shall be of electrically operated and cab controlled type and be complete with main traverse girders, cab, main and auxiliary hoists, shaftings, gearings, complete electrical equipment including motors, limit switches, current collector, trolley electrification, brakes, hoisting ropes, blocks and hooks, crane rails and their fittings, stoppers, ladders, platforms, guard and handrails and necessary components for proper and efficient operation of the crane.

F.2.2 Design Conditions

Each crane shall be designed in accordance with the following conditions.

(1) Hoisting capacity

Main hoist	:	32 tons
Auxiliary hoist	:	8 tons

(2) Speed

Lifting speed of main hoist	:	1.6 m/min.
Lifting speed of auxiliary hoist	:	10 m/min.
Traverse speed of trolley	:	10 m/min.
Travel speed of crane girder	:	20 m/min.

(3) Span (Centre to centre of crane rails) : 10.500 m for platform OHTC
10.000 m for machine OHTC

(4) Lifting Height : 22.0 m for platform OHTC
20.0 m for machine bay OHTC

(5) Power Source : AC 220/127 V, 3 phase,4 wire 60 Hz

(6) Design General

The design shall be such that all movements take place smoothly and positively. No slipping or creeping of the load shall occur at any time. The crane shall be designed for continuously repeated cycles upto one hour total duration and shall be capable of travelling with the full load suspended in any position of the pumping equipment provided in the pump station. Special care shall be taken to guard against oil or grease dripping from the crane.

F.2.3 Structural General

Each crane shall be designed and manufactured to conform to the following requirements.

(1) Crane Structure

The crane structure shall be of steel and all-welded construction. The main traverse girder shall consist of two main girders connected together at each end. A system of lateral bracing supported by auxiliary trusses shall be provided for each main girder.

Checkered plate walkways and steel handrails shall be provided on top of each main girder.

An operator's cab shall be provided for each crane, suspending from a main girder and access to it shall be from a staircase to be provided by other contractor at each platform and erection bay of the pumping station. The cab shall be of steel and toughened glass and close type. All controls shall be so arranged that the operator has a clear view of operations without moving from the operating position and an operator's seat shall be provided. The complete girder structure shall be mounted on four pivoting bogies designed to compensate for any irregularities in the level of the running rails. Each bogies shall contain double-flanged steel wheels which shall operate on fixed axles with ball or roller bearings. Two matched wheels, one at each end of the crane, shall be driven.

(2) Travel Mechanism of Crane Girder

The travel mechanism of the crane girder shall be mounted on the crane girder assembly and its drive unit shall be mounted at mid-span and shall incorporate a motor driving enclosed gear reducer through a flexible coupling to cross-shafts.

Provision shall be made to permit access to the travel mechanism for inspection and maintenance. The shafts shall be mounted on ball or roller bearings.

(3) Crab

The crab frame shall be of fabricated steel construction. Wherever possible, crab steelwork shall be arranged to support checkered plate walkways for convenient and safe access to all on the crab. The crab traverse drive unit shall incorporate a motor driving enclosed gear reducer through a 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.

(4) Travel and Traverse Brakes

Spring applied, pivoted-shoe, self-aligning brakes, incorporating thruster release, shall be applied for the travel mechanism of the crane girder and the traverse mechanism of the crab. These brakes shall release as soon as the main contactor of the crane is closed and shall operate only when the main contactor is tripped by the travel or traverse limit switches, or any other operation which causes the main contactor to open. In addition, mechanical or hydraulic brakes, operated by foot pedals from the cab, shall be fitted to the drive units for emergency use.

(5) Main and Auxiliary Hoists

The main and auxiliary hoist drums shall be fitted with bronze-bushings 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. The hoist ropes shall be performed ordinary lay construction.

A spring applied, pivoted-shoe, self-aligning brake, incorporating thruster release, shall be applied for the main and auxiliary hoists respectively and shall operate automatically as soon as the power supply to the motor is interrupted. A lowering speed control feature shall be incorporated in both hoists in order to reduce the speed to approximately one quarter to one third of full speed.

The hooks of the main and auxiliary hoist fallblocks shall be of swiveling type, supported on a ball or roller thrust bearing.

(6) Others

All gearings other than final drives, shall be enclosed in gearboxes with automatic oil circulation , oil filling and drain connections, oil level indicators 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.

F.2.4 Electrical Equipment

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 bare hard-drawn copper collector wires supported by brackets, attached to the building. The Contractor shall supply the collector wires, three collectors of renewable carbon-head type, and all necessary end strainers, brackets, insulators and other required fittings.

All motors shall be wound rotor, crane rated, totally enclosed type, 40% ED rated. The motors shall be controlled by reversing drum-type controllers mounted in dustproof metal casing and provided with starting resistances.

A control and protection panel enclosed in a cabinet, of dustproof sheet metal construction, shall be mounted within the cab. The equipment fitted to the panel shall include main isolating switch, main contactor, magnetic overload relays for each motor and all necessary fuses, control switches and wiring for the motors, control circuits, a cab light and one AC 127 V power outlet. A "power on" indicating light shall be fitted to the cabinet.

A fallblock operated, whole current overhoisting limit switch shall be provided for each hoist. In addition, a shunt type limit switch shall be fitted to each hoist to limit the travel in

the "raise" and "lower" directions. Shunt type limit switches shall be provided also for the traverse and travel motions of the crab and crane girder respectively. Striker gear for the traverse and travel limit switches shall be supplied by the Contractor. All limit switches shall be self-resetting and shall be electrically connected in a manner permitting "backing out" after tripping.

The traverse collector wires shall be of hard-drawn copper type. Collectors of removable carbon head type shall be fitted. All crane wiring shall be laid in screwed conduit or troughing.

F.2.5 Accessories

The following shall be supplied for the cranes:

(1)	Trolley wires insulators and brackets.	1 lot for each crane
(2)	Lubricating oil, grease, machine oil with 50 per cent spare for each crane.	
(3)	Tools for maintenance.	1 lot
(4)	Working light.	1 lot for each crane
(5)	Signal horn.	1 set for each crane
(6)	Other necessary accessories.	1 set for each crane

F.2.6 Spare Parts

The following spare parts shall be supplied for each crane:

(1)	Insulators for travelling trolley wires for one line.	
(2)	Bearings.	100% of normal use
(3)	Grease nipples.	2 pcs for each type or size
(4)	Carbon brush holders, fuses and lamps.	100% of normal use
(5)	Moving and fixed contacts for switches, contactors, relays, etc.	100% of normal use
(6)	Fingertip and segment for controller.	100% of normal us
(7)	Carbon brushes for motors.	200% of normal use
(8)	Other necessary spare parts including coils, thermal relays, resistors, capacitors and small parts recommended by the manufacturer.	

F.2.7 Tests

Each crane shall be completely assembled at Contractor's shop and the following tests shall be carried out and the results shall be certified before shipment:

(1) Structure deflection test.
(2) Full load test (including brake system tests).
(3) Overloading test (125 per cent of the rated load).
(4) Operation test.
(5) Dimensional inspection.

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

F.3 DRAINAGE PUMPING SYSTEMS

F.3.1 Description

Two (2) sets of drainage pumping systems shall be provided at each of two sump pits by the Contractor to use for the following:

(1) Discharging waste water in the sump pit, gathered from pump house, discharge penstock, etc.

(2) Dewatering water in each suction pipe of Main Pump through the sump pit for maintenance and repair of the main pumping equipment.

(3) Filling water in each discharge penstock prior to the main pump starting, which is done to boost internal pressure additionally after the penstock be filled water by gravitational flow through by-bass system of the guard valve.

The drainage pumping systems shall include steel drain pipes from the suction pipes of main pump, discharge pipe, auto strainers and pump bearing to the sump pits and discharge pipes from the sump pits to the suction pondage, valves, sump pumps, control facilities and necessary components. Two sets of the pump including one standby unit shall be supplied for each sump pit. The arrangement of the drainage pumping systems and its flow diagram shall be as shown on the Drawings for Tender, Nos. 3-I-005and 3-I-013, respectively.

F.3.2 Design Conditions

The drainage pumping systems shall be designed in accordance with the following conditions.

(1) Type of pump : Vertical shaft submersible type pump.

(2) Discharging capacity : 3 m^3/min. per each pump at rated design head.

(3) Rated design head : 30 m

(4) Driving method : Driven by electric motor directly coupled with pump.

(5) Type and rating of motors

Type	: Vertical shaft, submersible type induction motors.
Output	: Continuous output of the motor shall be ample to driven a corresponding pump at the rated voltage ±10% allowance.
Torque	: Starting torque of the motor shall be sufficient to drive the pump under the conditions that the discharge pipe is fully filled with water.
Frequency	: 60 Hz
Speed	: Recommended by the Contractor.
Voltage	: 220/127 volts.
Insulation	: Class E.

F.3.3 General Requirement

The drainage pumping equipment shall conform to the following requirements.

(1) Drainage Pumps

The drainage pumps shall be of submersible, removable construction with bolt fitting, vertical shaft type and shall be provided with effective lubricating system. All sections of the pump and motor casing shall be rigidly connected to maintain correct alignment of all parts.

The impeller of the pump shall be made of corrosion resistant material and stainless steel sleeves shall be fitted to the shaft where shaft pass through the gland and bearings. Special attention shall be given to the selecting material and design of motor seal with due consideration of severe operating conditions of the pumps.

Adequate provision shall be made in the design of the pump for preventing from the entry of solid materials which are too large to pass freely through the pump.

The design and construction of the motor shall be made to prevent entry of external water, foreign material or contaminations into the motor under any operating conditions.

The motor cables shall be waterproof.

(2) Check Valves

A check valve shall be provided at outlet side of each pump to stop adverse water flow when the pump stops.

The valve shall be of flap type and shall withstand internal water pressure 5 kgf/cm^2.

The valve body shall be made of cast iron and the sealing surfaces of the valve shall accurately machined for complete water seal when the valve closes.

The diameters of the valve shall be same as the outlet diameter of the pump.

(3) Sluice Valves

Hand operating sluice valves shall be provided in the drainage pumping systems as shown on the Drawings for Tender, No. 3-I-013.

The valves shall be of gate valve and shall withstand internal water pressure 5 kgf/cm^2 and 13 kgf/cm^2 for the connecting with discharge penstock. The valve body shall be made of cast iron and the contact surfaces to seal parts shall be accurately machined for sufficient water seal when the valve closes.

The connection of the valves to the pipe shall be made by flange coupling.

(4) Drain Pipes

A steel drain pipe including branch pipe shall be provided for the drainage pumps of each sump pit. The drain pipe shall conform to the following requirements.

(a) Kind of pipe : Carbon steel pipes for ordinary piping.
(b) Internal diameter : 200 mm
(c) Internal water pressure for design : 5 kgf/cm^2
(d) Corrosion allowance : 2 mm
(e) The thickness of pipe shell including the corrosion allowance shall not be less than 5 mm.
(f) The branch and bend parts shall be designed to minimize the head loss in the parts during pump operation.

(5) Dewatering Pipes

200 mm diameter dewatering pipes made of carbon steel pipes for ordinary piping, connecting the suction pipe of each main pump and the discharge penstocks to each sump pit shall be provided as shown on the Drawings for Tender, No. 3-I-013

Each pipe shall be equipped with a manually operated sluice valve from the floor.

The pipe shall be designed to withstand the internal and external water pressures of 5 kgf/cm^2 respectively except that some portion of dewatering pipe of discharge penstoch shall be designed to withstand the internal water pressure of 13 kgf/cm^2 and the corrosion allowance and thickness of pipe shell shall conform to the requirements of the drain pipe in paragraph (4) of this Clause.

(6) Control Facilities

Each of the following pump control shall be performed.

(a) Automatic starting and stopping of the drainage pumps shall be made by detecting the water level in the sump pit by the level detecting device provided in the sump pit.

(b) Manual starting and stopping of the drainage pumps shall also be made from the control panel provided adjacent to the drainage pump at EL.45.0 m floor by the change over of selecting switch equipped in the control panel.

The contractor shall supply the panels, water level detecting devices, wiring materials and other apparatus required for the above pump control.

F.3.4 Accessories and Spare Parts

The following shall be supplied for the drainage pumps.

(1) Floor plates and frames.
(2) Pressure gauges.
(3) Sling fitting.
(4) Tools.
(5) Other necessary accessories.

The following spare parts shall be supplied for the drainage pumping systems.

(1) Two (2) pump impellers.
(2) One (1) pump bearing set.
(3) Other necessary spare parts recommended by the manufacturer.

F.3.5 Tests

The drainage pumps shall be completely assembled at the Contractor's shop and tested to prove the capacity of them before shipment.

After installation at Site, the operation test of the drainage pumping systems shall be carried out and test results shall conform to the contract requirements.

F.4 MACHINES AND TOOLS FOR REPAIR SHOP AND OTHERS

F.4.1 Description

For minor repair and routine maintenance works of all mechanical and electrical equipment provided in this Contract, the repair shop shall be provided on El. 55.000 floor in the pump station.

The machines, tools and meters to be furnished for the repair shop and other use shall be as itemized in Clause F.4.2.

F.4.2 Machines, Tools and Meters

The Contractor shall supply the following machines, tools and meters.

(1) One (1) set of engine lathe with accessories and bits.
(2) One (1) set of bench drilling machine with accessories and drills.
(3) One (1) set of portable electric drill with accessories and drills.
(4) Two (2) sets of electric welding machines with accessories such as welding rods desiccator, welding masks, holders, groves, cabtyre cords, etc. and welding rods.
(5) One (1) acetylene and oxygen gas cutting set with accessories such as gas regulators, rubber hoses, cutting torches, etc.
(6) One (1) set of portable air compressor with accessories.
(7) Each one (1) set of electrical bench grinder and potable type grinder with grinding stones.
(8) One lot of measuring instruments such as micrometer, calipers, steel rule, thickness gauge, tachometer, stop watch, etc.
(9) One lot of tools for general use such as wrench sets, iron level, cutting pliers, screw drivers, wire brushes, hammers, vices, jacks, chisels, files, saws, oil and grease guns, etc.
(10) One lot of cargo work tools such as lever blocks, chain blocks, snatch blocks, wire ropes, manila ropes, etc.

(11) One lot of meters such as voltmeter, ammeter, frequency meter, phase rotation meter, etc.

(12) One lot of testers such as insulation tester, universal tester, earthing tools, etc.

(13) One (1) set of portable type electrical submersible water pump with vinyl hose of 50 m.

The details of the machines, tools and meters such as size, capacity, kinds and numbers of the accessories, etc., shall be made by the Contractor upon approval of the Engineer. The Contractor shall show the details of them in his Tender.

Electric source provided for the repair shop shall be of A.C. 3-phase, 220 V, 60 Hz and A.C. single phase, 127 V, 60 Hz. The machines, tools and meters shall be suitable for the above mentioned electric source.

F.4.3 Tests

The machines, tools and meters shall be inspected and tested at the Contractor's shop to prove the specifications, numbers and proper operation of them before shipment.

The following shall be actually tested to prove the specifications of them after installation at the Site.

(1) Engine lathe.

(2) Bench drilling machine.

(3) Welding machines.

(4) Portable air compressor.

(5) Grinders.

(6) Portable drilling set.

(7) Portable pump.

F.4.4 Installation and Storage

The engine lathe, bench drilling machine and bench grinder shall be installed in the repair shop of the pumping station in accordance with the approved drawing and other machines, tools and meters shall be set or stored in the store room or repair shop in accordance with the Engineer's direction. All materials necessary for setting or storage of them shall be supplied by the Contractor.

F.5 STORAGE BATTERY

F.5.1 Type and Rating

One set of storage battery consisting of 60 cells each in sealed plastic transparent container shall be provided to supply 125-volt, D.C. power coordinating with battery charger specified in Subsection 6E for the pumping station controls and emergency light. The battery shall be of lead acid, enclosed type, with gas filter, 125-volt, 200 ampere-hour at 10-hour discharge rate.

F.5.2 Construction

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

(1) Positive plate of pasted or Tudor 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 shall be fitted with spray proof vent plugs. Sufficient sediment 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.

F.5.3 Accessories

The following items shall be supplied under this Contract.

(1) Requisite quantity of sulfuric acid with 10% extra.
(2) Sufficient quantity of distilled water for first filling up.
(3) Mixing tank of adequate capacity.
(4) Voltmeter, hydrometers (portable and vent mounted) and vent mounted thermometer.
(5) Intercell connectors between cells and terminal lugs.
(6) Other necessary accessories.

F.5.4 Spares

- Diluted sulfuric acid 30%
- Distilled water 30%
- Other necessary spare parts recommended by the manufacture

F.5.5 Test

(1) Shop Test

(a) Construction check

(b) Efficiency test (Certificate of type test may be acceptable.)

(2) Site Test

After initial charging, the following test will be carried out at site:-

(a) Test of capacity.

F.6 OIL HANDLING AND PURIFYING EQUIPMENT

F.6.1 General

During treatment of insulating oil of the transformers, the oil transported or stored in 200 liter metal drums will be transferred to an insulating oil tank. An oil transfer pump and strainer will be used to handle the insulating oil. A vacuum oil purifier will be used to remove contaminating gases, sludge, insoluble solids and moisture from insulating oil. A oil tester will also be used for the insulating oil.

The electric source for oil handling and purifying shall be three-phase 220 V or single-phase 127 V, 60 Hz.

F.6.2 Oil Transfer Pump and Strainer

One oil transfer pump shall be provided and rated to handle the most viscous oil at the lowest average daily ambient temperature. The pump shall have a capacity of about 70 liters per minute when pumping oil to the top oil level of the transformer. The pump pressure rating shall include an allowance for hydraulic losses in the hoses, connecting pipes and filter. The pump shall be provided with a relief valve connected to discharge to the pump suction and set to protect the pump from over-pressure. A pressure gauge shall be provided

to the pump discharge and shall be fitted with a filter-pulsation damper. The pump shall be driven by an electric motor.

The transfer pump and strainer shall be mounted on a mobile cart. The cart shall be provided with oil resistant tired casters, lifting lugs and pull bar. Racks shall be provided on the cart for storing houses and the electrical power cable.

A suction and a discharge oil resistant hose shall be provided, each about 20 meters in length for connection to the pump, strainer and oil sumps or transformers. These hoses shall also be used for connecting the oil purifier to the sump or transformer. All hose connections shall be the swivel coupling type, and corresponding adapters and coupling valves shall be provided on the sump for fill and drain connection.

An electrical oil resistant insulated cable of 25 meter length shall be provided with a metal plug suitable for the outlets.

The strainer shall be mounted on the mobile cart and shall be rated for the transfer pump discharge at corresponding viscosity. The strainer shall be fitted with a differential pressure gauge and the body shall be rated for the pressure setting of the pump relief valve. The filtering medium shall be of non-corrosion metal or synthetic fiber and shall be cleanable. The filter shall effectively remove particles of 0.25 mm size up to 98 percent and shall, when 2/3 blocked, pass the rated flow at a differential of 1 kg per sq.cm. The filter element shall not blow out or fail at this differential and shall not form channels which will conduct the flow. The strainer body shall have a suitable drain, supports and easy means of access to the filter element. A suitable flexible connection shall be provided between the pump and strainer.

F.6.3 Vacuum Oil Purifier

A vacuum oil purifier shall be provided to dehydrate, de-aerate, purify and filter the transformer insulating oil. The purifier shall be complete with all components, controls, valves, thermostats, pumps, motors, starters, relays, filters etc., required to control the unit and ensure the removal of water to a concentration of 10 ppm and of solids greater than a particle size of one microns. The capacity of the unit shall be within the range 3,000 to 4,000 liters per hours.

In the purifier uses disposal filtering or oil dispersion material, the Contractor shall supply with the unit not less than 5 years supply of such material. The quantity of filtering material shall be sufficient to allow changing the filtering media after an annual treatment of the oil for the transformers. The filtering media shall be changed after the treatment of the quantity of oil in each sump or system.

The purifier shall be movable and provided with all attachments appropriate to obtaining easy maneuverability and to locating the purifier adjacent to the transformers.

F.6.4 Oil Tester

A potable dielectric oil tester shall be provided. The rating shall be 5 kVA, with maximum capacity of a test voltage of 50 kV. The test voltage shall be adjustable by the voltage regulator and indicated on a kilovoltmeter with maximum voltage pointer. The unit shall be complete with switches, instruments and accessories.

F.6.5 Transfer Cart

The Contractor shall supply a transfer cart of steel construction with oil resistance tired casters, lifting lugs and pull bar. The transfer cart shall be designed to carry two 200 - liter shipment containers.

F.6.6 Storage Oil Tank

One movable type oil storage tanks shall be provided with for handling transformer oil.

The oil tank shall be welded steel construction in accordance with the relevant vessel code. The capacity of oil tank shall be more than 6,000 liters with all connection pipes and valves, manhole, air vent, a sight gauge to indicate the oil level.

The interior surface of the tank shall be thorougly cleaned and coated with oil resistant paint.

F.6.7 Spare Parts

The following spare parts shall be furnished and quoted.

(1) One (1) set of replacement seals and gaskets for pumps and valves of the oil purifier and pump.

(2) One (1) set of replacement bearing or bushing, including one of each size and type used in the pumps, motors, wheels or other rotating component of the equipment supplied under this item.

(3) One (1) set of replacement components for the control equipment associated with the equipment supplied under this item, such as, contactors, relays, valve springs, and seats, thermostat and pressure switch serving element.

(4) Other spare parts recommended by the manufacturer.

F.6.8 Test

The following tests shall be carried out at the manufacturer's plant in compliance with this Specification:

(1) Construction check
(2) Operation test
(3) Treatment characteristic test
(4) Continuous operation and leakage test
(5) Power-frequency voltage withstand test

F.7 DIESEL ENGINE GENERATOR SET

F.7.1 General

One 200 kVA diesel engine generator set complete with the necessary switchgear, accessories and materials shall be provided to supply electric power for emergency.

The diesel engine generating set will be installed and erected in the diesel engine room on the premises of the pump station.

F7.2 Diesel Engine

The diesel engine shall be of the full compression ignition vertical cylinder, single-acting, 4-cycle, solid injection, water-cooled type. The cooling water jacket of engine shall be designed for safe operation at maximum water pressure of 5 kg/cm^2. The engine shall not require premium fuel for satisfactory performance.

The diesel engine and generator specified in Clause F.7.3 below, shall be placed on a common bed plate.

Continuous output of diesel engine generating set shall be guaranteed to be 160 kW at generator terminals, under the climatic conditions stated in Clause GS.1.7 of "General Specifications" and at the engine speed of 1,500 rpm.

The diesel engine shall be automatically started by a starter motor when the normal electricity supply is cut off and manually stopped.

The diesel engine shall be stopped automatically and locked when fault happens.

F.7.3 Generator

The generator shall be 3-phase, 4-wire, revolting field type with damper winding, self-excited, self-ventilated open type, single bearing synchronous alternator.

The rating of the generator shall be 220-127 V, 60 Hz, 0.8 lagging, 200 kVA continuous output and shall be directly connected and flange-mounted to engine. Insulation shall be Class "F".

The excitation current shall be controlled by both voltage and current of the generator through rectifiers to have compound characteristics. The automatic voltage regulator shall be provided for the excitation system, capable of controlling voltage within ±2% from no load to full load.

The neutral point of armature winding shall be connected to neutral bus of the low tension switchgear and solidly grounded. If necessary, shaft grounding gear shall be provided to prevent damage to bearings due to high frequency circulating currents, caused by the static excitation equipment.

The maximum temperature rise of the generator shall not exceed the following:-

Stator winding (by thermometer)	: 80 degrees C
Rotor field winding (by resistance)	: 95 degrees C
Iron core and other parts (by thermometer)	: 95 degrees C

F.7.4 Materials

All materials, which are not specifically mentioned herein but necessary for the performance of the works among the diesel engine generator, the generator control cubicle and the low tension switchgear shall be provided according to the drawings and/or as directed by the Engineer.

F.7.5 Accessories

The following accessories shall be supplied:-

(1) Engine

(a) One daily fuel oil tank of 450 liter capacity with float level gauge.
(b) One set of engine shaft driven pumps for lubricating oil and fuel oil injection.
(c) One set of filters for fuel oil and lubricating oil, cleanable type to avoid frequent replacements.

(d) One set of thermometers for cooling water.
(e) One radiator with cooling fan.
(f) One tachometer.
(g) One lubricating oil cooler.
(h) One common bed plate, foundation bolts and nuts with vibration free materials.
(i) One set of reamer bolts with nuts, for coupling up with generator.
(j) One set of alarm and automatic shut down devices in the event of lubricating oil pressure drop, cooling water high temperature and over-speed.
(k) One panel for safety device with alarm, associated with the generator control as required.
(l) One pressure gauge for lubricating oil.
(m) One set of all piping materials with valves and cocks.
(n) One air suction strainer, cleanable type to avoid frequent replacements.
(o) One set of maintenance tools.
(p) One maximum-pressure indicator.
(q) One test pump with a pressure gauge for fuel injection valve.
(r) One set of silencer and exhaust pipe with expansion and flexible joint to atmosphere.
(s) One set of flexible fuel line and float tank for gravity feed.
(t) any accessories according to manufacturer's standard.

(2) Generator Control Cubicle

The control cubicle shall be of sheet metal dead front, indoor type, floor mounted and self standing. The panel-mounted equipment and devices shall include, but not be limited to, the following:-

(a) One 600 V, 630 AF no fuse breaker.
(b) One A.C. ammeter with selector switch.
(c) One A.C. voltmeter with selector switch.
(d) One frequency meter.
(e) One wattmeter with three elements.
(f) One watthour meter with three elements.
(g) One contactor for starter motor.
(h) One regulating switch for governor motor.
(i) One set of group annunciator.
(j) Three current transformers of 600/5 A, dry type.
(k) One rheostat for AVR voltage setting.
(l) One set of cable terminals, back wiring and terminal boards and name plates.

(m) One set of test terminals.
(n) One over-voltage relay.
(o) Three over-current relays.
(p) One directional ground relay
(q) One alarm bell.
(r) One set of connections for fault indication of:-
- Excessive temperature rise of cooling water.
- Pressure drop of lubricating oil.
- Overspeed.
(s) One set of indicating lamps.
(t) One set of cabinet type static exciter with AVR with necessary accessories.
(u) One set of special tools for erection and repair.

Any necessary accessories of the manufacturer's standard.

F.7.6 Spare Parts

The following items shall be supplied as spares:-

(1) 100 per cent of packings and gaskets of each type.
(2) 100 per cent of brushes for slip ring.
(3) 200 per cent of filter elements for fuel oil, lubricating oil and air system.
(4) Electrical spare parts.
(5) Other necessary spare parts recommended by the manufacturer

F.7.7 Tests

The following tests shall be carried out.

(1) Combined Shop Tests

(a) Starting test.
(b) Load test including temperature rise and oil consumption measurement.
(c) Governor test.
(d) Overspeed test: 110 per cent of rated speed 1 min.

(2) Site Tests

(a) Starting test.

(b) Load test.

(c) Governor test.

SUBSECTION - G

MISCELLANEOUS MATERIALS

G.1 GENERAL

G.1.1 Scope

This Subsection covers the design, manufacture, testing before shipment, transportation to the Site, installation and erection, commissioning and performance tests at the Site of the following:

(1) Electrical conductors and fittings.
(2) Insulators and fittings.
(3) Steel structures and towers.
(4) Other materials.

G.1.2 Tests

The tests to be carried out before shipment at the Contractor's shop are stated in the relevant clauses. The commissioning tests, specified in Clause GS.11.2 of part-I General Specifications, as applicable shall be conducted at site. No performance tests are required for equipment under this subsection.

G.2 ELECTRICAL CONDUCTORS AND FITTINGS

(1) Power cables.
(2) Control cables.
(3) Insulated wires.
(4) Aluminum conductor steel reinforced.
(5) Galvanized steel wire.
(6) Bare hard drawn and soft annealed copper conductors.
(7) Fittings.

G.2.1 Power Cables

(A) Cables

Power cable shall be of single or multi-core copper, cross-linked polyethylene insulated polyvinyl chloride sheathed type (CV) with suitable cable ends. 4.16 kV and 13.8 kV cables shall have metal shield or have semi-conducting tape and thinned copper wire shield.

Chemicals for the protection of cables against termite shall be added to the sheath.

Following power cables shall be used for each circuit.

	Cable	Circuit
(1)	4.16 kV, single core, 400 sq.mm CV cable	4.16 kV circuits from main transformer to high tension switchgear cubicle. The cable shall be used in duplicate to each phase.
(2)	4.16 kV, three-core, 300 sq.mm CV cable	4.16 kV circuits from high tension switchgear cubicle to pump motor.
(3)	4.16 kV, three-core, 50 sq. mm CV cable	4.16 kV circuits from high tension switchgear cubicle to static condensers, local transformer and station service transformers
(4)	13.8 kV, three-core, 35 sq.mm CV cable	13.8 kV circuits from local transformer to 13.8 cubicle and from the cubicle to deadend tower for distribution line.
(5)	600 V single-core, 300 sq.mm CV cabe	220-127 V circuit from diesel engine generator to low tension switchgear cubicle, but 600 V single core 100 sq.mm for neutral circuit.
(6)	600 V single-core 600 sq.mm	220-127 V circuit from station service transformer to low tension switchgear cubicle, but 600 V single core 100 sq.mm for neutral circuit.

(B) Cable Heads

Following cable heads shall be required:

(1)	For 4.16 kV, single core, 400 sq.mm power cable	12 sets
(2)	For 4.16 kV, three core, 300 sq.mm power cable	6 sets
(3)	For 13.8 kV, three core, 50 sq.mm power cable	12 sets
(4)	For 13.8 kV, three core, 35 sq.mm power cable .	6 sets

Necessary accessories for above cable heads shall also be supplied.

(C) Cable Termination Materials

Power cable connection in main transformer secondary, main motors and 220/127 V circuits shall be applied for the cable end termination treatment using appropriate insulation tape on Site, instead of the cable heads.

All necessary materials for the above cable end termination treatment on site shall be provided.

G.2.2 Control Cables

Control cables shall be of jacket type, 600 V, polyvinyl chloride insulated, PVC sheathed, single or multi-copper-core. The sectional area of core shall not be less than 2.0 sq.mm. Chemicals for protection of cable against termite shall be added to the sheath.

Colours of core insulation shall be as follows:-

One core	Black
Two cores	Black and white
Three cores	Black, white and red
Four cores	Black, white, red and green
Five cores	Black, white, red, green and yellow
Six cores	Black, white, red, green, yellow and brown

G.2.3 Insulated Wires

600 V, PVC insulated wires shall be supplied for power and heater circuits for auxiliary equipment. The minimum size shall be 2.0 sq.mm.

PVC insulated wires connecting low tension switchgear cubicle with motor control centres, AC-1 panel, AC-2 and DC panel shall be at least 22 sq.mm.

G.2.4 Bare Hard Drawn Copper Conductor and Soft Annealed Copper Conductor

Bare hard drawn copper stranded wire of suitable size shall be applied for connection between any equipment terminals and bus or others.

Soft annealed copper stranded wire of 100 sq.mm (19/2.6 mm) and smaller size with a minimum of 8 sq.mm, based on the likely fault current and protection in the circuit shall be provided to connect motors, ancillary equipments, motor control centers, cubicles, control

switchboards, steel structures etc. to the grounding system. Solderless clamps shall be provided.

G.2.5 Aluminum Conductor Steel Reinforced (ACSR)

Aluminum conductor steel reinforced (ACSR Oriole) of 170 sq.mm (Al 30/2.69 St 7/2.69) shall be provided for 138 kV connecting circuits between main transformer yard and 138 kV switchgear yard, 138 kV switchgear circuits in Severino and 138 kV switchgear circuits in Daule Peripa. Aluminum conductor steel reinforced shall comply with JIS C-3110 or equivalent standards.

G.2.6 Galvanized Steel Wires

Galvanized steel wires of 55 sq.mm (7/3.5) shall be provided for overhead ground wires for 138 kV connection circuits, 138 kV switchgear in Severino and 138 kV switchgear in Daule Peripa.

G.2.7 Joints

Joints of ACSR for 138 kV circuits shall be of compression type and shall be free from slipping off, damage to or failure of the complete conductors, groundwires or any parts thereof at a load less than 95% of the ultimate breaking strength of the conductor or groundwire.

The electrical conductivity and current carrying capacity of joints shall not be less than those of equivalent length of the conductor.

The cut ends of steel wires and steel component inside the joint shall be protected from the weather in an effective and permanent manner.

G.2.8 Vibration Dampers

Vibration dampers for 138 kV connecting circuits between main transformer yard and 138 kV switchgear yard shall be of Stockbridge pattern for the conductors and the groundwires.

Stockbridge dampers shall be designed to be attached to the conductors and the groundwires in a manner which will prevent damage thereto and free from droop of the weight in service. Clamping bolts shall be provided with domed heads and designed to prevent corrosion to the thread.

G.2.9 Fittings

Suitable PG clamps, T clamps and terminals for conductors, and suitable clamps for galvanized steel wire shall be provided.

The clamp for connections of copper conductor and ACSR shall be free from electrolytic corrosion.

G.2.10 Tests

The following tests shall be carried out at Contractor's shop:-

(1) Construction test.
(2) Tensile test.
(3) Elongation test.
(4) Resistance test.
(5) Insulation test for power cable and PVC wire.
(6) Characteristics.

G.3 INSULATORS AND FITTINGS

The following items shall be supplied under this clause:-

(1) Insulator units.
(2) Fittings.

G.3.1 Insulator Units

Each suspension or strain insulator string shall be of 10 units for 138 kV circuits without arcing horn. The insulator unit shall be standard 254 mm porcelain disc type with ball and socket, and have a spacing of 146 mm between discs.

The connection between units shall be such as to allow sufficient flexibility for freedom of movement, and to prevent the possibility of becoming separated accidentally either during or after the erection.

The interlocking sockets shall be designed to allow easy passage of the ball into the socket and rating pins or locking devices are required to keep in the socket under all service conditions.

The dimension of socket and pin shall be in accordance with gauge of JIS standard, C-3817 or equivalent.

The insulator units shall be brown glazed.
Each insulator unit shall have following characteristics:-

(1) Withstand Voltage

Wet (1 min.)	50 kV
Impulse	125 kV

(2) 50% Dry Impulse Flashover Voltage

Impulse, positive wave	
1.2 x 50 micro-second	120 kV

(3) Puncture Voltage in Oil ..... 110 kV

(4) Minimum Breaking Load ..... 12,000 kg

(5) Loading under Broken Wire Condition

Under brokenwire condition, in which any one conductor or groundwire shall be assumed to be broken for all types of towers, longitudinal loads due to the unbalanced tension of conductor or groundwire shall be added to the loading above mentioned.

The tension of unbalance shall be taken to be 60% of the working tension of a conductor or a groundwire for suspension tower, and 100% for terminal towers.

For vertical loading and wind pressure for broken wire, same span as for normal condition shall be considered.

G.3.2 Arcing Horns

All insulator sets for connecting circuits shall be fitted with arcing horns at both the line and earth ends. The horns of suitable design for tension insulator sets shall be directed upwards.

The design and lift of the arcing horns are to be such as to obviate damage to clamps and conductors and to prevent cascading over insulator units when flashover occurs, and shall give at the same time the maximum impulse flashover voltage.