

DIVISION 16 ELECTRICAL WORKS

SECTION 16.1 GENERAL

16.1.1 SCOPE OF WORK

The Contractor shall provide all labor, materials, equipment and incidentals to furnish and install the complete electrical system as shown on the drawings and/or specified herein.

It is the intent of these specifications, that when completed, the electrical systems shall be suitable in every respect for the service intended, and the Contractor shall, at no extra cost, supply all the materials and do all the work which may be reasonably implied as being incidental to the work.

The Contractor shall be responsible for all wiring and connections, testing and placing in satisfactory operation the complete electrical system to the approval of the Engineer.

16.1.2 RULES AND REGULATIONS

All equipment and work under this Contract shall be installed in accordance with the requirements of Authority of the Country. The Contractor shall file the required notice with any municipal department having jurisdiction over such permits and obtain and pay for all permits required.

16.1.3 REFERENCES

All equipment, materials and fabrication shall conform to the latest applicable IEC, JIS, BS, or equivalent standards.

The above-mentioned specifications and reference standards, in their current editions, form a part of these specifications to the extent specified in each section.

16.1.4 SCHEDULE

Schedule of each section specified hereinafter will be specified in the Particular Specifications.

The completeness of these schedules is not guaranteed and the omission of a electrical system in the schedule needed to complete the work shall not relieve the Contractor from his responsibility for installation of the work complete.

16.1.5 INTERPRETATION OF DRAWINGS

All three-phase circuits shall be run in separate conduits unless otherwise shown on the drawings.

The Contractor shall verify with the Engineer the exact locations and mounting heights of lighting fixtures, switches, and receptacles prior to installation.

Any work installed contrary to or without approval by the Engineer shall be subject to change as

directed by the Engineer, and no extra compensation will be allowed the Contractor for making these changes.

The locations of equipment, fixtures, outlets, and similar devices shown on the drawings are approximate only. Exact locations shall be as approved during construction. The Contractor shall obtain in the field all information relevant to the placing of electrical work and in case of any interference with other work, shall proceed as instructed by the Engineer, and shall furnish all labor and materials necessary to complete the work in an approved manner.

Surface mounted panels, boxes, junction boxes, conduit, etc., shall be supported by spacers to provide a clearance between walls and equipment.

The drawings are diagrammatic and functional only and are not intended to show exact circuit layouts, number of fittings, or other installation details. The Contractor shall furnish all labor and materials necessary to install and place in satisfactory operation all power, lighting, and other electrical systems shown. Additional circuits shall be installed by the Contractor wherever needed to conform to the specific requirements of the equipment.

The ratings of motors and other electrically operated devices, together with the size shown for their branch circuit conductors and conduits, are approximate only and are indicative of the probable power requirements insofar as they can be determined in advance of the purchase of equipment. The ratings shown for motor branch circuit protective devices are the maximum ratings permitted. Lower ratings may be used where approved as being proper for the dynamic characteristics of the motor and its connected load.

Unless otherwise specified, all conduits, wires, cables and the support systems for the conduits and cables that are required to make the electrical connections to equipment shall be furnished and installed by the Contractor. All connections to equipment shall be made as shown, specified, and directed and in accordance with the approved shop drawings.

16.1.6 SIZE OF EQUIPMENT

The Contractor shall investigate each space in the building through which equipment must pass to reach its final location. If necessary, the manufacturer shall be required to ship his material in sections sized to permit passing through such restricted areas in the building.

16.1.7 EQUIPMENT MARKING

The Contractor shall provide nameplates of laminated plastic with engraved black letters on white background, secured to the equipment in a permanent manner. All markings shall be as approved by the Engineer and shall be applied to all pieces of equipment such as switches, circuit breakers, panelboard, motor starters, etc.

16.1.8 MATERIALS

The materials used in all systems shall be new, unused, and as hereinafter specified. All materials where not specified shall be of the very best of their respective kinds. Samples of materials or manufacturer's specifications shall be submitted for approval.

Electrical equipment shall at all times during construction be adequately protected against mechanical injury or damage by water. If any apparatus has been damaged, such damage shall be repaired by the Contractor at his own cost and expense. If any apparatus has been subject to possible injury by water, it shall be thoroughly dried out and put through a special dielectric test as directed at the cost and expense of the Contractor or shall be replaced by the Contractor at his own expenses.

16.1.9 ENCLOSED TYPE

1. WATERPROOF TYPE

All equipment which will be installed outdoors or installed in basement room of the buildings shall be waterproof type, and designed and manufactured in accordance with the JIS C 0920, "Tests to Prove Protection against Ingress of Water for Electrical Equipment", grade 5.

2. EXPLOSION-PROOF TYPE

The explosion-proof type shall be manufactured in accordance with the following standards.

JIS C 0930	Electrical apparatus for explosive gas atmospheres -- General requirements
JIS C 0931	Electrical apparatus for explosive gas atmospheres -- Construction and verification test of flameproof enclosures of electrical apparatus
JIS C 0932	Electrical apparatus for explosive gas atmospheres -- Type of protection "p"
JIS C 0933	Electrical apparatus for explosive gas atmospheres -- Oil-immersed apparatus
JIS C 0934	Electrical apparatus for explosive gas atmospheres -- Increased safety "e"
JIS C 0935	Electrical apparatus for explosive gas atmospheres -- Intrinsic safety "i"

16.1.10 SHOP DRAWINGS

Shop drawings shall be submitted in the required number of copies for approval of all materials, equipment, installation and wiring.

All shop drawings shall be checked by the Contractor for accuracy and Contract requirements before submittal. Shop drawings shall bear the signature of the Contractor and date checked and shall be accompanied by the statement that the shop drawings have been examined for conformity to specifications and drawings. This statement shall also list all discrepancies with the specifications and drawings. Shop drawings, not so checked and noted by the Contractor shall be returned to him without

approval.

The Engineer's check shall be only for conformity with the design concept of the Project and compliance with the specifications and contract drawings. The Engineer's approval shall in no way relieve the Contractor from the responsibility of, or the necessity of, furnishing materials and workmanship required by the contract drawings and specifications which may not be indicated on the shop drawings.

The Contractor shall be responsible for all dimensions to be confirmed and correlated to the job site and for coordination of his work with the work of all other trades.

No material shall be ordered or shop work started until the Engineer's approval of shop drawings has been given.

16.1.11 PAINTING

All equipment and material shall be painted with double coats of sealing primer and surface, and not less than double coats of finish paint. Before prime-painting, surface of the switchgear shall be treated by sand blast or dipping with acid solution.

Painting colors shall be approved by the Engineer.

16.1.12 SMALL WIRING

All small wirings of equipment and panels shall be made with 600 V PVC insulated wire of 2.0 mm square and larger having enough flexibility for operation for long duration.

Color of PVC insulant shall be as follows:

Grounding circuit : Green

All small wirings other than grounding circuit : Yellow

All small wirings shall run neatly, fixed securely and taken at terminal boards, and provided with ferrous of white tape of self-sticking type. Also they shall be provided with solderless terminal lugs to connect to terminal boards.

Permanent wire markings shall be provided according to the specifications.

16.1.13 NAME PLATES

Each switchgear, panel, device and each power and control circuit shall have been provided with an engraved nameplate or with other suitable means of identification approved by the Engineer.

Each nameplate shall be laminated plastic with black letters on a white background.

16.1.14 TESTS

All equipment shall be completely assembled at the factory. They shall be subject, unless otherwise noted, to each test as specified in the Standard and/or Particular Specifications by the Contractor.

The Contractor shall notify the Engineer at least thirty (30) calendar days prior to the manufacture's factory tests. The inspector reserved the right to witness all tests.

The Contractor shall furnish the service of the manufacture's serviceman, all special tools, temporary materials, electricity, fuel, assistance, labor, apparatus and instruments as may be requisite and as may reasonably demanded to carry out such shop and field tests efficiently.

The Contractor shall provide a safe working environment for shop and field test.

Sufficient data shall be obtained during shop and field tests to permit the inspection and to plot characteristic curves for various specified operation conditions.

The tests can be made at either 50 Hz or 60 Hz. If the tests are made at 60 Hz, the manufacturer shall submit six (6) certified sets of calculations showing the equivalent 50 Hz test parameters together with the 60 Hz test data.

The Contractor shall furnish six (6) certified copies of reports of the results of tests, curves and standard application data.

16.1.15 REPLACE AND REMEDY

It shall be the duty of the Contractor to apply such tests, replace, or remedy all defective work, and adjust such systems as and within such time as the Engineer shall require. He shall also instruct in the use of the systems or apparatus such persons as the Engineer shall designate.

16.1.16 ACCESSORIES AND SPARE PARTS

1. ACCESSORIES

For all equipment and panels, all essential and desirable accessories for an installation, operation and maintenance shall be furnished and installed, which shall include but not be limited to the each item specified herein-after.

2. SPARE PARTS

All spare parts shall be properly preserved and packaged for a long period of storage before use, in a hot and humid climate and shall be properly marked in English and Russian languages on the outside to permit easy identification of the contents without opening and exposing the contents to the atmosphere.

3. TOOLS

The Contractor shall furnish all standard and special tools that may be required for the installation, testing and servicing of the equipment. These tools shall be properly packed in a suitable steel box with the contents listed on the outside in neat lettering in contrasting color, in English and Russian languages. Each tool box shall be provided with a lock and keys. Hinges for the tool box shall be of the continuous hinge type.

DIVISION 16 ELECTRICAL WORKS**SECTION 16.2 HIGH-VOLTAGE SWITCHGEAR****16.2.1 GENERAL****1. GENERAL**

The Contractor shall furnish and install all high-voltage switchgear and metal enclosed bus duct as hereinafter specified and as shown on the drawings.

2. REFERENCES

The following standards or other internationally accepted standards or manufacturer's standards as approved by the Engineer are referred to.

IEC 60060	High-Voltage Test Techniques
IEC 60831	Shunt power capacitors of the self-healing type for a.c. systems having a rated voltage up to and including 1000 V
IEC 60871	Shunt capacitors for a.c. power systems having a rated voltage above 1000 V
IEC 60931	Shunt power capacitors of the non-self-healing type for a.c. systems having a rated voltage up to and including 1000 V
IEC 60071	Insulation Co-ordination
IEC 60947-4-1	Low-voltage switchgear and controlgear - Part 4-1: Contactors and motor-starters - Electromechanical contactors and motor-starters
IEC 60289	Reactors
IEC 60298	A.C. metal-enclosed switchgear and control gear for rated voltage above 1 kV and up to and including 72.5 kV
IEC 60470	High-voltage alternating current contactors and contactor - based motor - starters
JIS H 3140	Copper Bus Bars
JIS C 1102	Direct acting indicating analogue electrical measuring instruments and their accessories
JIS C 1103	Dimensions of Electrical Indicating Instruments for Switchboards
JIS C 1216	Alternating-current Watt-Hour Meters (for Connection through Instrument Transformer)
JIS C 4602	Overcurrent Relay for 6.6 kV Receiving
JEM 1153	High-Voltage Metal-Enclosed Switchgear from 3.3 KV to 33 KV

16.2.2 SCHEDULE

The high-voltage switchgear schedule will be specified in the Particular Specifications.

16.2.3 TYPE, RATING AND CHARACTERISTICS

The type, ratings and characteristics of the high-voltage switchgears and metal-enclosed bus duct shall be as follows:

NOMINAL VOLTAGE	NOMINAL VOLTAGE	NOMINAL VOLTAGE
35kV	11Kv	6kV

a. Type

- Switchgear: Indoor or outdoor, self-supported, metal enclosed type

- Bus duct: Indoor or outdoor, metal-enclosed, non-ventilation type

b. Number of phases: Three(3)-Phase

c. Rated frequency: 50 Hz

d. Rated voltage (kV): 36 12 7.2

e. Lightning impulse withstand voltage

- To earth (kV): 170 75 60

- Across the isolating distance (kV): 195 85 70

f. Power frequency with-stand voltage (r.m.s.)

- To earth (kV): 70 28 22

- Across the isolating distance (kV): 80 32 25

- Control circuit (kV): 4 4 4

g. Rated operating and Control voltage

- DC: 100V ± 25V

- AC (r.m.s.): 220V ± 22V

33V

16.2.4 CONSTRUCTION

1. HIGH-VOLTAGE SWITCHGEAR

The high-voltage switchgear and metal enclosed bus duct shall be an assembly which is enclosed in an earthed metal-enclosure.

The switchgear shall be comprised from units of circuit breakers, disconnecting switches, instrument

transformers, power transformers and power capacitors.

Each unit circuit shall be segregated by an earthed metallic partition or insulating partitions.

The switchgear enclosure type shall conform to "JEM-1153, G form".

Withdrawable type shall be provided with a self coupling primary circuit disconnecting device and a manual coupling control circuit disconnecting device.

Withdrawable circuit breakers shall be provided with interlocking not to be withdrawn from or inserted to their operating position unless they are opened previously.

The complete switchgear including circuit breakers, bus bars, and instrument transformers shall be capable of withstanding without damage the electro-magnetic and thermal stresses resulting from the maximum asymmetrical value of short circuit current corresponding to the fault level specified in the specifications.

The high voltage switchgear and metal enclosed bus duct shall be fabricated from flat rolled steel not less than 3.2 mm thick panels, reinforced where necessary, in such a manner that the complete structure shall be rigid and free from twist and weave during handling and after installation.

The switchgear shall be provided with lockable hinged front door and removable panels of adequate thickness on rear and bottom.

Provisions shall be made for bottom plate for bottom entry of power and control cable.

Outgoing connections shall be used of heat shrinkable sleeve for termination of plastic and rubber insulated cable.

The switchgear shall be provided with the panel board for all required control power distribution and the panel board shall include main and branch molded case circuit breakers, fuses, signal lights and each terminals.

For safety of operating personnel, it is essential that should an arc develop in any one of the compartments it shall be confined to that compartment without affecting the other compartments.

Minimum thickness of steel for each part of the switchgear shall be:

Side and rear plate	2.3 mm
Bottom plate	1.6 mm
Ceiling plate	1.6 mm
Roof plate	2.3 mm
Partition plate	1.6 mm

Front door plate 3.2 mm

Space heater, fluorescent lamp fixtures and receptacles shall be provided inside each switchgear with thermostat and lighting switch.

2. METAL-ENCLOSED BUS DUCT

Metal-enclosed bus duct of outdoor type shall be fabricated from steel sheet, and finished with hot-dip galvanized and painted.

The connecting parts of the metal-enclosed bus duct shall ensure complete mechanical and electrical connection and shall have openings with covers to inspect the inside of the connected parts.

The metal-enclosed bus duct shall have expansion joint parts where deemed necessary and at points as shown on the drawing.

16.2.5 POWER BUS BAR AND EARTH BUS BAR

All bus bars of switchgear and metal-enclosed bus duct shall be made of copper conforming to JIS H3140, "Copper Bus Bar", Class C 1100 or equivalent and shall be totally enclosed with long life and durable insulating material.

Power buses shall be copper having suitable current ratings, and shall be supported by non-hygroscopic insulators designed to withstand forces due to the momentary short circuit current of the system.

Earth bus shall be of copper and size shall be not less than 6 mm x 75 mm.

A tee connection from the main earth-bus shall project into each circuit breaker compartment for the automatic earthing of the circuit breaker when it is inserted into the compartment.

The power bus bar shall be located at the upper side of panel and shall have expansion joint part.

Both end of buses shall be arranged properly for future connection work of bus bar.

16.2.6 TESTS

1. FACTORY TESTS

The high-voltage switchgear shall be completely assembled at the factory. The switchgear shall be subject, unless otherwise noted, to the following tests by the Contractor.

- a. Verification of construction
- b. Mechanical operation tests
- c. Electrical operation tests

- d. Temperature rise tests
- e. Withstand voltage tests
- f. Short-time current tests
- g. Short circuit current tests
- h. Weatherproofing tests
- i. Accessories and spare parts test

2. FIELD TESTS

After installation, the following tests shall be executed before energizing.

- a. Verification of construction
- b. Mechanical operation tests
- c. Electrical operation tests (include remote)
- d. Withstand voltage tests

16.2.7 EQUIPMENT INCLUDED

The high-voltage switchgear shall include necessary equipment as presented herein.

1. INSTRUMENTS AND RELAYS

Voltmeters, wattmeters, power factor meters, zero - phase voltmeter and ammeters shall be not less than 110 mm square, 240 degrees from zero to full scale, $\pm 1.5\%$ of full scale accuracy, panel mounted type and shall be provided with external zero adjustment. The scale ranges shall be determined from the potential transformer and current transformer ratios.

Watt-hour meters shall be the draw-out type, rated voltage 110 V and rated current 5A, panel mounted type with puls contact for remote counter and shall be provided with puls composed device.

Protection relays shall be draw-out, panel mounted, dust proof, induction disc type.

Each protection relay shall be equipped with an operation indicator, front operated resetting device and contacts for operation on 220 volt A.C. from UPS.

Each relay shall be suitable type for operation with instrument transformer ratios and connections as shown on single line diagrams under both normal and short circuit conditions.

- a. AC. Undervoltage Relay
AC. Undervoltage relay shall be three (3) - phase type
- b. Over Current Relays
Over current relays shall have inverse or definite time delay characteristics with adjustable

current setting range from 2 to 6 ampere or from 4 to 12 ampere.

c. Differential Relays

Differential relays for power transformer shall be single phase, high speed variable percentage differential type. The relay shall be suitable type for protection of three (3)-phase, two (2) winding transformer and shall be provided with positive protection against tripping on magnetizing inrush current.

2. PHASE AND SEQUENCE SELECTOR SWITCHES

Phase and selector switches shall be heavy-duty, rotary type. The phase and sequence selector switches shall be near resistant type and arc-proof type, and with dust cover.

3. CONTROL SWITCHES

Control switches shall be twist type or pull switch type. The control switches shall be wear-proof type and arc-proof type, and with dust cover.

4. ANNUNCIATOR

Annunciator shall be back lighted and shall be relay operated. An alarm condition shall cause the appropriate lamp to light up and sound the horn. The light shall go out when the alarm condition is removed.

5. AUXILIARY RELAYS

Auxiliary relays shall be the general purpose industrial type, and shall be the dust cover enclosed plug-in type.

6. SIGNAL LIGHTS

Red signal lights shall be used for "ON" position and green lights for "OFF" position.

Color caps shall be made of a material which will not be softened by the heat from the lamps.

Each signal light shall be provided with an auxiliary transformer.

16.2.8 INSTALLATION

The high voltage switchgear shall be mounted on steel channels which are installed on the concrete floor. The channels shall cover the full length of the switchgear and shall be installed level in all directions.

The switchgear shall be maintained in an upright position at all times. Lifting shall be only at the floorsills or the top mounted lifting angle.

The switchgear shall be protected against damage at all times. Any damage to the paint shall be carefully repaired using touch-up paint furnished by the switchgear manufacturer.

DIVISION 16 ELECTRICAL WORKS

SECTION 16.3 POWER TRANSFORMERS

16.3.1 GENERAL

1. GENERAL

The Contractor shall furnish and install all power transformers as hereinafter specified and as shown on the drawings.

2. REFERENCES

The following standards or other internationally accepted standards or manufacturer's standards as approved by the Engineer are referred to.

IEC 60060	High-Voltage Test Techniques
IEC 60071	Insulation Co-ordination
IEC 60076	Power transformer
IEC 60137	Insulating Bushings for Alternative Voltage above 1000 V
IEC 60214	On-load tap-changers
IEC 60354	Loading guide for oil-immersed power transformer
IEC 60542	Application guide for on-load tap-changers
IEC 60551	Determination of transformer and reactor sound levels
IEC 60616	Terminal and tapping markings for power transformer
JIS C 2320	Electrical insulating oils
JIS C 4304	6kV Oil-immersed distribution transformer
JEC 204	Power transformer

16.3.2 SCHEDULE

The power transformers schedule will be specified in the Particular Specifications.

16.3.3 TYPE, RATING AND CHARACTERISTICS

1. OIL IMMERSED TYPE

The type, ratings and characteristics of power transformers and bushings shall be as follows:

	NOMINAL VOLTAGE	NOMINAL VOLTAGE	NOMINAL VOLTAGE	NOMINAL VOLTAGE
	35 kV	11 kV	6 kV	3.3 kV
a. Type	: Indoor or waterproof outdoor, Oil-immersed type			
b. Type of cooling	: Natural Air-cooled			
c. Number of phase	: Three(3)-phase		: Three(3)-phase, four(4)-wire	
d. Rated frequency	: 50 Hz			
e. Rated	: Continuous			
f. Lightning impulse withstand voltage (peak)				
- Primary (kV)	: 200	90	60	45
- Secondary (kV)				
6.6 kV	: 60	60	-	-
3.3 kV	: 45	45	45	-
380 V	: -	4	4	4
- Neutral low-voltage	: Same as the above secondary voltage			
g. Power frequency withstand voltage				
- Primary	: 70	28	22	16
- Secondary				
6.6 kV	: 22	22	-	-
3.3 kV	: 16	16	16	-
380 V	: -	4	4	4
h. Vector group	: Dd0	Dd0	Dy11	Dy11
i. Off load tap Changer	: Rated voltage tap with four (4)-full taps			
j. Impedance voltage				
at rated current (%)	: 7.5	5.0	3.5	3.5
k. Temperature rise				
- Winding (resistance method)	: Not exceed 55 degree C			
- Oil (thermometer method)				
average	: Not exceed 50 degree C			
maximum	: Not exceed 65 degree C			
top oil	: Not exceed 55 degree C			
l. Audio sound levels	: Not exceed 70 decibels in accordance with the applied standards			

2. DRY MOLDED TYPE

The type, ratings and characteristics of power transformers and bushings shall be as follows:

	NOMINAL VOLTAGE 22 kV	NOMINAL VOLTAGE 6 kV	NOMINAL VOLTAGE 3.3 kV
a. Type	:	Indoor, epoxy resin molded type	
b. Type of cooling	:	Natural Air-cooled	
c. Number of phase	:	Three (3) -phase	Three (3)-phase, four (4)-wire
d. Rated frequency	:	50 Hz	
e. Rated	:	Continuous	
f. Lightning impulse withstand voltage (peak)			
- Primary (kV)	: 95	35	25
- Secondary 6.6 (kV):	35	-	-
3.3 (kV):	25	25	-
380 (V):	4	4	4
- Neutral low-voltage	:	Same as the above secondary voltage	
g. Power frequency withstand voltage			
- Primary (kV)	: 50	16	10
- Secondary 6.6 (kV):	16	-	-
3.3 (kV):	16	16	-
380 (V):	4	4	4
h. Vector group	: Dd0	Dy11	Dy11
i. Off load tap Changer	:	Rated voltage tap with four (4)-full taps	
j. Impedance voltage			
at rated current (%)	: 5.0	5.0	5.0
k. Class of insulation	:	B Class	
l. Winding temperature rise			
(resistance method)	:	Not exceed 75 degree C	
m. Audio sound levels	:	Not exceed 70 decibels in accordance with the applied standards	

16.3.4 35 kV AND 11 kV CLASS CONSTRUCTION

1. TANKS

The transformer shall be provided with a steel case of substantial construction, which shall be oil-tight.

The tanks shall be suitable for filling in the field under 1 kilogram per square centimeter vacuum. Vacuum pumps and any other necessary equipment shall be furnished by the Contractor to permit evacuation of the tanks preparatory to filling with oil if necessary. This equipment will remain the property of the Contractor.

The tanks shall also have suitable jacking boss, lifting eyes and pulling lugs. The transformer tank shall be provided with a fabricated or structural steel base. The base shall be designed and built so as to allow skidding or moving on rollers in either direction. Flat base plates are not acceptable.

2. CORES

Cores shall be constructed of high quality, non-aging high permeability silicon steel. The steel shall be in thin laminations, annealed after cutting and rolled to ensure smooth surfaces at the edges.

Both sides of each sheet shall be insulated with a durable, heat-resistant baked enamel or varnish.

The cores shall be rigidly clamped to ensure adequate mechanical strength to support the windings and to prevent shifting of laminations during shipment, and also to reduce vibration to a minimum during operation.

3. TRIPPING AND CLOSING

Tripping and closing shall be controlled by AC.220V power from UPS.

4. WINDINGS

The windings shall be of the best modern design.

Coils shall be made up, shaped, and braced to provide for expansion and contraction due to temperature changes in order to avoid abrasion of insulation and to provide rigidity to resist movement and distortion caused by abnormal operating conditions. Adequate barriers shall be provided between the windings and the core. End coils shall have extra protection against abnormal line disturbances.

The coils shall be wound and supported in a manner to provide sufficient oil ducts which will be maintained without obstruction. End coils shall have extra insulation.

The assembled core and coils shall be vacuum dried, immediately impregnated, and immersed in dry oil.

5. TAP CHANGERS

Tap changing equipment shall be furnished.

The tap changers shall be designed so that they can be operated conveniently by a man standing on the same level as the transformer base, and shall include an operating hand wheel or handle, indicating pointer and dial, and means for locking the tap changer in any desired position.

The locking device shall be arranged to prevent locking the tap changer in the off position.

A lock, two (2) keys and one master key shall be provided for each operator.

6. BUSHINGS

The bushings shall conform to the applied standard.

All porcelain parts shall be one piece. Porcelain parts constructed of assembled segments will not be acceptable. Threaded studs shall be furnished on all bushings.

All bushings shall be interchangeable between items of like voltage.

7. TERMINAL CONNECTORS

Expansion-type terminal connectors shall be furnished and equipped with an alignment guide.

The size of conductor and method of take-off will be furnished when shop drawings are submitted by the Contractor for approval.

8. INSULATING OIL

The insulating oil furnished for use in the power transformers shall be pure mineral oil prepared and refined especially for use in transformers and shall be compatible with the oil remaining on the core and coils after factory testing of the transformers.

The oil shall be shipped in non-returnable steel drums which shall become the property of the Employer. PCB type oils will not be acceptable.

9. OIL PRESERVATION SYSTEM

The transformer shall be provided with an oil preservation system in which the transformer oil cannot come in contact with the outside air.

The system may be either the diaphragm-sealed constant pressure type, gas-oil-sealed conservator or expansion tank type.

The sudden pressure relay shall have alarm contacts operated by an accumulation of gas, produced by incipient fault and shutdown contacts, operated by a sudden flow of oil from a heavy fault.

10. COOLING EQUIPMENT

The transformers shall be designed with a sufficient number of radiators or cooling units to operate as natural air-cooled units.

Radiators shall be connected to the transformer tank by machined-steel-flanges with the flanges welded to the radiator and to the tank, and the flanges shall be provided with gaskets.

Radiator valves shall be installed on each radiator connection, so that any individual radiator may be removed without taking the transformer out of service.

An oil tight blank flange shall be provided for each connection, for use when radiators are detached. Each radiator shall have a lifting eye, an oil drain, and a vent.

If cooler units furnished are of the finned-tube type; tubes, fins, and tube sheets shall be of corrosion resistant material and shall be designed to permit replacement of individual cooler tube groups.

11. TERMINAL CABINET, DUCT AND WIRING

The Contractor shall furnish and install where practicable, metal conduit and duct for wiring the accessories. The conduit duct shall be suitably connected to the transformer accessories and shall be connected to a terminal cabinet upon the transformer tank.

Within the terminal cabinet shall be mounted a terminal board to facilitate completing the wiring to external circuits.

The Contractor shall furnish and install, where practicable, cable and wire required for connecting the accessories and terminal board. The bottom of the terminal cabinet shall be equipped with removable blank cover plates.

12. ON-LOAD TAP CHANGER

On-load tap changing equipment shall be furnished to provide the characteristics and features outlined below.

The equipment shall be designed to withstand full-voltage short-circuit conditions and also to initiate and complete any desired tap change under full-voltage short-circuit conditions.

For regulation of voltage, the circuits and components shall be arranged so that with a constant voltage held on any high or low-voltage rated kVA tap, the equipment will operate to provide + 10% voltage regulation of the low or high-voltage transformer terminals.

The on-load tap changer taps may be located wherever necessary in the windings or circuits to produce the desired result. A series transformer may be used if necessary.

Power transformer tank shall include :

- a. Series transformer (if required by design)
- b. Preventive resistor
- c. Current transformer for line-drop compensator
- d. Primary current determined by rating and design

Separate oil-filled compartment shall include :

- a. Tap selector switch and contractor mechanism, with reversing or transfer switch
- b. Mechanical stops at limits of switch movement
- c. Compartment breather
- d. Liquid-level gage, similar to gage used on transformer tanks, with alarm contact
- e. Drain and filling valve, screw-end globe valve

Separate air-filled compartment shall include :

- a. Static control equipment, including :
 - 1) Voltage-level circuit with hemostatic adjustment and test rheostat
 - 2) Bandwidth circuit with rheostatic adjustment
 - 3) Time-delay circuit with rheostatic adjustment
 - 4) Line-drop compensator with resistance and reactance adjustments
 - 5) Reactance reversing switch
 - 6) Band edge test lights and switch
 - 7) Potential circuit breaker
 - 8) Output-voltage test terminals
 - 9) Potential-supply input terminals and disconnect
- b. Drive motor-380 or 220 V ac., 50 Hz.
- c. Provision for manual operation with electrical interlock with drive motor
- d. Position indicator with drag hands and electrical limit switches in motor control circuit
- e. Motor drive power-supply switch with thermal breaker
- f. Operation counter
- g. Lamp with manual switch for compartment illumination
- h. Convenience outlet
- i. Strip heater
- j. Terminal blocks for customer connection

- k. Conduit entrance in bottom of compartment
- l. Limit switches for upper and lower limit
- m. Contacts for remote indication of "OFF" and "ON" positions.

For remote control, equipment shall include:

- 1) Selsyn position indicating transmitter at the transformer
- 2) At the remote station:
 - "MANUAL-OFF-AUTO" selector switch
 - "LOWER-OFF-RAISE" switch
 - Selsyn position indicating receiver

13. ANNUNCIATORS

There shall be included all necessary devices and at least one set of alarm contacts for the following annunciation functions:

- | | | |
|----|------------------------------|------------|
| a. | Top oil temperature | "HIGH" |
| b. | Winding temperature | "HIGH" |
| c. | Oil level | "LOW" |
| d. | Mechanical relief | "OPERATED" |
| e. | Sudden pressure relay | "TRIPPED" |
| f. | Auxiliary power | "OFF" |
| g. | Nitrogen (if used) | |
| | Pressure in transformer tank | "LOW" |
| | Pressure in transformer tank | "HIGH" |
| | Bottle pressure | "LOW" |
| h. | Gas accumulation | "HIGH" |

(if sealed bladder type oil preservation is used in place of nitrogen blanket)

The contacts of all relays, gauges, and thermometers shall be insulated from ground and shall be of a positive, snap-action or mercury type. Separate alarm-relay devices may be furnished if desired.

14. ACCESSORIES

All accessories shall be furnished with each power transformer. The accessories shall include but not be limited to the following.

14.1 Oil-immersed type

- a. Dial-type liquid and winding thermometers with alarm contacts

- b. Oil-level gauge, with low-level alarm contacts
- c. Pressure-vacuum gauge
- d. Pressure relief device with alarm contacts and provision to prevent any ruptured parts from falling into the transformer oil
- e. Oil drain and exhaust valves
- f. Oil sampling device
- g. Upper and lower filter-press connections
- h. Diagrammatic name plate
- i. Oil inlet-outlet valves
- j. Oil strainers, if required
- k. Two (2) ground terminal connectors for copper table.
Size of cable will be furnished at the time shop drawings are submitted by the Contractor
- l. Suitable handholds or manholes for servicing
- m. Sudden pressure relay with one alarm contact and one trip contact
- n. Terminal box
- o. Skid base and foundation bolts
- p. Ladder and safety flap
- q. Nitrogen gas cylinder and regulators (if used)
- r. Dehydrating breather
- s. Bus duct and Cable duct
- t. Primary and secondary connection terminals

14.2 Dry - molded Type

- a. Dial type winding thermometers with alarm contacts.
- b. Diagrammatic name plate
- c. Skid base and mounting material
- d. Two (2) ground terminal connectors for copper table.
Size of cable will be furnished at the time shop drawings are submitted by the Contractor

16.3.5 TESTS

In the testing, the Contractor shall take the precautionary measures to protect all staff of the Employer, the Engineer and the Contractor, and third party from physical injury.

1. FACTORY TESTS

The power transformers shall be completely assembled at the factory. The transformer shall be subject, unless otherwise noted, to the following tests by the Contractor.

- a. Verification of construction
- b. Mechanical operation tests
- c. Electrical operation tests
- d. Measurement of winding resistance
- e. Polarity tests
- f. Voltage ratio and vector relationship tests
- g. Induced potential tests
- h. Impedance voltage and short-circuit impedance tests
- i. Load loss tests
- j. No-load loss and current tests
- k. On-load tap changers tests
- l. Power frequency withstand voltage tests
- m. Temperature rise tests
- n. Lightning impulse withstand voltage tests
- o. Short-time current tests
- p. Short circuit current tests
- q. Acoustic sound level tests
- r. Weather proofing tests
- s. Accessories and spare parts tests

2. FIELD TESTS

After installation, the following tests shall be executed before energizing:

- a. Verification of construction
- b. Mechanical operation tests
- c. Electrical operation tests
- d. Measurement of winding resistance
- e. Voltage ratio and vector relationship checks
- f. Insulation oil check
- g. Operation test of on-load tap changer

- h. Power frequency withstand voltage tests
- i. Acoustic sound level tests
- j. Weather proofing tests
- k. Accessories and spare parts tests

3. IMPULSE TESTS

These tests shall be performed in the presence of the Engineer's inspector and representative of the Employer.

The tests shall be performed on the high voltage winding, without normal frequency excitation. Ungrounded terminals not being tested may be protected by a gap, provided the gap does not flash-over during the test.

The Contractor may perform any other impulse tests desired after the initial reduced-wave and prior to the last two chopped-wave and the final full-wave tests.

No impulse testing shall be performed after the tests are accepted.

DIVISION 16 ELECTRICAL WORKS

SECTION 16.4 HIGH-VOLTAGE DISCONNECTING SWITCHES

16.4.1 GENERAL

1. GENERAL

The Contractor shall furnish and install all high-voltage disconnecting switches as hereinafter specified and as shown on the drawings.

2. REFERENCES

The following standards are referred to:

IEC 60060	High-voltage test Techniques
IEC 60129	Alternating Current disconnectors and earthing switches
JIS C 4606	6.6 kV Disconnectors for indoor use

16.4.2 SCHEDULE

The high-voltage disconnecting switches schedule will be specified in the Particular Specifications.

16.4.3 TYPE, RATING AND CHARACTERISTIC

The type, ratings and characteristics of high-voltage disconnecting switches shall be as follows:

	NOMINAL VOLTAGE	NOMINAL VOLTAGE	NOMINAL VOLTAGE	NOMINAL VOLTAGE
	35 kV	11 kV	6 kV	3.3 kV
a. Type	: Indoor or outdoor, three (3) - pole, single-throw, vertical or horizontal break, group operation type			
b. Number of phases	: Three (3) - Phase			
c. Rated frequency	: 50 Hz			
d. Rated voltage	: 36	12	7.2	3.6
e. Lightning impulse withstand voltage (kV)	: 200	90	60	45
f. Power frequency withstand voltage (kV)	: 70	28	25	19
g. Rating operating and control voltage				
- DC	:	100V ± 25V		
- AC (r.m.s.)	:	220V ± 22V		
		33V		
h. Rated operation air pressure (kg/cm ²)	:	15		

16.4.4 CONSTRUCTION

1. CONSTRUCTION

The main high voltage disconnecting switch shall be complete with bases, insulators, contacts, and terminal blades. Operating mechanism shall include motor or pneumatic driving device, operating pipes, interface shafts, pipe couplings, guide bearings, ground braids, mounting brackets, mounting bolts, operating handle and auxiliary switches required for operating from the ground.

The operating mechanism shall be so designed and fabricated that it will not cause excessive deflections in the members to which it is attached.

All operating rods and levers shall be cut to length and all machining operations and threading shall be completed in the factory.

The operating mechanism shall have provisions for grounding and for padlocking in the open and closed positions. All switch bases, operating mechanisms, operating rods and other steel parts shall be hot-dip galvanized after all machining and threading operations have been completed.

All breaker disconnect switches shall be suitable for mounting in a horizontal, vertical break position. Switch base shall be drilled to match the drilling of the switch support stands.

The switch terminal pads shall be machined flat and tin plated to assure a low resistance current transfer and to prevent formation of aluminium oxide. Each terminal shall be furnished with a bolted type connector.

2. ACCESSORIES

All accessories shall be furnished with high-voltage disconnecting switches. The accessories shall include but not be limited to the following:

- a. Motor driven device, or pneumatic driven with the air-compressor and air-tank device
- b. Auxiliary switch
- c. Position indicator (lamp and mechanical indicator)
- d. Key mechanical interlock
- e. Supporting structures made of galvanized steel
- f. Two (2) - handles (common type for all the same type switches)
- g. Hand-operated set with locking device
- h. Operating panel with wiring to complete to terminal blocks for remote control

16.4.5 TESTS

1. FACTORY TESTS

The high-voltage disconnecting switches shall be completely assembled at the factory. The disconnecting switches shall be subject, unless otherwise noted, to the following tests by the Contractor.

- a. Verification of construction
- b. Mechanical operation tests
- c. Electrical operation tests
- d. Resistance measuring tests
- e. Temperature rise tests
- f. Short-time current tests
- g. Withstand voltage tests

2. FIELD TESTS

After installation, the following tests shall be executed before energizing:

- a. Verification of construction
- b. Mechanical operation tests
- c. Electrical operation tests
- d. Resistance measuring tests
- e. Temperature rise tests
- f. Short-time current tests
- g. Withstand voltage tests

DIVISION 16 ELECTRICAL WORKS

SECTION 16.5 HIGH VOLTAGE CIRCUIT BREAKERS

16.5.1 GENERAL

1. GENERAL

The Contractor shall furnish and install all high-voltage circuit breakers as hereinafter specified and as shown on the drawings.

2. REFERENCES

The following standards are referred to:

IEC 62271	High-voltage switchgear and controlgear
IEC 60060	High-Voltage Test Techniques
IEC 60137	Insulating Bushings for Alternating Voltage above 1000 V
JIS C 4603	A.C. Circuit Breakers for 3.3 kV or 6.6 kV
JEC 181	A.C. Circuit Breakers

16.5.2 SCHEDULE

The high-voltage circuit breakers schedule will be specified in the Particular Specifications.

16.5.3 TYPE, RATING AND CHARACTERISTICS

The type, ratings and characteristics of high-voltage circuit breakers shall be as follows.

NOMINAL VOLTAGE	NOMINAL VOLTAGE	NOMINAL VOLTAGE	NOMINAL VOLTAGE
35 kV	11 kV	6 kV	3.3 kV

a. Type	:	Indoor or outdoor, single-throw, vacuum or sulfur-hexafluoride (SF6) gas filled type			
b. Form	:	Draw-out type			
c. Number of phases	:	Three (3) - Phase			
d. Rated frequency	:	50 Hz			
e. Rated voltage (kV)	:	36	12	7.2	3.6
f. Lightning impulse withstand voltage (kV)	:	200	90	60	45
g. Power frequency withstand voltage (kV)	:	70	28	22	16
h. Rated operating duty	:	CO - 1 minute - CO - 3 minute - CO			
i. Interrupting time	:	5-cycle			
j. Rated operating and control voltage	:				
- DC	:	100V ± 25V			
- AC	:	220V ± 22V			
		33V			
k. Rated operating pressure (MPa)	:	1.47			

16.5.4 VACUUM TYPE AND SF6-GAS FILLED TYPE

The vacuum circuit breaker or the sulfur-hexafluoride (SF6) gas filled unit serve the same purpose in the substation; therefore, either must have the equivalent or better ratings than those given, must be operated under the same conditions and must perform the same functions described below.

Either unit shall be of the three (3) vertical pole type mounted on a common horizontal base which contains the operating mechanism. The gas filled unit shall use a puffer cylinder to aid in extinguishing the air.

16.5.5 CONSTRUCTION

1. CLOSING MECHANISM

1.1 69 kV Class

The closing mechanism shall be pneumatic driven with the breaker closed and tripped by action of springs. The closing mechanism shall also be capable of manual operation. The mechanism shall be designed so that the breaker cannot be closed under any conditions unless the system is fully charged. The closing mechanism shall be designed to allow closing if control power is lost.

Slow closing of the breaker shall be provided for checking of contact adjustment.

The mechanism shall be trip free in any position and shall include a motor driven compressor and air tank, ten stage auxiliary switch with silver plated contact surfaces, operation counter, instrument and control panel, space heaters, position and terminal blocks.

All heaters and other accessories required for the operation of the breaker shall be included and shall be connected for operation from one power supply circuit of 380/220 V, 3-phase, 4 wire, 50 Hz.

All breaker control wiring shall be complete and wired to terminal blocks to facilitate remote control.

1.2 33 kV and 11 kV Class

The closing mechanism shall be 220 V AC motor driven spring charged operation. The closing mechanism shall also be capable of manual operation. The mechanism shall be designed so that the breaker cannot be closed under any conditions unless the spring is fully charged.

The mechanism shall be trip free in any position and shall include auxiliary contact, operation counter, position indicator, space heater and terminal blocks.

1.3 6.6 kV-and 3.3 kV Class

The circuit breaker shall have a motor operated stored energy, spring-driven mechanism or solenoid.

The mechanism shall pre-charge immediately after a closing operation, or upon insertion of the removable breaker into the stationary structure, so that the breaker may be tripped and closed manually if control power is subsequently lost.

The stored energy mechanism shall be capable of manual charging. Circuit breaker shall have automatically engaging and disengaging primary and secondary contacts.

Automatic metal safety shutters shall close the entrance to the stationary primary disconnecting devices when the circuit breaker is withdrawn or in test position.

Interlock shall be furnished to prevent racking of a closed breaker from any position. Interlocks shall be provided to automatically discharge the closing springs on insertion or removal of the breaker.

Provisions for manual closing and opening and slow closing of the main contacts shall be furnished.

2. TRIPPING AND CLOSING

Tripping and closing control power shall be obtained from DC. supply equipment (DC. 100V).

Interposing relays shall be provided in the close and trip circuits for remote control of the circuit breakers.

Local test switch shall be provided for electrically testing the closing and tripping operations of the circuit breaker.

A separate manually operated cutout device to disconnect the circuits from remote closing and tripping devices shall be provided on each circuit breaker. This cutout device shall be mechanically interlocked with the test switch to prevent operation of the breaker from remote closing, reclosing or tripping devices during test operation of the breaker.

The control circuit for each local "close" test switch shall be brought out to terminal blocks so that positions associated with the circuit breaker disconnect switches can be wired to prevent closing any circuit breaker by the local close switch unless the associated disconnect switches are open.

3. BUSHING TYPE CURRENT TRANSFORMERS

Bushing type current transformer shall be furnished for differential protection and metering.

Current transformer shall have double-ratio winding and mounted on bushings of circuit breaker.

All secondary leads from current transformer shall be brought to short-type terminal blocks located in the mechanism housing.

4. AUXILIARY POWER AND CONTROL CIRCUITS

All auxiliary power, control and alarm circuits requiring connection to external circuits shall be brought to suitable terminal blocks marked with circuit identification in accordance with the manufacturer's wiring diagram as approved by the Engineer. These terminal blocks shall be located in a common weatherproof housing.

The circuit breaker shall be provided with 100V dc control power disconnecting and protective devices and one AC 380/220V, 3-phase, 4-wire, 50 Hz, control power disconnecting and protective device consisting of a molded case circuit breaker or an enclosed fuse pull out. One shall be used in the DC closing circuit, one in the DC tripping circuit and the other for AC control power.

5. ACCESSORIES

All accessories shall be furnished with each breaker. The accessories shall include but not be limited to the following :

5.1 69 kV Class

- a. Motor driven device pneumatic driven with air compressor and air tank device
- b. 220 V AC thermostatically controlled space heaters for the mechanism housing
- c. Auxiliary switch
- d. Operation counter
- e. Operating panel shall be vermin, dust and moisture proof and provides with wiring complete to terminal blocks for remote control.
- f. Position indicator (lamps and mechanical indicator)
- g. Local test switch
- h. Cutoff and latch checking switches
- i. Two (2) maintenance closing devices
- j. A suitable nameplate showing all ratios of the bushing current transformers shall be mounted either on the circuit breaker frame or inside the control panel
- k. Air valves, air pressure gage, air pressure switch and piping
- l. Supporting structures made of galvanized steel

5.2 33 kV and 11kV Class

- a. Motor driven spring charging mechanism
- b. 220 V AC thermostatically controlled space heater for the mechanism housing
- c. Auxiliary switch
- d. Operation counter
- e. Position indicator (lamps and mechanical indicator)
- f. Operating panel with wiring complete to terminal blocks
- g. Control switch (local control only)
- h. Manual spring charging handle
- i. Nameplate including bushing type current transformer
- j. Supporting structures made of galvanized steel
- k. Three (3)-phase surge capacitors
- l. Maintenance lifter and cart for circuit breaker

5.3 6.6 kV and 3.3 kV Class

- a. Secondary couplers
- b. Auxiliary switch
- c. Operation counter

- d. Operation cabinet with wiring complete to terminal blocks for remote control
- e. Position indicator (lamp and mechanical indicator)
- f. Three (3)-phase surge capacitors
- g. Local test switch
- h. Interlocked switch
- i. Two (2)-maintenance closing devices
- j. Nameplate
- k. Maintenance lifter and cart for circuit breaker

6. SPARE PARTS

The following spare parts shall be furnished for each circuit breaker.

The spare parts shall include but not be limited to the following:

- a. Three (3) Complete set of vacuum bulbs
- b. Each one (1) Complete set of closing coil and tripping coil
- c. One (1) Complete set of auxiliary switch
- d. Each Type 500% pieces of lights bulb and fuses
- e. One (1) Complete set of signal lights

16.5.6 TESTS

1. FACTORY TESTS

The circuit breakers shall be completely assembled at the factory. The circuit breakers shall be subject, unless otherwise noted, to the following tests by the Contractor.

- a. Verification of construction
- b. Mechanical endurance and operation tests
- c. Electrical operation tests
- d. Measurement of resistance
- e. Short circuit breaking current tests
- f. Charging current breaking tests
- g. Small inductive current breaking tests
- h. Bushing current transformer tests
- i. Power frequency withstand voltage tests
- j. Temperature rise tests

- k. Lightning impulse withstand voltage tests
- l. Air-compressor tests
- m. Weather proofing tests
- n. Accessories and Spare parts tests

2. FIELD TESTS

After installation, the following tests shall be executed before energizing:

- a. Verification of construction
- b. Mechanical operation tests
- c. Electrical operation tests
- d. Air-compressor tests
- e. Power frequency withstand voltage tests
- f. Accoustic sound level tests
- g. Weather proofing tests
- h. Accessories and spare parts tests

DIVISION 16 ELECTRICAL WORKS

SECTION 16.6 LIGHTNING ARRESTERS

16.6.1 GENERAL

1. GENERAL

The Contractor shall furnish and install all lightning arresters as hereinafter specified and as shown on the drawings.

2. REFERENCES

The following standards or other internationally accepted standards or manufacturer's standards as approved by the Engineer are referred to:

IEC 60099	Surge Arresters
JEC 203	Lightning Arresters

16.6.2 SCHEDULE

The lightning arresters schedule will be specified in the Particular Specifications.

16.6.3 TYPE, RATING AND CHARACTERISTICS

The type, ratings and characteristics of lightning arresters shall be as follows:

	NOMINAL VOLTAGE	NOMINAL VOLTAGE	NOMINAL VOLTAGE	NOMINAL VOLTAGE
	35 kV	11 kV	6 kV	3.3 kV
a. Type	: Indoor or outdoor, single-pole, metal oxide, gapless type			
b. Form	: Drawout type			
c. Number of phase	: Three (3)-Phase			
d. Rated frequency	: 50 Hz			
e. Rated voltage (kV)	: 42	14	8.4	4.2
f. Lightning impulse withstand voltage	: 200	90	60	45
g. Power frequency withstand voltage (kV)	: 70	28	22	16
h. Impulse sparkover voltage - 10,000 A (kV)	: 130	45	33	17
i. Slow wave sparkover voltage - 10,000 A (kV)	: 130	45	33	17
j. Residual voltage current characteristics	:	8 x 20 microseconds		
k. Maximum residual voltage - 10,000 A (kV)	: 269	94	33	17
- 5,000 A (kV)	: -	100	33	17

16.6.4 ACCESSORIES

All accessories shall be furnished with each lightning arrester. The accessories shall include but not be limited to the following:

- a. Impulse counter four (4)-digit, non reset type
- b. Supporting structures made of galvanized steel
- c. Disconnecting switch

16.6.5 TESTS

1. FACTORY TESTS

The lightning arresters shall be completely assembled at the factory. The lightning arresters shall be subject, unless otherwise noted, to the following test by dry condition.

- a. Verification of construction. Verification will be made on construction, name plate data and other accessories and the quality of construction and the completeness of accessories will be checked
- b. Power frequency sparkover voltage test. The lowest value of sparkover voltages for the arrester shall not be less than the specified value.
- c. Impulse sparkover voltage test. Testing voltage: 100% sparkover voltage for arrester shall be below the value.
- d. Power frequency withstand voltage tests
- e. Lightning impulse withstand voltage tests
- f. Insulation resistance test and leakage current tests

Insulation resistance of series gaps, non-linear resistors and high resistance grading ring shall be measured and they shall be confirmed to be within the guaranteed values.

Grading current tests shall be made to measure the grading current at the voltage of 100, 60 and 40% of its voltage rating, and their values shall be confirmed to be within those of the guarantee.

2. FIELD TESTS

After installation, the following tests shall be executed before energizing:

- a. Verification of construction
- b. Insulation resistance tests
- c. Power frequency withstand voltage tests

DIVISION 16 ELECTRICAL WORKS

SECTION 16.7 INSTRUMENT TRANSFORMERS

16.7.1 GENERAL

1. GENERAL

The Contractor shall furnish and install all instrument transformers as hereinafter specified and as shown on the drawings.

2. REFERENCES

The following standards are referred to:

- IEC 60044-1 Instrument transformers - Part 1: Current transformers
- IEC 60044-2 Instrument transformers - Part 2: Inductive voltage transformers
- JIS C 1731 Instrument Transformers for Testing Purposes and Use with General Instrument
- JEC 190 Instrument Transformers for Protective Relays

16.7.2 SCHEDULE

The instrument transformers schedule will be specified in the Particular Specifications.

16.7.3 TYPE, RATING AND CHARACTERISTICS

The type, ratings and characteristics of instrument transformers shall be as follows.

1. POTENTIAL TRANSFORMER

NOMINAL VOLTAGE	NOMINAL VOLTAGE	NOMINAL VOLTAGE	NOMINAL VOLTAGE
35 kV	11 kV	6 kV	3.3 kV

a. Type

- Outdoor : Oil-filled completely sealed type
- Indoor : Oil-filled Dry epoxy resin molded, built-in completely sealed type

b. Number of phases : Three (3) - Phase

c. Rated frequency : 50 Hz

d. Primary voltage (kV) : 35 11 6.0 3.3

e. Secondary " (V) : 110

f. Accuracy class

- General : 1.0 class
- Tariff metering : 0.5 class

g. Lighting impulse

withstand voltage (kV) : 200 90 60 45

h. Power frequency withstand voltage

- Primary winding (kV) : 70 28 22 16
- Secondary " (kV) : 2 2 2 2

i. Rated burden : 2 x 200 VA more than

j. Polarity : Subtractive

2. GROUNDING POTENTIAL TRANSFORMER

NOMINAL VOLTAGE	NOMINAL VOLTAGE	NOMINAL VOLTAGE	NOMINAL VOLTAGE
35 kV	11 kV	6 kV	3.3 kV

a. Type

- Outdoor : Oil-filled completely sealed type
- Indoor : Oil-filled Dry epoxy resin molded, built-in completely sealed type

b. Number of phases : Three (3) - Phase

c. Rated frequency : 50 Hz

d. Primary voltage (V) : 35 11 6 3.3

e. Secondary " (V) : 110 or 190

f. Tertiary voltage(V) : 110/3 or 190/3

g. Accuracy class

- Secondary : 1.0 class
- Tertiary : 3G class

h. Lighting impulse

withstand voltage (kV) : 200 90 60 45

i. Power frequency withstand voltage

- Primary winding (kV) : 70 28 22 16
- Secondary " " : 12 12 12 12

j. Rated burden : 2 x 200 VA more than

- Secondary : 2 x 200 VA more than

- Tertiary : 3 x 200 VA more than

k. Polarity : Subtractive

3. CURRENT TRANSFORMER

NOMINAL VOLTAGE	NOMINAL VOLTAGE	NOMINAL VOLTAGE	NOMINAL VOLTAGE
35 kV	11 kV	6 kV	3.3 kV

a. Type

- Outdoor : Oil-filled completely sealed type
- Indoor : Oil-filled Dry epoxy resin molded, completely built-in sealed type

b. Number of phases : Single-phase

c. Rated frequency : 50 Hz

d. Primary voltage(kV) : 35 11 6 3.3

e. Secondary Current(A) : 5 5 5 5

f. Accuracy class

- General : 1.0 class
- Tariff metering : 0.5 class

g. Short term current

for one (1) second : 100% x normal interrupting capacity

h. Overcurrent factor : $N > 10$

i. Lighting impulse

withstand voltage(kV) : 200 90 60 45

j. Power frequency withstand voltage

- Primary winding(kV) : 70 280 22 16

- Secondary " " : 2 2 2 2

k. Rated burden : 40 VA more than

l. Polarity : Subtractive

4. ZERO PHASE SEQUENCE CURRENT TRANSFORMER

	NOMINAL VOLTAGE 11 kV	NOMINAL VOLTAGE 6 kV	NOMINAL VOLTAGE 3.3 kV
a. Type	:	Indoor, dry epoxy resin molded type	
b. Number of phases	:	Single-phase	
c. Rated frequency	:	50 Hz	
d. Primary voltage (kV)	: 11	6	3.3
e. Zero-phase current ratio	:	200/1.5 mA	
f. Accuracy class	:	H class	
g. Short-time current for one (1)-second	:	100% x nominal interrupting capacity	
h. Overcurrent factor	:	N > 10	
i. Lighting impulse withstand voltage (kV)	: 90	60	45
j. Power frequency withstand voltage			
- Primary winding (kV)	: 28	22	16
- Secondary winding (kV)	: 2	2	2
k. Rated burden	:	100 VA	
l. Polarity	:	Subtractive	

5. RATED BURDEN

Rated burden of each instrument transformer shall be confirmed by the Contractor in accordance with the total necessary burden of the proposed meters, relays and cables and be responsible for modification of burden when the above mentioned burden is insufficient.

16.7.4 CONSTRUCTION

Current transformer shall be rated to withstand the thermal and magnetic stresses from currents equal to the short time rating of the circuits breakers.

The case shall be welded and weatherproof, finished for outdoor service. If made of ordinary steel it shall be galvanized and painted.

Polarity marks shall be permanent; shall be the integral parts of the transformer; and shall not be obliterated.

The terminal box shall be weatherproof design. The cover of the compartment shall be held by non-corrosive fasteners which are drilled to accommodate the seal wire.

Ground terminals shall be welded to the base plate and be provided with a clamp type connector.

16.7.5 TESTS

1. FACTORY TESTS

The instrument transformers shall be completely assembled at the factory. The instrument transformers shall be subject, unless otherwise noted, to the following tests by the Contractor.

1.1 Potential and Ground Potential Transformers

- a. Verification of construction
- b. Polarity tests
- c. Temperature rise tests
- d. Lightning impulse withstand voltage tests
- e. Power frequency withstand voltage tests
- f. Voltage ratio error tests
- g. Residual voltage tests

1.2 Current and Zero-Phase Sequence Transformers

- a. Verification of construction
- b. Polarity tests
- c. Short time current tests
- d. Temperature rise tests
- e. Secondary circuit open tests
- f. Lightning impulse withstand voltage tests
- g. Power frequency withstand voltage tests
- h. Current ratio error tests
- i. Residual current tests
- j. Over current factor tests

2. FIELD TESTS

After installations, the following tests shall be executed before energied:

- a. Verification of construction
- b. Polarity check

- c. Power frequency withstand voltage tests

DIVISION 16 ELECTRICAL WORKS

SECTION 16.8 POWER CAPACITORS

16.8.1 GENERAL

1. GENERAL

The Contractor shall furnish and install all power capacitors as hereinafter specified and as shown on the drawings.

2. REFERENCES

The following standards or other internationally accepted standards or manufacturer's standards as approved by the Engineer are referred to:

IEC 60831	Shunt power capacitors of the self-healing type for a.c. systems having a rated voltage up to and including 1000 V
IEC 60871	Shunt capacitors for a.c. power systems having a rated voltage above 1000 V
IEC 60931	Shunt power capacitors of the non-self-healing type for a.c. systems having a rated voltage up to and including 1000 V
IEC 60289	Reactors
JIS C 2320	Electrical Insulating Oils
JIS C 4902	High-voltage Power Capacitors and Attached Apparatus

16.8.2 SCHEDULE

The power capacitors schedule will be specified in the Particular Specifications.

16.8.3 TYPE, RATING AND CHARACTERISTICS

The type, ratings and characteristics of power capacitors shall be as follows.

1. POWER CAPACITOR

	NOMINAL VOLTAGE	NOMINAL VOLTAGE
	6 kV	3.3 kV
a. Type	: Indoor, SF6 gas filled type or molded type	
b. Number of phases	: Three (3) - Phase	
c. Rated frequency	: 50 Hz	
d. Rated voltage (kV)	: 6	3.3
e. Maximum voltage	: 11% x Rated voltage	
f. Maximum current	: 135% x Rated current	
g. Lightning impulse withstand voltage (kV)	: 60	45
h. Power frequency withstand voltage (kV)	: 22	16
i. Accessories	: Discharge device	

2. SERIES REACTOR

	NOMINAL VOLTAGE	NOMINAL VOLTAGE
	6 kV	3.3 kV
a. Type	: Indoor, dry (oil-less), hermetically sealed, self-cooled type	
b. Number of phases	: Three (3) - Phase	
c. Rated frequency	: 50 Hz	
d. Circuit voltage (kV)	: 6	3.3
e. Rated capacity	: 6% x Power capacitors	
f. Lightning impulse withstand voltage (kV)	: 60	45
g. Power frequency withstand voltage (kV)	: 22	16

16.8.4 CONSTRUCTION

The enclosure shall be manufactured from steel plates, durable and oil-tight, so that they will not be

damaged during transportation and use, and be processed with rust prevention or corrosion prevention by means of coating and other proper method.

16.8.5 TESTS

1. FACTORY TESTS

The power capacitors shall be completely assembled at the factory. The power capacitors shall be subject, unless otherwise noted, to the following tests by the Contractor:

- a. Verification of construction
- b. Capacity tests
- c. Power frequency withstand voltage tests
- d. Capacitor loss tests
- e. Temperature rise tests
- f. Oil-tightness tests

2. FIELD TESTS

After installation, the following tests shall be executed before energizing:

- a. Verification of construction
- b. Power frequency withstand voltage tests

DIVISION 16 ELECTRICAL WORKS**SECTION 16.9 BATTERY AND CHARGER PANEL****16.9.1 GENERAL****1. GENERAL**

The Contractor shall furnish and install all battery and charger panels as hereinafter specified and as shown on the drawings.

2. REFERENCES

The following standards are referred to:

JIS H 3140	Copper Bus Bars
JIS C 1102	Direct Acting Indicating Analogue Electrical Measuring Instruments and their Accessories
JIS C 1103	Dimensions of Electrical Indicating Instrument for switchboards
JIS C 1731	Instrument Transformer for Testing Purpose and Use with General Instrument
JIS C 4402	Thyrister Rectifier for Floating Charge
JIS C 4901	Low-voltage Power Capacitors
JIS C 8201-4-1	Low-voltage switchgear and controlgear -- Part 4: Contactors and motor-starters, Section 1: Electromechanical contactors and motor-starters
JIS C 8370	Molded Case Circuit Breakers (MCCB)
JIS C 8371	Residual Current Operated Circuit Breakers
JIS C 8374	Residual Current Sensing and Relaying Equipment
JEM 1195	Motor control center
JEM 1265	Low-voltage metal-enclosed switchgear

16.9.2 SCHEDULE

The battery and charger panel schedule will be specified in the Particular Specifications.

16.9.3 TYPE, RATING AND CHARACTERISTICS

The type, ratings and characteristics of battery and charger panel shall be as follows:

- a. Type : Self-supported, metal-enclosed, indoor, battery built-in type
- b. Rated insulation voltage
 - Main circuit : 600V AC. r.m.s

- Control Circuit: 250V AC. r.m.s
- c. Rated operation voltage
 - Input : 380V AC. Three (3)-phase
 - Output : 110V DC
- d. Input rated frequency : 50 Hz
- e. Power frequency withstand voltage
 - Main circuit : 2,500V AC.
 - Control Circuit: 1,500C AC.
- f. Rated operating and control voltage
 - DC : 100V \pm 25V
 - AC : 220V + 22V
 - 33V

16.9.4 CONSTRUCTION

The battery and charger panel shall be fabricated from flat rolled steel panel, reinforced where necessary, in such a manner that the complete structure shall be rigid and free from twist and weave during handling and after installation.

The front shall be fabricated not less than 3.2 mm thick steel and other parts shall be fabricated not less than 2.3 mm thick steel.

The complete battery and charger panel including circuit breakers transformer, thyristor and reactor shall be capable of withstanding without damage the electro-magnetic and thermal stresses resulting from the maximum asymmetrical value of the short-circuit current.

The panel shall be provided with lockable hinged front door and removable panels of adequate thickness on rear and bottom.

Provisions shall be made for bottom plate for bottom entry of power and control cable.

For safety of operating personnel, it is essential that should an arc develop in any one of the compartments it shall be confined to that compartment without affecting the other compartments.

The panel shall be equipped with a space heater, a lamp and consent.

The panel shall be furnished as a completely factory-assembled unit where transportation facilities and installation requirements permit.

16.9.5 TESTS

1. FACTORY TESTS

The battery and charge panels shall be completely assembled at the factory. The panels shall be subject, unless otherwise noted, to the following tests by the Contractor:

- a. Verification of construction
- b. Voltage current characteristic test
- c. Temperature test
- d. Efficiency test
- e. Power frequency withstand voltage test
- f. Acoustic sound level test
- g. Mechanical operation tests
- h. Electrical operation tests
- i. Accessories and spare parts tests

2. FIELD TESTS

After installation, the following tests shall be executed before energized:

- a. Verification of construction
- b. Mechanical operation tests
- c. Electrical operation tests

16.9.6 EQUIPMENT INCLUDED

The battery and charger panel shall include the necessary equipment presented herein.

1. BATTERY

Battery shall be of the nickel-cadmium type having cells contained in heat resistant, transparent, high impact plastic containers.

Cell containers shall be clearly marked to show the maximum and minimum levels of electrolyte, and shall be provided with vented filler plugs.

Cells shall be numbered consecutively. Cell terminals shall be of robust construction and shall be permanently marked to show their polarity.

Battery trays shall be factory treated with an electrolyte corrosion resistant finish, plastic coatings.

Battery shall be of the following type and ratings:

- | | |
|---------------------------------------|--|
| a. Type: | Nickel-cadmium, pocket alkaline high discharge rate type (AMH) |
| b. Number of cells: | 86 cells |
| c. Float charging voltage: | 1.45 V/cell |
| d. Boost/Equalizing charging voltage: | 1.6 V/cell |
| e. Nominal voltage: | 103.2 V (all cells) |
| f. Battery temperature: | 25 degrees C |
| g. Final voltage: | 1.06 V/cell |
| h. Nominal ampere-hour: | 5 hour discharge rate |

2. BATTERY CHARGER

Battery charger shall be of the solid state constant voltage type incorporating a self-protecting current limiting feature for protection against low battery volts and short circuits. Reserve battery shall also be provided.

Battery charger shall be suitable for continuous operation in an ambient temperature of 40 degrees C. Their output voltage regulation shall be not less than + 2% irrespective of AC main input variations of + 10% for load variation from 0% to 100%.

Battery charger shall have the following type and ratings :

- | | |
|-------------------------------------|---|
| a. Type: | "Thyristor rectifier switching type automatic boost/equalizing charge and load voltage compensator" |
| b. Rated: | Continuous |
| c. Temperature rise of components : | |
| Transformerwinding | less than 50 deg. C |
| Silicon diode | less than 85 deg. C |
| Thyristor | less than 65 deg. C |
| Resistor | less than 200 deg. C |

Battery charger shall be fitted with an "ON/OFF" switch, DC-ammeter, DC-voltmeter with selector switch and indicating lamps for "AUTOMATIC CHARGE", "CHARGE OUTPUT FAILED" and other failed.

3. POWER INVERTER

The power inverter shall be designed to invert 110 V DC input power to 220 V AC. 50 Hz. single phase and to have a transfer switch which shall have following features :

- a. Upon power failure, the transfer switch will operate automatically in order to

distribute alternative power from battery, 220 V AC, 50 Hz, single phase which will be inverted by the power inverter.

- b. Even if power supply being restored, the transfer switch will not operate automatically in order to distribute power, 220 V AC, 50 Hz, single phase.
- c. The transfer switch can be manually set to distribute the said power.

4. ACCESSORIES

The following accessories shall be supplied:

a. Maintenance tools	1 set
b. Portable D.C. voltmeter (D-3V, 1.0 class)	1 set
c. Syringe hydrometer (1.1-1.3)	1 set
d. Vent mounted thermometer (0-100 deg.C)	3 sets
e. Mixing tank	1 set
f. Funnel (made of synthetic resin)	3 sets
g. Bottle (made of synthetic resin)	3 sets
h. Requisite quantity of potassium hydroxide with 10% extra	1 set
i. Sufficient quantity of distilled water first filling up	1 set
j. Steel locker for containing accessories	1 set

5. CIRCUIT BREAKER

Circuit breakers shall be the molded case type with auxiliary switch, bolted-in. Circuit breakers shall have an interrupting current value not less than 40,000 A (asymmetrical).

6. ELECTROMAGNETIC SWITCHES

The switch shall be three (3)-pole, 50 Hz, 600V AC. and two (2)-pole 250V DC magnetically operated, as shown on the drawings.

Each motor starter shall have 220V AC or 100V DC operating coil and three (3)- or one (1)- element overload relays. Auxiliary contacts shall be provided as shown on the drawings or as required.

Overload relays shall be adjustable and manually reset.

7. INSTRUMENTS AND RELAYS

Voltmeters, water meters and ammeters shall be not less than 110 mm square, 240 degrees from zero to full scale, + 1.5% of full scale accuracy, panel mounted type and shall be provided with external zero adjustment.

Watt-hour meter shall be draw-out type, rated voltage 110 V and rated current 5A, panel mounted type.

Relays shall be the draw-out, panel mounted, induction disc type.

8. PHASE AND SEQUENCE SELECTOR SWITCHES

Phase and selector switches shall be heavy-duty, rotary type.

9. CONTROL SWITCHES

Control switches shall be twist type or pull switch type. The control switches shall be wear-proof type and arc-proof type, and with dust cover.

10. ANNUNCIATOR

Annunciator and signal light shall be back lighted and shall be relay operated. An alarm condition shall cause the appropriate lamp to light and sound the horn. Pressing the acknowledge button shall silence the horn. The light shall go out when the alarm condition is removed.

11. AUXILIARY RELAYS

Auxiliary relays shall be general purpose industrial types, and shall be the dust cover enclosed plug-in type.

12. SIGNAL LIGHTS

Red signal lights shall be used for "ON" position and green lights for "OFF" position.

Color caps shall be made of a material which will not be softened by the heat from the lamps.

Each signal light shall be provided with auxiliary transformer.

13. TEST TERMINALS

Test terminals shall be furnished secondary circuit of the potential transformer and the current transformer. All matching test plugs shall be furnished. Test plugs and lead wires for each type of protective relay shall be furnished.

16.9.7 INSTALLATION

The battery and charger panel shall be mounted on steel channels. The steel channels shall be installed on the concrete floor. The channels shall have the full length for the battery and charger panel and shall be installed at a level in all directions.

The battery and charger panel shall be maintained in an upright position at all times. Lifting shall be only at the floorsills or the top mounted lifting angle.

The battery and charger panel shall be protected against damage at all times. Any damage to the paint

shall be carefully repaired using touch-up paint furnished by battery and charger panel manufacturer.

DIVISION 16 ELECTRICAL WORKS**SECTION 16.10 LOW VOLTAGE SWITCHGEAR****16.10.1 GENERAL****1. GENERAL**

The Contractor shall furnish and install all low-voltage switchgear and metal enclosed bus duct as hereinafter specified and as shown on the drawings.

2. REFERENCES

The following standards are referred to.

IEC 60947-1	Low-voltage switchgear and controlgear - Part 1: General rules
IEC 60439	Low-voltage switchgear and control gear assemblies
JIS H 3140	Copper Bus Bars
JIS C 1102	Direct acting indicating analogue electrical measuring instruments and their accessories
JIS C 1103	Dimensions of Electrical Indicating Instruments for Switchboards
JIS C 1216	Alternating-current Watt-hour Meters (for Connection through Instrument Transformer)
JIS C 1731	Instrument Transformer for Testing Purpose and Used with General Instrument
JIS C 8201-4-1	Low-voltage switchgear and controlgear -- Part 4: Contactors and motor-starters, Section 1: Electromechanical contactors and motor-starters
JIS C 8370	Molded Case Circuit Breakers (MCCB)
JIS C 8371	Residual Current Operated Circuit Breakers
JIS C 8374	Residual Current Sensing and Relaying Equipment
JEM 1195	Motor control center
JEM 1265	Low-voltage metal-enclosed switchgear

16.10.2 SCHEDULE

The low-voltage switchgear enclosed bus duct schedule will be specified in the Particular Specifications.

16.10.3 TYPE, RATING AND CHARACTERISTICS

The type, ratings and characteristics of the low-voltage switchgears and enclosed bus duct shall be as follows.

- | | | |
|----|------------------------------------|---|
| a. | Type | : Indoor, self-supported, metal-enclosed type |
| b. | Number of phases | : Three (3)-phase, four (4)-wire |
| c. | Rated frequency | : 50 Hz. |
| d. | Rated insulation voltage | |
| | - Main circuit | : 600V AC r.m.s |
| | - Control circuit | : 250V AC r.m.s |
| e. | Rated operation voltage | |
| | - Main circuit | : 380V AC |
| | - Control circuit | : 220V AC or 100V AC |
| f. | Power frequency with-stand voltage | |
| | - Main circuit | : 2,500V AC r.m.s |
| | - Control circuit | : 1,500V AC r.m.s |

16.10.4 CONSTRUCTION

The low-voltage switchgear shall be provided to be connected on low-voltage circuits of nominal voltage 600V AC.

The low-voltage switchgear shall be comprised from panels of air circuit breakers, molded case circuit breakers and instrument transformers.

Each switchgear shall be segregated by earthed metallic partitions or insulating partitions.

The switchgear enclosure type shall conform to "JEM-1265, AX form", as shown on the drawings.

Withdrawable type shall be provided with a self coupling primary circuit disconnecting device and a manual coupling control circuit disconnecting device.

Withdrawable circuit breakers shall be provided with interlocking not to be withdrawn from or inserted to their operating position unless they are opened previously.

The complete switchgear including circuit breakers, bus bars, and instrument transformers shall be capable of withstanding without damage the electro-magnetic and thermal stresses resulting from the maximum asymmetrical value of short circuit current corresponding to the fault level specified in the specifications.

The switchgear shall be fabricated from flat rolled steel not less than a 3.2 mm thick panel, reinforced where necessary, in such a manner that the complete structure shall be rigid and free from twist and weave during handling and after installation.

The switchgear shall be provided with a lockable hinged front door and removable panels of adequate

thickness at the rear and bottom.

Provisions shall be made in the bottom plate for bottom entry of power and control cable.

Outgoing connections shall be used consisting of heat shrinkable sleeve for termination of plastic and rubber insulated cable, if necessary.

For safety of operating personnel, it is essential that should an arc develop in any one of the compartments it shall be confined to that compartment without affecting the other compartments.

Minimum thickness of steel for each part of the switchgear shall be:

Side and rear plate	2.3 mm
Bottom plate	1.6 mm
Ceiling plate	1.6 mm
Roof plate	2.3 mm
Partition plate	1.6 mm
Front door plate	2.3 mm or 3.2 mm

Fluorescent lamp fixtures shall be provided inside each switchgear with lighting switch.

16.10.5 POWER BUS BAR AND EARTH BUS BAR

All bus bars shall be made of copper conforming to JIS H3140, "Copper Bus Bar", Class C 1100 or equivalent and shall be totally enclosed with long life and durable insulating material.

Power buses shall be copper having suitable current rating, and shall be supported by non-hygroscopic insulators designed to withstand forces due to the momentary short circuit current of the system.

Earth bus shall be of copper and size shall be not less than 3 mm x 25 mm.

A tee connection from the main earth-bus shall project into each circuit breaker compartment for the automatic earthing of the circuit breaker when it is inserted into the compartment.

Power bus bar shall be located at upper side of panel.

16.10.6 TESTS

1. FACTORY TESTS

The low-voltage switchgear shall be completely assembled at the factory. The switchgear shall be subject, unless otherwise noted, to the following tests by the Contractor.

- a. Verification of construction
- b. Mechanical operation tests

- c. Electrical operation tests
- d. Withstand voltage test
- e. Accessories and spare parts test

2. FIELD TESTS

After installation, the following tests shall be executed before energizing.

- a. Verification of construction
- b. Mechanical operation tests
- c. Electrical operation tests (include remote)
- d. Withstand voltage tests

16.10.7 EQUIPMENT INCLUDED

The low-voltage switchgear shall include the necessary equipment presented herein.

1. AIR CIRCUIT BREAKER

1.1 Type and Rating

The air circuit breaker shall have the following ratings and features:

- a. Type : Four (4)-pole, single-throw, air break, drawout type
- b. Number of phase : Three (3)-phase, four (4)-wire
- c. Rated frequency : 50 Hz
- d. Rated insulation voltage : 600V AC
- e. Rated operation voltage : 380V AC
- f. Power frequency with-stand voltage
 - Main circuit : 2,500V AC. r.m.s
 - Control circuit : 1,500V AC. r.m.s
- g. Rated control and operating voltage : 100V \pm 25V DC

1.2 Accessories

All accessories shall be furnished with the each air-circuit breaker. The accessories shall include but not be limited to the following.

- a. Primary and secondary couplers
- b. Auxiliary switch

- c. Position indicator (lamp and mechanical)
- d. Operation counter
- e. Operation cabinet with wiring complete to terminal block for remote control
- f. Name plate
- g. Closing and tripping devices
- h. Protection tripping device by over-load relay and voltage or no-voltage relay
- i. Interlock switch
- j. Local test switch
- k. Maintenance lifter and cart for air circuit breaker

1.3 Spare Parts

The following spare parts shall be furnished for each air circuit breaker.

- a. Three (3) Complete sets of fixed and moving contacts assembly
- b. One (1) Complete sets of tripping and closing coils assembly
- c. One (1) Complete set of auxiliary switch
- d. One (1) Complete set of signal light
- e. Two (2) Complete set of over-load detectors and relays
- f. Each type 500% pieces of lights bulbs and fuels

2. MOLDED CASE CIRCUIT BREAKER

Circuit breaker shall be of molded case type with auxiliary switch bolted-in. Circuit breaker shall have an interrupting current value not less than 40,000 A (symmetrical value). If required, circuit breaker shall be furnished with motor operation for interlocking and operating.

3. INSTRUMENT TRANSFORMERS

Potential transformers and current transformers shall be molded resin-rubber insulated.

Potential transformer and current transformer shall have the following ratings and features :

- a. Type : Indoor, single-phase or three-phase type
- b. Primary voltage : 380V ac
- c. Secondary voltage and secondary current : 110V and 5A
- d. Accuracy class : 1.0 class
- e. Insulation level : 3 kV R.M.S.

Current transformers shall have sufficient thermal and mechanical strength to withstand, without damages, current equal to the momentary and interrupting rating of the breaker.

4. INSTRUMENTS AND RELAYS

Voltmeters and ammeters of receiving panel shall be not less than 110 mm square, 240 degrees from zero to full scale, $\pm 1.5\%$ of full scale accuracy, panel mounted type and shall be provided with external zero adjustment. Other voltmeters and ammeters of local control panels shall be not less than 100 mm square, 90 degrees from zero to full scale, $\pm 2.5\%$ of full scale accuracy, panel mounted type and shall be provided with external zero adjustment.

5. PHASE AND SEQUENCE SELECTOR SWITCHES

Phase and selector switches shall be heavy-duty, rotary type.

6. CONTROL SWITCHES

Control switches shall be twist type or pull switch type. The control switches shall be wear-proof type and arc-proof type, and with dust cover.

7. ANNUNCIATOR

Annunciator and signal light shall be back lighted and shall be relay operated. An alarm condition shall cause the appropriate lamp to light and sound the horn. Pressing the acknowledge button shall silence the horn. The light shall go out when the alarm condition is removed.

8. AUXILIARY RELAYS

Auxiliary relays shall be general purpose industrial types, and shall be dust cover enclosed plug-in type.

9. SIGNAL LIGHTS

Red signal lights shall be used for "ON" position and green lights for "OFF" position.

Color caps shall be made of a material which will not be softened by the heat from the lamps.

Each signal light shall be provided with auxiliary transformer.

10. TEST TERMINALS

Test terminals shall be furnished on the secondary circuit of the potential transformer and the current transformer. All matching test plugs shall be furnished. Test plugs and lead wires for each type of protective relay shall be furnished.

16.10.8 INSTALLATION

The low-voltage switchgear shall be mounted on steel channels which are installed on the concrete floor. The channels shall run the full length for the switchgear and shall be installed level in all directions.

The low-voltage switchgear shall be maintained in an upright position at all times. Lifting shall be only at the floorsills or the top mounted lifting angle.

The low-voltage switchgear shall be protected against damage at all times. Any damage to the paint shall be carefully repaired using touch-up paint furnished by the switchgear manufacture.

DIVISION 16 ELECTRICAL WORKS**SECTION 16.11 HIGH-VOLTAGE MOTOR CONTROL PANELS****16.11.1 GENERAL****1. GENERAL**

The Contractor shall furnish and install all high-voltage motor control panels as hereinafter specified and as shown on the drawings.

The high-voltage motor control panels shall be composed of the high-voltage motor panels and auxiliary relay panels.

2. REFERENCES

The following standards are referred to.

IEC 60044-1	Instrument transformers - Part 1: Current transformers
IEC 60044-2	Instrument transformers - Part 2 : Inductive voltage transformers
IEC 60831	Shunt power capacitors of the self-healing type for a.c. systems having a rated voltage up to and including 1000 V
IEC 60871	Shunt capacitors for a.c. power systems having a rated voltage above 1000 V
IEC 60931	Shunt power capacitors of the non-self-healing type for a.c. systems having a rated voltage up to and including 1000 V
IEC 60947-1	Low-voltage switchgear and controlgear - Part 1: General rules
IEC 60947-4-1	Low-voltage switchgear and controlgear - Part 4-1: Contactors and motor-starters - Electromechanical contactors and motor-starters
IEC 61095	Electromechanical contactors for household and similar purposes
IEC 60289	Reactors
IEC 60298	A.C. metal-enclosed switchgear and controlgear for rated voltages above 1 kV and up to and including 52 kV
IEC 60470	High voltage alternating current contactors
JIS H 3140	Copper Bus Bars
JIS C 1102	Direct acting indicating analogue electrical measuring instruments and their accessories
JIS C 1103	Dimensions of Electrical Indicating Instruments for switchboards
JIS C 1216	Alternating-current Watt-hour Meters (for connection through Instrument Transformer)

JIS C 4604	High-voltage Current-Limiting Fuses
JIS C 4605	AC. Load Break Switches for 3.3 kV or 6.6 kV
JEM 1153	High-voltage metal-enclosed switchgear from 3.3 kV to 33 kV
JEM 1195	Motor control center

16.11.2 SCHEDULE

The high-voltage motor control panel schedule will be specified in the Particular Specifications.

16.11.3 TYPE, RATING AND CHARACTERISTICS

The type, ratings and characteristics of the high-voltage motor control panels shall be as follows.

	NOMINAL VOLTAGE	NOMINAL VOLTAGE
	6 kV	3.3 kV
a. Type	: Indoor, self-supported metal-enclosed type	
b. Number of phases	: Three (3)-phase	
c. Rated frequency	: 50 Hz	
d. Lightning impulse withstand voltage		
- To earth (kV)	: 60	45
- Across the isolating distance(kV)	: 22	16
e. Power frequency with-stand voltage		
- To earth (kV)	: 22	16
- Across the isolating distance(kV)	: 35	25
- Control circuit(kV)	: 4	4
f. Rating operating and control voltage		
- DC	: 100V ± 25%	
- AC (r.m.s)	: 220V + 22V	
		- 33V

16.11.4 CONSTRUCTION

1. HIGH VOLTAGE MOTOR CONTROL PANELS

The high-voltage motor control panels shall be an assembly which is enclosed in an earthed metal-

enclosure.

The high-voltage motor control panels shall be fabricated from motor controllers, power capacitors, series reactors, instrument transformers, control transformers and bus bars.

Each unit circuit shall be segregated by earthed metallic partition or insulating partitions.

The high-voltage motor control panels enclosure type shall conform to "JEM-1153, G form", except as shown on the drawings. Withdrawable type shall be provided with a self-coupling primary circuit disconnecting device and a manual coupling control circuit disconnecting device.

Withdrawal motor controllers shall be provided with interlocking not to be withdrawn from or inserted to their operating position unless they are opened previously.

The complete high voltage motor control panels including motor controllers, bus bars, and instrument transformers shall be capable of withstanding without damage the electro-magnetic and thermal stresses resulting from the maximum asymmetrical value of short circuit current corresponding to the fault level specified in the specifications.

Motor controllers shall be full-voltage and reduced-voltage type for each motor.

Reduce-voltage starters shall be reactor and rotor resistance starting type.

The high voltage motor control panels shall be fabricated from flat rolled steel not less than 3.2 mm thick panel, reinforced where necessary, in such a manner that the complete structure shall be rigid and free from twist and weave during handling and after installation.

The high-voltage motor control panels shall be provided with a lockable hinged front door and removable panels of adequate thickness at rear and bottom.

Provisions shall be made in the bottom plate for bottom entry of power and control cable.

Outgoing connections shall be used of heat shrinkable sleeve for termination of plastic and rubber insulated cable.

For safety of operating personnel, it is essential that should an arc develop in any one of the compartments it shall be confined to that compartment without affecting the other compartments.

Minimum thickness of steel for each part of the high-voltage motor control panels shall be :

Side and rear plate	2.3 mm
Bottom plate	1.6 mm
Ceiling plate	1.6 mm
Roof plate	2.3 mm

Partition plate	1.6 mm
Front door plate	3.2 mm

Space heater fluorescent lamp fixtures and receptacle shall be provided inside each switchgear with thermostat and lighting switch.

2. AUXILIARY PANELS

The auxiliary relay panels shall include auxiliary relays, sequence controllers, timers, annunciators and other devices for automatic controls, link-up controls and manual controls of each high-voltage motor.

Type, and construction shall be as described in Section 16.12 of the specifications titled "Motor Control Center".

Space heater fluorescent lamp fixtures and receptacles shall be provided inside each relay panel with thermostat and lighting switch.

16.11.5 POWER BUS BAR AND EARTH BUS BAR

All bus bars shall be made of copper conforming to JIS H3140, "Copper Bus Bar", Class C 1100 or equivalent and shall be totally enclosed with long life and durable insulating material.

Power buses shall be copper having a suitable current rating, and shall be supported by non-hygroscopic insulators designed to withstand forces due to the momentary short circuit current of the system.

Earth bus shall be of copper and size shall be not less than 6 mm x 75 mm.

A tee connection from the main earth-bus shall project into each circuit breaker compartment for the automatic earthing of the circuit breaker when it is inserted into the compartment.

Power bus bar shall be located at upper side of panel.

16.11.6 TESTS

1. FACTORY TESTS

The high-voltage motor control panels shall be completely assembled at the factory. The switchgear shall be subject, unless otherwise noted, to the following tests by the Contractor.

- a. Verification of construction
- b. Mechanical operation tests
- c. Electrical operation tests
- d. Temperature rise tests

- e. Withstand voltage tests
- f. Short-time current tests
- g. Short circuit current tests
- h. Weatherproofing tests
- i. Accessories and spare parts test

2. FIELD TESTS

After installation, the following tests shall be executed before energizing.

- a. Verification of construction
- b. Mechanical operation tests
- c. Electrical operation tests (include remote)
- d. Withstand voltage tests

16.11.7 EQUIPMENT INCLUDED

The high-voltage motor control panels shall include necessary equipment presented herein.

1. MOTOR CONTROLLER

The motor controller shall have the following ratings and features :

1.1 Full-Voltage Starter Type

	NOMINAL	NOMINAL
	6 kV	3.3 kV

a. Vacuum switch

- Type	: Three (3)-pole, single-throw, vacuum load break switch, draw out type	
- Rated voltage(kV)	: 7.2	3.6
- Rated interrupting capacity (MVA)	: 50	25
- Switching frequency (times/hour)	: 600	
- Rated operating and control voltage		
- AC	: 220V + 22V	- 23V
- DC	: 100V \pm 25V	

b. Current limiting power fuse

- Type	: Single-pole, three (3)-units for the service of motor or condenser, mounted with vacuum switch	
- Rated voltage (kV)	: 7.2	3.6
- Rated interrupting capacity (MVA)	: 500	250

1.2 Reactor Starter Type

NOMINAL	NOMINAL
6 kV	3.3 kV

a. Vacuum switch

- Type	: Three (3)-pole, single-throw, vacuum load break switch, drawout type	
- Number of switches	: 2	2
- Rated voltage(kV)	: 7.2	3.6
- Rated interrupting capacity (MVA)	: 50	25
- Switching frequency (times/hour)	: 600	
- Rated operating and control voltage		
AC	: 220V + 22V	- 23V
DC	: 100V ± 25V	

b. Current limiting power fuse

- Type	: Single-pole, three (3)- units mounted with vacuum switch	
- Rated voltage (kV)	: 7.2	3.6
- Rated interrupting capacity (MVA)	: 500	250

c. Starting reactor

- Type	: Dry, built-in type	
- Rated voltage(kV)	: 7.2	3.6
- Insulation level	: B class	
- Reduced voltage tap	: 55% - 65% - 80%	
- Rating	: Intermittent periodic duty type with starting.	
- Capacity	: Capacity shall be sized to allow four motor in 5 minutes	

1.3 Construction

The contactor shall have a set of silicon rectifiers for operation and a latch mechanism. Control power 220 V AC shall be supplied from the each control power transformer in the high-voltage motor control

panel.

Controller shall be mounted in a separate enclosure. Enclosures shall have separate low voltage and high voltage compartments. The compartments shall be arranged to allow access to the low voltage section while the controller is energized without exposing the high voltage section.

Interlock shall be furnished to prevent operation of the isolating mechanism under load; opening of the high voltage compartment before the controller is isolated and closing the line contactor while the door is open.

All controllers shall have the following equipment:

- a. Induction type overload relays, external hand reset, in all three phases
- b. Three (3)-phase surge capacitors connected on the load side of the run contactor
- c. Protective relays shall be furnished with 2a + 2b, auxiliary contacts for operating alarms
- d. All necessary control relays and auxiliary contacts required for proper operation

1.4 Accessories

All accessories shall be furnished with each motor controller. The accessories shall include but not be limited to the following.

- a. Primary and secondary couplers
- b. Auxiliary switch
- c. Position indicator (lights and mechanical)
- d. Operator counter
- e. Operation cabinet with wiring complete to terminal block for remote control
- f. Three (3)-phase surge capacitors
- g. Name plate

1.5 Spare Parts

The following spare parts shall be furnished for each motor controller of each starter type. The spare parts shall include but not be limited to the following.

- a. Three (3) Complete sets of vacuum bulbs
- b. Each one (1) Complete set of closing coil and tripping coil
- c. One (1) Complete set of auxiliary switch
- d. Each type 500% pieces of high and low voltage fuses

- e. Each type 500% pieces of lights bulbes
- f. One (1) Complete set of signal lights

2. INSTRUMENTS AND RELAYS

Voltmeters, wattmeters and ammeters shall be not less than 110 mm square, 240 degrees from zero to full scale, $\pm 1.5\%$ of full scale accuracy, panel mounted type and shall be provided with external zero adjustment.

Watt-hour meter shall be draw-out type, rated voltage 110 V and rated current 5A, panel mounted type.

Relays shall be draw-out, panel mounted, induction disc type.

3. PHASE AND SEQUENCE SELECTOR SWITCHES

Phase and selector switches shall be heavy-duty, rotary type.

4. CONTROL SWITCHES

Control switches shall be twist type or pull switch type. The control switches shall be wear-proof type and arc-proof type, and with dust cover.

5. ANNUNCIATOR

Annunciator and signal light shall be back lighted and shall be relay operated. An alarm condition shall cause the appropriate lamp to light and sound the horn. Pressing the acknowledge button shall silence the horn. The light shall go out when the alarm condition is removed.

6. SEQUENCE CONTROLLER

All equipment shall be designed for nominal AC supply at 220 V $\pm 10\%$, 50 Hz, single phase. Automatic voltage regulator shall be furnished to provide a constant voltage source for the sequence controller with the specified $\pm 10\%$ input voltage variation. Ambient temperature will be 0 deg C to 45 deg C, and all offered equipment must be suitable for operation at these temperatures.

All equipment shall be treated to prevent the growth of fungus or other living organisms and shall be completely solid state, unless otherwise specified.

Unless otherwise specified all active and passive elements shall be manufactured to industrial standard specifications.

Lightning protection shall be provided for all equipment furnished under this section.

Self checking system and battery for power failure shall be provided.

Two sets of programing loader for programing shall be furnished. Specifications of sequence controller shall be as follows :

Program system:	Stored program system
Instructions:	Basic four (Read, And, Or and Write)
Computation functions:	Timer computation, counter computation, step control, shift register and logic control
Computation system:	usually cyclic computation
Input:	non-voltage contact
Output:	contact

7. AUXILIARY RELAYS

Auxiliary relays shall be general purpose industrial types, and shall be dust cover enclosed plug-in type.

8. SIGNAL LIGHTS

Red signal lights shall be used for "ON" position and green lights for "OFF" position.

Color caps shall be made of a material which will not be softened by the heat from the lamps.

Each signal light shall be provided with auxiliary transformer.

9. TEST TERMINALS

Test terminals shall be furnished on the secondary circuit of the potential transformer and the current transformer. All matching test plugs shall be furnished. Test plugs and lead wires for each type of protective relay shall be furnished.

16.11.8 INSTALLATION

The high voltage motor control panels shall be mounted on steel channels which are installed on the concrete floor. The channels shall run the full length of the switchgear and shall be installed level in all directions.

The high-voltage motor control panel shall be maintained in an upright position at all times. Lifting shall be only at the floorsills or the top mounted lifting angle.

The high-voltage motor control panel shall be protected against damage at all times. Any damage to the paint shall be carefully repaired using touch-up paint furnished by the switchgear manufacturer.

DIVISION 16 ELECTRICAL WORKS**SECTION 16.12 MOTOR CONTROL CENTER****16.12.1 GENERAL****1. GENERAL**

The Contractor shall furnish and install all motor control centers as hereinafter specified and as shown on the drawings.

The motor control centers shall be composed of the motor control centers and auxiliary relay panels.

2. REFERENCES

The following standards are referred to.

IEC 60831	Shunt power capacitors of the self-healing type for a.c. systems having a rated voltage up to and including 1000 V
IEC 60871	Shunt capacitors for a.c. power systems having a rated voltage above 1000 V
IEC 60931	Shunt power capacitors of the non-self-healing type for a.c. systems having a rated voltage up to and including 1000 V
IEC 60947-1	Low-voltage switchgear and controlgear - Part 1: General rules
IEC 60947-4-1	Low-voltage switchgear and controlgear - Part 4-1: Contactors and motor-starters - Electromechanical contactors and motor-starters
IEC 60439	Low-voltage switchgear and controlgear assemblies
JIS H 3140	Copper Bus Bars
JIS C 1102	Direct acting indicating analogue electrical measuring instruments and their accessories
JIS C 1103	Dimensions of Electrical Indicating Instrument for switchgear
JIS C 1731	Instrument Transformer for testing purpose and Use with General Instrument
JIS C 4901	Low-voltage Power Capacitors
JIS C 8201-4-1	Low-voltage switchgear and controlgear -- Part 4: Contactors and motor-starters, Section 1: Electromechanical contactors and motor-starters
JIS C 8370	Molded Case Circuit Breakers (MCCB)
JIS C 8371	Residual Current Operated Circuit Breakers
JIS C 8374	Residual Current Sensing and Relaying
JEM 1195	Motor control center

JEM 1265 Low-voltage metal-enclosed switchgear

16.12.2 SCHEDULE

The motor control centers schedule will be specified in the Particular Specifications.

16.12.3 TYPE, RATING AND CHARACTERISTICS

The type, ratings and characteristics of the motor control centers shall be as follows.

- a. Type : Indoor, self-supported, metal-enclosed, drawout type
- b. Number of phases : Three (3)-phase
- c. Rated frequency : 50 Hz
- d. Rated insulation voltage
 - Main circuit : 600V AC r.m.s
 - Control circuit : 250V AC r.m.s
- e. Rated operation voltage
 - Main circuit : 380V AC
 - Control circuit : 220V AC and 100V DC or AC
- f. Power frequency with-stand voltage
 - Main circuit : 2,500V AC r.m.s
 - Control circuit : 1,500V AC r.m.s
- g. Rated operating and control voltage
 - DC : 100V \pm 25V
 - AC (r.m.s) : 220V + 22V - 33V

16.12.4 CONSTRUCTION

1. MOTOR CONTROL CENTER

The motor control center shall consist of sections of equal height containing barriers and shall be isolated from adjacent compartments.

All devices and components used shall be of one manufacturer. The motor control center shall be furnished as a completely factory-assembled unit where transportation facilities and installation requirements permit.

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

Each section shall be provided with a horizontal wiring space which shall line up with a similar space in the adjacent section or sections, with openings between so that wires may be pulled the entire length of the motor control center. There shall also be provided in each section a vertical wiring space with suitable wiring clamps.

Vertical sections shall be mounted on steel channel sills continuous on four sides. Each compartment shall be provided with a hinged door of pan construction on the front and a door opening of sufficient size to permit ready removal of any of the equipment in the compartment.

Interlocks shall be provided to prevent openings of the compartment door when the circuit breaker or switch is closed. An interlock by pass device shall be furnished. Means of locking the circuit breakers or switches in the "OFF" position shall be provided.

Provisions shall be made in the bottom plate for bottom entry of power and control cable.

Outgoing connections shall consist of heat shrinkable sleeve for termination of plastic and rubber insulated cable.

For safety of operating personnel, it is essential that should an arc develop in any one of the compartments it shall be confined to that compartment without affecting the other compartments.

The motor control center shall provide equipment of type, capacity, and trip ratings shown on the drawings or otherwise specified.

The motor control center shall have engraved laminated name plates screwed to the doors of each individual compartment and wiring diagram posted inside each door. Compartments containing panel boards shall have a card holder on the inside of the door.

Compartments containing motor starters shall each have an overload heater selection table posted inside the door.

All control devices, meters and necessary appurtenances shall be arranged on front side of the motor control center. Any arrangement of back side of that will not be permitted.

The motor control center shall be made up with steel plates with a minimum plate thickness of 1.6 mm.

The construction of the motor control centers shall conform to following requirement specified in "JEM 1195".

- Class : 2
- Main circuit external connection method : C
- Auxiliary circuit external connection method : C

- Protection	: B
- Mechanism	
Condition	: 6
Requirements	: 5
- Control device	: C

2. AUXILIARY PANELS

The auxiliary relay panels shall include auxiliary relays, sequence controllers, timers, annunciators and other devices for automatic controls, link-up controls and manual controls of each low-voltage motor.

Space heater and fluorescent lamp fixtures shall be provided inside each relay panel with thermostat and lighting switch.

16.12.5 POWER BUS BAR AND EARTH BUS BAR

All buses shall be made of copper conforming to JIS H3140, "Copper Bus Bar", Class C1100 or equivalent. A continuous main horizontal bus shall be furnished. Main buses shall be rated as specified in the Particular Specifications.

A 6 mm x 50 mm ground bus shall be furnished the entire length of the motor control center.

Buses shall be braced for 50,000 A R.M.S., asymmetrical, short circuit current.

16.12.6 TESTS

1. FACTORY TESTS

The motor control centers shall be completely assembled at the factory. The motor control centers shall be subject, unless otherwise noted, to the following tests by the Contractor.

- a. Verification of construction
- b. Mechanical operation tests
- c. Electrical operation tests
- d. Temperature rise tests
- e. Withstand voltage tests
- f. Short-time current tests
- g. Short-circuit current tests
- h. Weatherproofing tests
- i. Accessories and spare parts test

2. FIELD TESTS

After installation, the following tests shall be executed before energizing.

- a. Verification of construction
- b. Mechanical operation tests
- c. Electrical operation tests (include remote)
- d. Withstand voltage tests

6.12.7 EQUIPMENT INCLUDED

The motor control centers shall include necessary equipment presented herein.

1. MOLDED CASE CIRCUIT BREAKER

Circuit breaker shall be of the molded case type with auxiliary switch, bolted-in. Circuit breaker shall have an interrupting current value not less than 40,000 A (asymmetrical value). If required, the circuit breaker shall be furnished with motor operation for interlocking and operating.

2. MOTOR STARTERS

Motor starters shall be bolted-in.

Motor starters shall be three (3)-pole, 50 Hz, 600V, magnetically operated, full and reduced voltage as shown on the drawings.

Each motor starter shall have a 220V operating coil and 380V three (3)-element overload relays. Auxiliary contacts shall be provided as shown on the drawings or as required.

Overload relays shall be adjustable three (3) - element and manually reset.

Control transformer (380V-220V) shall be provided with fuse in the panel and each unit.

Starters for the Blowers and Washwater Pumps shall be the reduced voltage type.

Reduced-voltage starters shall be star-delta or auto-transformer or reactor type.

Reactor starter type shall be closed circuit transition, with 55, 65 and 80% type. The 65% tap shall be used. Reactor over-temperature protection shall be furnished.

3. INSTRUMENT TRANSFORMERS

Potential transformers and current transformers shall be molded resin-rubber insulated.

Potential transformers and current transformers shall have the following rating and features :

- a. Type : Indoor, single-phase or three-phase type
- b. Primary voltage : 380V ac

- c. Secondary voltage and secondary current : 110V and 1A
- d. Accuracy class : 1.0 class
- e. Insulation level : 3 kV R.M.S.

Current transformers shall have sufficient thermal and mechanical strength to withstand, without damage, current equal to the momentary and interrupting rating of the breaker.

4. STATIC CAPACITORS

Static capacitors shall be provided with discharge resistance and shall be connected before contactor.

Static capacitors shall have the following ratings and features:

- a. Type: Indoor, all plastic film, hermetical type
- b. Number of phase: Three (3)-phase
- c. Rated frequency: 50 Hz
- d. Rated voltage: 400V
- e. Rated capacity: Improving power factor shall be required to 95% power factor

5. INSTRUMENTS AND RELAYS

Voltmeters, wattmeters and ammeters shall be not less than 110 mm square, 240 degree from zero to full scale, $\pm 1.5\%$ of full scale accuracy, panel mounted type and shall be provided with external zero adjustment.

Watt-hour meters shall be draw-out type, rated voltage 110 V and rated current 5A, panel mounted type.

Relays shall be draw-out, panel mounted, induction disc type.

6. PHASE AND SEQUENCE SELECTOR SWITCHES

Phase and selector switches shall be the heavy-duty, rotary type.

7. CONTROL SWITCHES

Control switches shall be twist type or pull switch type. The control switches shall be wear-proof type and arc-proof type, and with dust cover.

8. ANNUNCIATORS

Annunciator and signal lights shall be back lighted and shall be relay operated. An alarm condition shall cause the appropriate lamp to light and sound the horn. Pressing the acknowledge button shall

silence the horn. The light shall go out when the alarm condition is removed.

9. SEQUENCE CONTROLLER

All equipment shall be designed for nominal AC supply at 220 V \pm 10%, 50 Hz, single phase. Automatic voltage regulator shall be furnished to provide a constant voltage source for the sequence controller with the specified \pm 10% input voltage variation. Ambient temperature will be 0 deg. C to 45 deg.C, and all offered equipment must be suitable for operation at these temperatures.

All equipment shall be treated to prevent the growth of fungus or other living organisms and shall be completely solid state, unless otherwise specified.

Unless otherwise specified all active and passive elements shall be manufactured to industrial standard specifications.

Lightning protection shall be provided for all equipment furnished under this section.

Self checking system and battery for power failure shall be provided.

Two sets of programming loaders for programming shall be furnished.

Specification of sequence controller shall be as follows :

- Program System : Stored program system
- Instruction : Basic four (Read, And, Or and Write)
- Computation functions : Timer computation, counter computation, step control, shift-register and logic control
- Computation system : usually cyclic computation
- Input : non-voltage contact
- Output : contact

10. AUXILIARY RELAYS

Auxiliary relays shall be general purpose industrial types, and shall be dust cover enclosed plug-in type.

11. SIGNAL LIGHTS

Red signal lights shall be used for "ON" position and green lights for "OFF" position.

Color caps shall be made of a material which will not be softened by the heat from the lamps.

Each signal light shall be provided with auxiliary transformer.

12. TEST TERMINALS

Test terminals shall be furnished on the secondary circuit of the potential transformer and the current transformer. All matching test plugs shall be furnished. Test plugs and lead wires for each type of protective relay shall be furnished.

16.12.8 INSTALLATION

The motor control centers shall be mounted on steel channels which are installed on the concrete floor. The channels shall run the full length for the switchgear and shall be installed level in all directions.

The motor control centers shall be maintained in an upright position at all times. Lifting shall be only at the floorsills or the top mounted lifting angle.

The motor control centers shall be protected against damage at all times. Any damage to the paint shall be carefully repaired using touch-up paint furnished by the switchgear manufacturer.

DIVISION 16 ELECTRICAL WORKS

SECTION 16.13 LOCAL CONTROL PANEL

16.13.1 GENERAL

1. GENERAL

The Contractor shall furnish and install all local control panels as hereinafter specified and as shown on the drawings.

2. REFERENCES

The following standards or other internationally accepted standards or manufacturer's standards as approved by the Engineer are referred to.

IEC 60439-1	Low-voltage switchgear and controlgear assemblies - Part 1: Type-tested and partially type-tested assemblies
JIS C 1102	Direct acting indicating analogue electrical measuring instruments and their accessories
JIS C 8201-4-1	Low-voltage switchgear and controlgear -- Part 4: Contactors and motor-starters, Section 1: Electromechanical contactors and motor-starters
JIS C 8370	Molded Case Circuit Breakers (MCCB)
JIS C 8371	Residual Current Operated Circuit Breakers
JIS C 8374	Residual Current Sensing and Relaying
JEM 1265	Low-voltage metal-enclosed switch-gear

16.13.2 SCHEDULE

The local control panels schedule will be specified in the Particular Specifications.

16.13.3 TYPE, RATING AND CHARACTERISTIC

The type, ratings and characteristics of the local control panels, shall be as follows.

- a. Type : Indoor, self-standing type, Indoor, wall-mounted type,
Outdoor, self-standing type
- b. Number of phases : Three (3)-phase, four (4)-wire
- c. Rated frequency : 50 Hz
- d. Rated insulation voltage :
 - Main circuit : 600V AC r.m.s
 - Control circuit : 250V AC r.m.s

e. Rated operation voltage :

- Main circuit : 380V AC
- Control circuit : 220V AC and 100V AC

f. Power frequency withstand voltage :

- Main circuit : 2,500V AC. r.m.s
- Control circuit : 1,500V AC. r.m.s

16.13.4 CONSTRUCTION

The local control panels shall be made to conditions of each place, such as moisture, dust, chemicals and explosive gas etc.

Local control panel shall be fabricated of heavy gauge steel not less than 2.3 mm thick and shall be of rigid construction.

Ammeters, control switches, pushbuttons, signal lamps, selectors and annunciators shall be panel front mounted and relay, timer and terminals shall be panel inside installed.

Local control panels which will be in outdoor service or in service at basement floor of the building shall be provided with space heater and thermostat.

Door for maintenance shall be provided with key-locking.

All fastening devices shall be stainless steel.

16.13.5 TESTS

1. FACTORY TESTS

The local control panels shall be completely assembled at the factory. The local control panels shall be subject, unless otherwise noted, to the following tests by the Contractor.

- a. Verification of construction
- b. Mechanical operation tests
- c. Electrical operation tests
- d. Withstanding voltage tests

2. FIELD TESTS

After installation, the following tests shall be executed before energizing.

- a. Verification of construction
- b. Electrical operation tests

- c. Withstanding voltage tests

16.13.6 EQUIPMENT INCLUDED

The local control panels shall include necessary equipment as presented herein.

1. MOLDED CASE CIRCUIT BREAKER

Circuit breaker shall be of molded case type with auxiliary switch, bolted-in. Circuit breaker shall have an interrupting current value not less than 40,000A (asymmetrical value). If required, circuit breaker shall be furnished with motor operation for interlocking and operating.

2. INSTRUMENTS

Voltmeters and ammeters of receiving panel shall be not less than 110 mm square, 240 degrees from zero to full scale, $\pm 1.5\%$ of full scale accuracy, panel mounted type and shall be provided with external zero adjustment.

Voltmeters and ammeters of other local control panels shall be not less than 100 mm square, 90 degrees from zero to full scale, $\pm 2.5\%$ of full scale accuracy, panel mounted type and shall be provided with external zero adjustment.

3. PHASE AND SEQUENCE SELECTOR SWITCHES

Phase and selector switches shall be heavy-duty, rotary type.

4. CONTROL SWITCHES

Control switches shall be twist type or pull switch type and pushbutton type. The control switches shall be wear-proof type and arcproof type, with dust cover.

Push button of light shall have auxiliary transformer.

5. ANNUNCIATOR

Annunciator and signal light shall be back lighted and shall be relay operated. An alarm condition shall cause the appropriate lamp to light and sound the horn. Pressing the acknowledge button shall silence the horn. The light shall go out when the alarm condition is removed.

6. AUXILIARY RELAYS

Auxiliary relays shall be general purpose industrial types, and shall be dust cover enclosed plug in type.

7. SIGNAL LIGHTS

Red signal lights shall be used for "ON" position and green lights for "OFF" position.

Color caps shall be made of a material which will not be softened by the heat from the lamps.

Each signal light shall be provided with auxiliary transformer.

8. MOTOR STARTERS

Motor starters shall be bolted-in.

Motor starters shall be three (3) - pole, 50 Hz, 600 V, magnetically operated, full and reduced voltage as shown on the drawings.

Each motor starters shall have a 220 V operating coil and 380 V two (2) - element overload relays. Auxiliary contacts shall be provided as shown on the drawings or as required.

Overload relays shall be adjustable two (2) - element and manually reset.

Reduced-voltage starters of more than 7.5 kW motor shall be star-delta type.

9. STATIC CAPACITORS

Static capacitors shall be provided with discharge resistance and shall be connected before contactor.

Static capacitors shall have the following ratings and features:

- a. Type: Indoor, all plastic film, hermetical type
- b. Number of phase: Three (3) - phase
- c. Rated frequency: 50 Hz
- d. Rated voltage: 400 V
- e. Rated capacity: Improving power factor shall be required to 95% power factor

16.13.7 INSTALLATION

The local control panels shall be mounted on steel channels which are installed on the concrete floor. The channels shall run the full length for the switchgear and shall be installed level in all directions.

The local control panels shall be maintained in an upright position at all times. Lifting shall be only at the floorsills or the top mounted lifting angle.

The local control panels shall be protected against damage at all times. Any damage to the paint shall be carefully repaired using touch-up paint furnished by the switchgear manufacturer.

DIVISION 16 ELECTRICAL WORKS

SECTION 16.14 INSTRUMENTATION

16.14.1 GENERAL

1. GENERAL

The Contractor shall furnish and install all instrumentation as hereinafter specified and as shown on the drawings.

All equipment shall be designed for ease of maintenance and repair, and access to critical parts shall not require a major disassembly. Internal field adjustments where permitted or required herein shall be easily accessible upon removal of a panel or cover.

Materials and Installation shall comply with the requirements of the current editions of referenced electrical codes and standards, and the codes and standards referred to shall be used for establishing the minimum quality of the materials and equipment supplied and installed. All equipment of the same type shall be products of the same manufacturer. Capacities of all equipment shall not be less than that indicated on the Drawings or specified.

Manufacturer's literature, illustrations, specifications and engineering data including: dimensions, actual weight, performance data and curves showing overall pump efficiencies, flow rate, head, brake horsepower, motor horsepower, speed and shut-off head. Shop drawings showing: fabrication, assembly, installation and wiring diagrams.

Related work specified elsewhere:

- a. Electrical work shall be done under Division 16.
- b. Piping work shall be supplied under Division 15.
- c. Valves with limit switches and position transmitters shall be furnished under Division 15.
- d. Painting shall be in accordance with Division 9.
- e. Central monitoring system is specified in Division 16.

2. REFERENCES

The following standards or other internationally accepted standards or manufacturer's standards as approved by the Engineer are referred to.

JIS B 7552	Liquid Flowmeters -- Proving Methods
JIS B 7554	Electromagnetic Flowmeters

JIS C 0920	Tests to prove protection against ingress of water and degrees of protection against ingress of solid objects for electrical equipment
JIS C 1102	Direct acting indicating analogue electrical measuring instruments and their accessories
JIS C 1604	Resistance Thermometer Sensors
JIS Z 8762	Measurement of fluid flow by means of orifice plates, nozzles and venturi tubes inserted in circular cross-section conduits running full

3. QUALIFICATIONS

Equipment to be furnished hereunder shall be, insofar as possible, the products of one manufacturer who shall be responsible for the complete coordination and assembly of the components. The manufacturer shall have produced instrumentation equipment similar to that specified for a period of at least five (5) years. All equipment provided shall be compatible with previously supplied and installed equipment.

Manufacturers of flow measuring devices and associated instruments shall have made primary flow devices for a period of at least ten (10) years of comparable design and size and, who in the opinion of the Engineer has sufficient experimental data covering coefficient head loss, and susceptibility to influence of upstream and downstream conditions to demonstrate his competence. The tube manufacturer shall provide a certified curve showing differential head in millimeters of water column vs flow in m³/day over the specified range of the installation.

In the event the manufacturer cannot comply with the foregoing requirement, he shall provide certified curves in which at least two (2) points on the calibration curve shall have been obtained by actual laboratory calibration and shall be certified by a qualified hydraulic engineer.

4. SHOP DRAWINGS

Shop drawings shall be submitted in accordance with the General Conditions. They shall be certified and complete, giving details of connections wiring, range, dimensions and compliance with specifications. Other information to determine acceptability shall also be submitted.

Drawings, data sheets and pertinent literature submitted for approval shall be arranged, identified and bound in sequence by tag number. A suitable index shall be provided. There shall be two separate volumes; one for instrumentation, and one for in-line equipment. For in-line equipment, provide information as specified. Also for in-line equipment provide additional submittal data to be coordinated with the piping work.

5. GENERAL REQUIREMENTS

All instrumentation shall be of the pneumatic and/or solid state electronic type, and the manufacturer's latest design.

Standard input and output signals shall be 0.2 to 1.0 kg/sq.cm. pneumatic and 4 to 20 mA DC (milliamper direct current) or 1 to 5 volts DC electronic. Zero based signal transmission will not be allowed.

Standard output contact capacities shall be 0.5A 1a. 1b or more, for each voltages.

Electric equipment shall be designed for operation at 220V (+ 22V or - 33V) or 24 V (± 2.4 V) 50 HZ single phase and DC 100V (± 25 V). Pneumatic equipment shall be designed for operation at 5-7 kg/cm² pressure.

All necessary electric and pneumatic power supplies shall be furnished, as required.

All transmitters shall include span adjustments, such as, elevation, suppression and damping circuits.

All transmitters shall be provided with indication, in engineering units, on the equipment or near the transmitter.

All transmitters shall be provided with floor or wall stands as shown or as required.

All transmitters shall be provided with waterproof type terminal boxes.

All instrumentation shall be designed with selected materials and painted to fully withstand the installation environment.

All instrumentation shall be designed for easy maintenance and inspection, and shall provide interchange ability of common devices and parts.

All instrumentation shall be designed based on the following temperature and humidity conditions.

	Temperature	Humidity
	(degrees)	
Outdoor Use	: 55 C or more	95 % or more
Indoor Use	: 45 C or more	95 % or more

Lighting protection shall be provided to protect the electronic instrumentation from induced surge propagating along the signal and power supply lines. Lightning protection shall be such that the protective level shall not interfere with normal operation, but shall be lower than the instrument surge withstand level, and be maintenance free and self-restoring.

Instruments shall be housed in a suitable metallic case, properly grounded. Grounding cable for all surge protectors shall be connected to a good earth ground and where practical each grounding cable shall be run individually and insulated from each other.

An Instrument List for each station giving tagging, application location and range information is in the

Particular Specifications.

16.14.2 SCHEDULE

The instrumentations schedule will be specified in the Particular Specifications.

16.14.3 FLOW MEASURING DEVICES

1. ELECTROMAGNETIC FLOW METER

Magnetic flowmeters shall use electromagnetic induction to produce a dc voltage proportional to the liquid flow velocity.

Manufacturer shall calibrate and pressure test the flowmeters and provide certificates.

Overall accuracy better than + 1.0 percent throughout the operating range.

Sensor:

- a. Flanged NP 10 process connection
- b. Stainless steel 304 metering tube and flanges
- c. Stainless steel 316 electrodes
- d. Stainless steel 316 earthing ring or electrode
- e. Lining material suitable for withstanding abrasion of the fluid
- f. Enclosure fully submersible, protected to IP 68
- g. Sensor/transmitter cable to be fitted and potted by manufacturer. Screened and waterproof cable shall be used.

Transmitter

- a. Remotely installed from sensor
- b. 220 Vac 50 Hz power supply unless otherwise specified.
- c. Inbuilt flow rate and total flow display
- d. Isolated 4-20 mA dc and pulse outputs
- e. Inbuilt empty pipe detection and alarm
- f. Programmable range and engineering units
- g. Two inbuilt relays for alarm

2. FLOW METER ORIFICE

The flow metering device shall produce a differential pressure utilizing static pressure at the inlet and throat.

The orifice plate shall be designed and manufactured in accordance with the following conditions.

- a. Type : Concentric, flange-tapes type
- b. Overall accuracy : $\pm 1.5\%$ of full scale (including flow transmitter accuracy)

The orifice plate shall be fabricated of Type 304 stainless steel.

The orifice plates shall be installed between orifice flanges, drilled for flange tap differential pressure connections with stop valves.

Pressure loss shall be 0-60% of maximum differential pressure unless otherwise specified.

The orifice flanges shall be drilled compatible with the line flanges. The plate tab shall identify the upstream edge and the bore diameters.

Inlet taps shall be of low zinc brass or bronze bushing, and shall be a minimum of 19 mm to reduce time lag to flow transmitters.

A certified head versus flow curve shall be provided for each orifice plate.

3. ULTRASONIC FLOWMETER

The system shall comprise of a transducer and a transmitter as per the following specifications:

- a. The transmitter shall be certified intrinsically safe and suitable for hazardous area class 1, divisions 1, group D where specified in schedule.
- b. Overall accuracy shall be better than + 1% with a repeatability of + 0.5%
Overall accuracy shall be better than + 1% with a repeatability of + 0.5%
- c. Stainless steel 304 support wire
- d. Stainless steel 304 probe case

Transducer:

- a. Stainless steel 316 construction.
- b. Enclosure protected to IP68
- c. Inbuilt temperature compensation

- d. Supplied complete with mounting accessories.

Transmitter:

- a. Wall mounted and protected to IP55
- b. 220 Vac 50 Hz power supply
- c. 4-20 mA dc output proportional to measured level.
- d. Inbuilt flow indications
- e. When used for open channel flow measurement as specified in schedule, the transmitter shall have inbuilt flow rate and total indications.
- f. Programmable range
- g. Relays for sensor failure, level and flow alarms.

4 FLOW SWITCHES

Flow switches shall sense an adjustable preset flow rate of fluid in a pipe and operate a SPDT switch to actuate alarms or control circuits. The switch shall be rated for 1 ampere load at 220 Vac, 50 Hz.

Vane Type Flow Switches shall be housed in a watertight case, unless explosion proof is specified in the Schedule, with electrical conduit connection. Switches for mounting in 40 mm pipe or larger shall be fitted for ISO thread mounting directly in the pipe. Smaller sizes shall be supplied mounted on a pipe fitting with female ISO threads. The switch assembly shall be isolated from the flow by a diaphragm or suitable seal. The actuator vane and other wetted parts shall be stainless steel, monel, brass, or other corrosion resistant material suitable for the fluid in the pipe.

Operating Conditions. The flow switch shall be sized and adjusted for the pipe, fluid and flow rate or velocity shown in the Flow Switch Schedule. Repeatability of sensing shall be within 10 percent for any setting, and differential shall be less than 4.0 percent within the flow range specified. Set point shall be within 10 percent of flow rate or velocity specified.

16.14.4 LEVEL MEASURING DEVICES

1. FLOAT TYPE LEVEL TRANSMITTER

The level transmitter shall be a float actuated transmitter that will sense liquid level by means of a float installed as shown on the drawings.

The level transmitter shall consist of a float, float tape, counterweight, counterweight tape, a transmitter and protection pipe.

The level transmitter shall be designed and manufactured in accordance with the following conditions.

- a. Type : Potentiometer sensing type
- b. Accuracy : $\pm 0.5\%$ of full scale

The transmitter shall have a waterproof type housing.

Float position shall be translated into a 4 to 20 mA signal proportional to level over the range specified in the Instrument List.

The float shall be of corrosion-resistant materials. Instrument case and mounting shall be waterproof.

Float and counterweight assembly shall include a float, stainless steel float tape and counterweight tape, and counterweight. Float and counterweight tapes shall be protected by suitable cast iron pipe or FRP pipe of corrosion-protected pipe guards.

The transmitter shall be mounted on stainless steel angle forms and weatherproofed by painting.

The accessories shall include limit switches for high-low alarms (water-proof) and mechanical indicators.

The following spare parts shall be furnished for each float type level transmitter.

- One (1) Set of stainless steel floats
- One (1) Set of stainless steel counterweights
- One (1) Set of stainless steel taps for each float and counterweight
- Two (2) Sets of waterproof type limit switches

2. FLANGE TYPE LEVEL TRANSMITTER

The level transmitter shall utilize a sensing diaphragm in contact with the process fluid. Head measured on the diaphragm shall be converted to a linear output signal.

The level transmitter shall be designed and manufactured in accordance with the following conditions.

- a. Type : Diaphragm sensing type
- b. Accuracy : $\pm 0.5\%$ of full scale
- c. 4-20 mA dc output proportional to measured level.

The transmitter shall be the immersion proof and flanged end type.

The material of diaphragm shall be type 316L stainless steel, and flange and housing shall be type 316 stainless steel.

3. DISPLACEMENT TYPE LEVEL TRANSMITTER

The displacement level transmitter shall employ a continuous displacer of a length at least equal to the level range to be measured.

The level transmitter shall be designed and manufactured in accordance with the following conditions.

- a. Type : Buoyant effect type
- b. Accuracy : $\pm 0.5\%$ of full scale

The displacer shall be rigidly connected by the rod to the level sensing and transmitter mechanism. The unit shall be designed for flange mounting except when specified as cage enclosed for external tank.

The displacement level transmitter shall operate by sensing the relative buoyant effect, with level change of a displaced fluid on displacer weights which have a specific gravity greater than the sensed fluid.

This level transmitter shall be the cage mounted and waterproof type (continuous signal transmitter). The unit shall have flanged ends with two (2)-80 mm gate valves.

All material of displacer, connecting rod, cage, flange and gate valve shall be Type 316 stainless steel.

4. CAPACITANCE TYPE LEVEL TRANSMITTER

The capacitance level transmitter shall utilize the principle of the varying capacitance of a sensing probe as a function of the level of submersion. The sensing probe shall include negative electrode wire rope and weight. The system shall consist of probe and transmitter.

The level transmitter shall be designed and manufactured in accordance with the following conditions.

- a. Type : Capacitance sensing type
- b. Accuracy : $\pm 2.0\%$ of full scale
- c. 4-20 mA dc output proportional to measured level.

This level transmitter shall be the flange mounted and waterproof type. The transmitter shall have flanged ends.

The transmitter shall be provided with protection pipe, counterweight and spaces for probe as shown or as required.

The transmitter, flange and probe shall be Type 316 stainless steel.

5. IMMERSION TYPE LEVEL TRANSMITTER

The immersion type level transmitter shall utilize the principle of the varying actuated head water pressure of the sensing diaphragm as a function of the level of immersion.

The transmitter shall consist of a submerged detector, counterweight type stand, a transmitter, cable junction box and special cable.

The transmitter shall be designed and manufactured in accordance with the following conditions.

- a. Type : Diaphragm sensing type
- b. Accuracy : $\pm 0.5\%$ of full scale
- c. 4-20 mA dc output proportional to measured level.

The submerged detector shall be Type 316 stainless steel.

The detector shall be designed to be placed on the bottom of the structure and shall have a lifting Type 316 stainless steel wire for lifting which shall be extended to the operation floor.

The transmitter shall be connected to the submerged diaphragm detector by means of special cable having an air-introduced pipe.

The transmitter shall have a water proof type housing.

The submerged detector shall be Type 316 stainless steel.

The following spare parts shall be furnished for each immersion type level transmitter.

One (1) Set of diaphragm detector

One (1) Set of special cable

The transmitter shall be provided with a protection pipe for the detector and special cable as shown or as required.

6. ULTRASONIC TYPE LEVEL TRANSMITTER

The ultrasonic level sensor shall utilize sonic principles. An intense burst of sonic energy shall be directed toward the target surface of the fluid. The return time of the reflected echo shall be measured and converted into an electrical signal proportional to the distance from the detector to the surface. The system shall consist of detector, converter and coaxial cable.

The transmitter shall be designed and manufactured in accordance with the following conditions.

- a. Type : Ultrasonic reflection sensing type
- b. Overall Accuracy : $\pm 1.0\%$ of full scale (include converter accuracy).
- c. 4-20 mA dc output proportional to measured level.

Automatic temperature compensators shall correct for the change in sound velocity in the transmitting fluid. Temperature sensing shall be furnished in the detector and the temperature compensator shall be furnished in the converter.

The response time of measuring shall be less than 30 seconds.

The detector and converter shall have a waterproof type housing.

The detector shall be stainless-plate locally mounted and converter shall be for remote panel mounting.

All necessary accessories including the dry-calibration set for complete functioning shall be provided.

7. AIR BUBBLER PURGE ASSEMBLY

The air bubbler purge assembly shall consist of a constant differential pressure regulator, an adjusting needle valve air blow valve, and a sight-flow indicator.

Overall accuracy including differential pressure transmitter accuracy shall be $\pm 3.0\%$ of full scale.

Air supply for purge assembly shall be at least 0.35 kg/cm² greater than the maximum depth of immersion of the bubble pipe tip, expressed in kg/cm². Components shall be arranged in a compact assembly suitable for subpanel or bracket mounting.

Where transmitter assembly cannot be installed at an elevation at least 600 mm above maximum liquid level, the connection between the bubbler tip and the transmitter shall pass above the maximum liquid elevation by 600 mm to prevent siphon action on air failure.

An air supply in excess of 40 cm³/sec free air shall be furnished for each bubbler system.

Dip tubes shall be of 25 mm Type 304 stainless steel, and tip shall be cut on a 45 degree angle with sharp inside and outside corners free from burrs.

Where the level signal is required to operate remote gauges, a level transmitter shall be supplied to convert air pressure to a high level signal as shown on the Instrument List.

Dip tubes shall be mounted with Type 304 stainless steel slide flanges.

8. PROBE TYPE LEVEL SWITCH

The probes shall be of the conducting rod type with the process fluid acting as the conductor between the rods. The level switches shall consist of a probe assembly and an electronic sensing unit. Rods shall be stainless steel with teflon coating. The rod holder shall be adjustable gland type made of stainless steel with positive.

For acid chemical service rods and other parts which may contact with chemical shall be made of type 316 stainless steel unless otherwise specified.

16.14.5 PRESSURE MEASURING DEVICES

The following types of pressure measuring devices are specified herein and such equipment shall be complete with measuring apparatus.

- a. Pressure transmitter (PT)
- b. Pressure switch (PS)

1. PRESSURE TRANSMITTER

The pressure transmitter shall be pressure actuated through a diaphragm element. Transmitters shall be 2-wire loop powered with 4-20 mA dc output.

The accuracy shall be $\pm 0.5\%$ of full scale.

The material of the diaphragm and housing shall be Type 316L stainless steel.

The motion of the sensing element shall actuate the input linkage to the transmitter and have a locking type range adjustment. The drive linkage shall include a zero adjustment.

The input shall be as stated on the Instrument List.

The transmitter shall have an immersion proof type housing.

This transmitter shall be the 50 mm standing pipe mounted, stainless steel, schedule 40 and waterproof type.

2. PRESSURE SWITCH

The pressure switches shall incorporate bourdon tubes, diaphragms, or bellows as the sensing and actuating element.

The actuating element shall be stainless steel and the actuating point shall be readily adjustable in the range specified, and shall be of the narrow differential type.

The pressure switch shall have a waterproof type metal case.

16.14.6 TEMPERATURE MEASURING DEVICES

The following type(s) of temperature measuring devices shall be specified herein and such devices shall be complete with necessary apparatuses.

- a. Resistance type temperature sensor
- b. Temperature converter

1. RESISTANCE TYPE TEMPERATURE SENSOR

The temperature sensor shall utilize a sensing resistance element, and shall be designed and manufactured in accordance with the following conditions.

- a. Type : Platinum element of the three (3) lead wire method type
- b. Accuracy : 0.2 class confirming to JIS C 1604

This sensor shall have a temperature resistance relationship and tolerances for 100 ohm platinum resistance element. The resistance element shall be protected by an internal tube, and shall have a terminal box.

The temperature sensor shall be the flange mounted and explosion proof type.

The protection tube and flange shall be Type 316 stainless steel.

2. TEMPERATURE CONVERTER

The temperature converter shall be the panel mounted type and shall convert the temperature measuring to a 4 to 20 mA DC signal. Signal and power transmission shall be provided by a single pair of wires.

The accuracy shall be $\pm 0.5\%$ of full scale.

16.14.7 WATER QUALITY ANALYZER DEVICES

The following types of water quality analyzer devices shall be specified herein and such devices shall be complete with all necessary apparatuses.

- a. Turbidity analyzer (Tubt)
- b. pH analyzer (pHT)
- c. Residual chlorine analyzer (RCIT)
- d. Chlorine gas detection system (CGD)
- e. Analyzer mounting racks (ANAL-R)

1. TURBIDITY ANALYZER (TubT)

The turbidity analyzer shall utilize the principle of surface-scattered light and shall consist of detector, transducer, bubbler tank, zero adjustment filter and detector washing device.

The turbidity analyzer shall be designed and manufactured in accordance with the following conditions.

- a. Type : Surface-scattered light type
- b. Range of measuring : Three (3)
- c. Representability : ± 2.0 of full scale

- d. Response time : Approximately three (3) minutes
- e. Output signal : Proportional and isolated 4 - 20 mA DC

All parts of the analyzer shall be suitably housed by a waterproof type steel box, epoxy painted, and shall be designed to have suitable housing for mounting rack.

The analyzer shall have an automatic detector washing system and detector shall be intermittently washed with a preset time sequence by an automatic detector washing device. During the detector washing period, the output signal of the transducer shall be held just before washing.

The major material which may contact with the handling liquid shall be hard polyvinyl chloride.

2. PH ANALYZER (pHT)

The pH analyzer shall utilize the principle of the glass-electrode method and shall consist of detector, transducer, bubblers tank, special cable, KCl tank and continuous washing device for detector.

The pH analyzer shall be designed and manufactured in accordance with the following conditions.

- a. Type : Compound electrode type, included glass electrode, reference electrode and temperature compensating element
- b. Range of measuring : pH 4-10
- c. Representability : \pm pH 0.1
- d. Response time : Approximately 30-seconds
- e. Output signal : Proportional and isolated 4 - 20 mA DC.

The detector shall be washed continuously by the washing device using ultra-sonic wave.

This system shall have a waterproof type housing and shall be designed to have a suitable housing for the mounting rack.

The major material which may contact with the handling liquid shall be Type 316 stainless steel.

3. RESIDUAL CHLORINE ANALYZER (RCIT)

The residual chlorine analyzer shall utilize the principle of the polarograph and shall consist of detectors transducer, chemical agent tank, pump device and detector washing device.

The residual chlorine analyzer shall be designed and manufactured in accordance with the following conditions.

- a. Type: Rotating platinum pole and platinum comparative pole with automatic temperature compensating resistance type.
- b. Range of measuring: 0-3 ppm (total and free residual chlorine)

- c. Representability: $\pm 2.0\%$ of full scale
- d. Response time: Approximately four (4) minutes
- e. Output signal: Proportional and isolated 4 - 20 mA DC

The analyzer shall be designed to measure the total and free residual chlorine.

All parts of the analyzer shall be suitably housed with a waterproof type steel box, epoxy painted, and shall be designed to have a suitable housing for the mounting rack.

The analyzer shall have an automatic detector washing system and the detector shall be intermittently washed with a preset time sequence by the automatic detector washing device. During the detector washing period, the output signal of the transducer shall be held just before washing.

The chemical agent tank shall have enough capacity to operate continuously for not less than one-month without refilling of the agent.

4. CHLORINE GAS DETECTION SYSTEM (CGD)

The chlorine gas leakage system shall be composed of leakage detector, indicator and power supply unit, and shall be designed and manufactured in accordance with the following conditions.

- a. Type : Nonreagent, semiconductor sensing type
- b. Rate of measuring : 0-3 ppm
- c. Accuracy : Within $\pm 30\%$ of indicated value
- d. Response time : Approximately 30-seconds

The gas introduction method shall have diffused heat convection. The signal shall be transmitted to the indicator by a seven (7) - wire system. Alarm lights (for low and high leakage), test switch and power trouble light shall be mounted in the indicator. Indicator shall be the panel mounted type. The system using reagents will not be permitted.

Indicator shall be equipped with an alarm setter with adjustable high and low leakage alarm for displaying extreme leakage. The alarm setter shall have two (2) variable points.

Power supply of leakage system shall be AC 220V.

5. ANALYZER MOUNTING RACKS (ANAL-R)

The analyzer mounting racks shall be designed to collectively mount all water quality analyzers and shall be designed for easy maintenance and operation.

The mounting racks shall be designed to mount suitable water quality analyzers which will be specified elsewhere in the Particular Specifications.

The mounting racks shall be provided with panel board, terminal boards, overflow tanks and piping.

The panel board for power distribution shall be installed at either side rack, and shall include main and branch molded case circuit breakers, signal lights and signal terminals.

Mounting arrangement for analyzers shall be as shown on the drawings. Analyzers shall be grouped in vertical sections.

The panel board and terminal board interconnections shall be wired with plastic conduits.

Type and quantity of analyzers will be specified in the Particular Specifications.

The overflow tanks for the debubbler shall be made of transparent plastic with valves for sampling, draining and washing.

The related piping shall consist of drains overflows, wash and sampling lines with three (3) way change over valves, and shall be complete.

The pipes and valves shall be hard polyvinyl chloride and shall be sized with at least the following.

Inlet pipe	: 20 mm	or more
Drain pipe	: 40 mm	or more
Main drain pipe	: 200 mm	or more
Overflow pipe	: 50 mm	or more

The mounting racks shall be made from hot-dip galvanized angle steel painted with epoxy resin paint system D2.

16.14.8 PANEL MOUNTED INSTRUMENTATION EQUIPMENT

The following types of panel mounted instrumentation equipments shall be specified herein and such equipment shall be complete with all necessary apparatus.

- a. Process indicators (I)
- b. Recorder (R)
- c. Totalizer (Q)
- d. Controller (C)
- e. Alarm unit (A)
- f. Summator (Y)
- g. Signal converter (SC)
- h. Square root extractor (SQ)
- i. E/E Positioner (EE)

- j. Arrester (Ar)
- k. Power supply unit (PWS)
- l. Distributor (DBT)
- m. Signal limiter (SI)
- n. Signal isolater (SI)
- o. AC. circuit transducer (TD)

All panel mounted equipment described herein shall be designed and manufactured in accordance with the following conditions.

1. PROCESS INDICATORS (I)

Process variable indicators shall be of three (3) types : (1) automatic balance type (2) wide angle type and (3) moving coil type. Automatic balance type shall have the accuracy of $\pm 0.5\%$ of full scale and scale shall be at least 100 mm length. Moving coil type shall have the accuracy of $\pm 1.5\%$ of full scale and scale shall be at least 100 mm length or 240 degrees from zero, not less than 110 mm square. Each indicator shall be panel mounted. Zero and span adjustment shall be provided. Automatic balance type indicator shall have high and low alarm unless otherwise specified.

2. RECORDER (R)

Pen strip chart recorder of automatic balance type shall be installed where indicated. The inputs to recorder shall be provided as shown. Charts shall be 100 mm wide and scale shall be oriented vertically. The recorder pen shall be servo motor driven. Electrical zero and span adjustment shall be provided. Chart graduations shall be rectilinear. The chart speed shall be 20 mm/hour minimum to 120 mm/hour speed by manually changing. The accuracy shall be $\pm 0.5\%$ of full scale. Recorder shall be panel mounted. Charts shall record 31 days at 20 mm/hour.

The recorder shall have high and low alarm contacts unless otherwise specified.

The following spare parts shall be furnished for each recorder.

- Fifty (50) Rolls of recording papers
- Each color fifty (50) Pieces of ink cartridges
- Each color three (3) pieces of recording pen
- 500 % pieces of fuses
- Five (5) pieces of index cards
- Ten (10) pieces of blotting papers
- One (1) sets of string
- One (1) pieces of syringe

One (1) set of check pins

3. TOTALIZER (Q)

Totalizer shall be provided panel mounted. Totalizer shall consist of integrator and counter. The integrator shall accept a 4 to 20 mA DC signal and convert it to a pulse train the frequency of which is linearly proportional to the input. Counter shall be of the electro-mechanical non-reset type. Counter shall have a minimum of six (6) decimal digits. The accuracy shall be $\pm 0.5\%$ of input signal.

4. CONTROLLER (C)

The indicating controller shall be of solid state design. Input and output shall be mA DC signal compatible with other instruments in the panel.

Unit shall be housed in a metal case with slide out chassis. Unit shall be provided with continuously adjustable proportional band and reset controls. An AUTO / MANUAL (automatic/manual) selector switch shall be provided.

The output indicator accuracy shall be $\pm 3.0\%$ of full scale and the process value indicator accuracy shall be $\pm 0.5\%$ of full scale.

Units shall be provided with intergration capacitor over-charge protection, dead zone adjustment device and high-low alarm contacts devices.

5. ALARM UNIT (A)

The alarm unit shall compare the input signal with set point, outputs alarm signal and alarm light on the front panel of the unit. Direct or reverse alarm acting shall be selected by a switch on the alarm unit board.

The dial set point accuracy shall be $\pm 3\%$ of full scale and repeatability shall be $\pm 0.5\%$ of full scale.

6. SUMMATOR (Y)

The summator shall be provided where indicated, mounted back-of-panel. They shall accept up to 4 input 4 to 20 mA DC signals and output a 4 to 20 mA DC signals which is the specified function of the inputs, each of which shall have a scaling factor, and retransmit this summated signal as required. The accuracy shall be $\pm 0.5\%$ of full scale.

7. SIGNAL CONVERTER (SC)

The signal converter shall convert a potentiometer input signal, mV, V and mA input signals to a 4 to 20 mA DC output signal.

The accuracy shall be $\pm 0.5\%$ of full scale.

8. SQUARE ROOT EXTRACTOR (SQ)

The square root extractor shall be provided where indicated, mounted back-of-panel and shall accept 4 to 20 mA inputs and output a 4 to 20 mA signal which is proportional to the square root of the input. Zero and span adjustment shall be provided.

The accuracy shall be $\pm 0.5\%$ of full scale.

9. E/E POSITIONER (EE)

The electro-electro positioner for motorized valve control shall receive 4 to 20 mA DC input from controller, and compare the feed back signal from the motorized valve position potentiometer.

The E/E positioner shall analyzer and send the command to open or close the motorized valve control unit.

The accuracy shall be $\pm 0.5\%$ of full scale.

The positioner shall have a dead zone adjustment device and time lag adjustment device.

10. ARRESTER (Ar)

The arrester shall be provided for protecting all transmitters and all receiving instruments in the circuit from surge voltage induced intranmission lines and power supply lines due to lightning.

	Two line system V	Power supply
	<u>24 V</u>	<u>220V AC.</u>
Line-to line voltage		
pulse height	: Within 60V	Within 1000V
Line-to earth voltage		
Pulse height	: Within 200V	Within 1000V
Transmission loss	: Within 5 uA	Within 5 uA
Surge discharge		
capacity	: 2 kA or more	2 kA or more

The arrester shall be the plug-in type.

11. POWER SUPPLY UNIT (PWS)

The power supply unit shall be designed to stabilize DC power for instruments and to be installed in the auxiliary relay panels or monitor and control panels. The output voltage setting accuracy shall be $\pm 1\%$.

The unit shall be designed to short circuit and have an over current protection device with low-voltage alarm device.

Power supply unit shall have a rating of 150% of required power.

12. DISTRIBUTOR (DBT)

The distributor shall supply power to two-wire transmitters, receiving units and convert a 4 to 20 mA DC signal to a 1 to 5 V DC output signal. Isolation between input/output and distributor power supply shall be provided.

The accuracy shall be $\pm 0.2\%$ of full scale.

The distributor shall have as spares, at least 120% of the required units.

The distributor shall be provided and installed in the auxiliary relay panel or monitor and control panels.

13. SIGNAL LIMITER (SI)

The signal limiter shall be provided where indicated or as required for system stability. Rate limiter shall accept a 4 to 20 mA DC input signal and output a 4 to 20 mA DC rate limiter signal such that if the input varies at a rate in excess of preset increase or decrease rates the output shall change linearly at the preset rate.

The accuracy shall be $\pm 0.5\%$ of full scale.

14. SIGNAL ISOLATOR (Si)

The signal isolator shall be provided as required to ensure system compatibility and shall be either field-mounted or back-of-panel.

Each signal isolator for input/output signals and signal/power supply shall be completely isolated.

15. AC. CIRCUIT TRANSDUCER (Td)

The AC. circuit transducer shall convert input signal of following table to a 4 to 20 mA DC. output signal.

a. Type	Voltage	Ampere	Active and reactive power	Power factor	Frequency
	<u>VTd</u>	<u>ATd</u>	<u>kWTd</u>	<u>PFTd</u>	<u>HTd</u>
b. Mounting method	:	Back-of-panel Center mount			
c. Input	:	0-150V or	0-5A or	3 0/ 3W or	Lead 0.5 or 45-55 HZ

- | | | | | | |
|-----------------------------|--------|-------------|---|---------|---------------|
| | 0-220V | 0-1A | 3 0/ 4W | lag 0.5 | |
| d. Output | : | | 4-20mA DC. or 1-5V DC. | | |
| e. Accuracy of full scale: | 0.5% | $\pm 0.5\%$ | $\pm 0.5\%$ | ± 3 | ± 0.05 HZ |
| f. Resistance to over input | | | | | |
| | | | - Voltage circuit continuous 120% 2 hour momentarily 200% 1 minute | | |
| | | | - Current circuit continuous 200% 2 hour, momentarily 400% 1 second | | |

16.14.9 MISCELLANEOUS FIELD INSTRUMENTATION EQUIPMENT

The following types of miscellaneous field instrumentation equipment shall be specified hereinafter and such equipment shall be complete with all necessary apparatuses.

- a. Position transmitter (ZT)
- b. Direct flow indicator (Id)
- c. Pressure gauges (PG)

1. POSITION TRANSMITTER (ZT)

Position transmitter shall be provided and mounted at the motorized valve. Output shall be a 4 to 20 mA DC signal. Signal and power transmission shall be provided by a single pair of wires.

The transmitter shall have a waterproof type housing.

The accuracy shall be $\pm 0.5\%$ of full scale.

2. DIRECT FLOW INDICATOR (Id)

Direct flow indicator shall be provided and mounted at the differential pressure tapping pipes. The type shall be the differential pressure operated mechanical type and measuring element shall be of liquid-filled differential bellows movement transfer by crank. The accuracy shall be $\pm 1.0\%$ of full scale. The type of indicator shall be crescent-scale, sector-scale or circular-scale. Pointer of crescent or sector scale shall travel not less than 150 mm. Indicator diameter of circular-scale shall be not less than 150 mm.

3. PRESSURE GAUGES (PG)

Pressure Gauges shall, unless otherwise specified, conform to the following. Gauge shall be for stem mounting directly on the pipe as shown on the drawings. Gauge shall be of the bourdon tube type or equal. Dials shall be white with black numerals.

16.14.10 TESTS

Following installation and final adjustment of all instruments, meters, and flow control devices, a

performance check shall be made on each metering and flow control system. Meters shall be tested at 10% or 12 1/2%, 20%, 50%, and 100% of scale, as required.

The total error based on the manufacturer's certification for differential producer, when added to the field determined instrument errors, shall not exceed +1.0% of the actual flow within the specified range as computed from the differential manometer readings taken during tests.

If, during running of the tests, one or more points appear to be out by more than the specified amount, the manufacturer's field engineer shall make such adjustments or alterations as are necessary to bring equipment up to specification performance. Following such adjustment, the tests shall be repeated for all specified points to ensure compliance.

1. FACTORY TESTS

The instruments shall be completely assembled at the factory. The instruments shall be subject, unless otherwise noted, to the following tests by the Contractor.

- a. Verification of construction
- b. Mechanical operation tests
- c. Characteristics tests
- d. Accuracy tests
- e. Insulation resistance tests
- f. Withstand voltage tests
- g. Strength test
- h. Accessories and spare parts tests

2. FIELD TESTS

After installation, the following tests shall be executed before energizing.

- a. Verification of construction
- b. Mechanical operation tests
- c. Electrical operation tests
- d. Insulation resistance tests
- e. Withstand voltage tests
- f. Accuracy tests
- g. Accessories and spare parts tests.

16.14.11 INSTALLATION

The instrumentation and accessory equipment shall be installed in accordance with the manufacturer's

instructions and located as shown on the drawings or as approved by the Engineer. Local electrical shutoff for power supplies to field instrumentation shall be provided. All piping including to and from field instruments shall be provided with test tees, shutoff and disconnect unions as shown. Electrical work shall be in accordance with Division 16.

It shall be the responsibility of the Contractor to check Division 16, Electrical Work and the electrical drawings to ensure that the wiring and power availability, is sufficient, and if not, to provide all additional facilities necessary at the Contractors expense.

Special instruction for proper field handling and installation, required by the manufacturer for proper protection and performance, shall be securely attached to the flow detectors, pressure detectors and others.

DIVISION 16 ELECTRICAL WORKS

SECTION 16.15 MONITOR AND CONTROL PANELS

16.15.1 GENERAL

1. GENERAL

The Contractor shall furnish and install all monitor and control panels as hereinafter specified and as shown on the drawings.

2. REFERENCES

The following standards are referred to.

IEC 60439	Low-voltage switchgear and controlgear assemblies
JIS C 1102	Direct acting indicating analogue electrical measuring instruments and their accessories
JIS C 1103	Dimensions of Electrical Indicating Instrument for switchgear
JIS C 8201-4-1	Low-voltage switchgear and controlgear -- Part 4: Contactors and motor-starters, Section 1: Electromechanical contactors and motor-starters
JIS C 8370	Molded Case Circuit Breakers (MCCB)
JEM 1265	Low-voltage metal-enclosed switch- gear

16.15.2 SCHEDULE

The monitor and control panels schedule will be specified in the Particular Specifications

16.15.3 TYPE, RATING AND CHARACTERISTICS

The type, ratings and characteristics of monitor and control panels shall be as follows.

- a. Type
 - Panels: Self-supporting, metal-enclosed
 - Enclosed panel: Either front or rear door type
 - Dual panel: Front and rear stationary panel door for access to aisle type
 - Control desk: Front and rear doors top-sloping type
 - Benchboard: Rear and sloping doors type
 - Dual benchboard: Front and rear stationary panel, sloping face door, door for access to aisle type
 - Graphic: Either semi or all graphic or mimic bus
- b. Number of phases: Single-phase

- c. Rated frequency: 50 Hz
- d. Rated insulation voltage: 250 V AC
- e. Rated operating and control voltage
 - DC: 100V \pm 25V
 - AC: 220V \pm 33V
- f. Power supply of each equipment
 - Instruments
 - General: 220V AC (220/220V Transformer)
 - Water analyzer: 220V AC (220/220V Transformer)
 - Level and other: 220V AC (Invertor)
 - Auxiliary relay circuits
 - Annunciator: 220V AC (UPS)
 - Substation: 220V AC (UPS)
 - Each motor and other: 24V AC (220/24V Transformer)
 - Lights
 - Annunciator: 24V DC (Series resistor)
 - Substation: 24V DC (Series resistor)
 - Graphic: 24V AC (220/24V Transformer)
 - Signal: 24V AC (From local panel)
 - Panel inside: 220V AC (With receptacle)
 - Hour meter: 220V AC (From local panel)
 - Speaker system: 220V AC (Invertor)
- g. Power frequency withstand
 - voltage: 1,500 V AC r.m.s.

16.15.4 CONSTRUCTION

1. STRUCTURES

The supervisory and control panels shall consist of a benchboard panel and separate supervisory-control panel types.

The separate type shall consist of main dual enclosed panels and sub-control desks.

The benchboard type is a combination of a control desk and a vertical panel in a common assembly.

The enclosed panel has front and rear panels on which electrical devices are mounted. Both ends and the top are enclosed. On at least one side the panels are hinged to provide access to panel wiring.

The dual panels consist of panels, front and rear, forming a common aisle which is enclosed at the ends and top. Entry doors are provided at each end for access to the common aisle between the panels.

The control desks shall have front, rear and top slope panels on which the mimic diagram of bus bars, control switches of circuit breakers, signal lights and pushbutton of annunciators are mounted. Front, rear and slope panels shall be hinged to provide access to panel wiring and maintenance.

The benchboard panel shall be a combination of a control desk and an enclosed panel in a common assembly.

The dual benchboard shall be a combination of a control desk and a dual panel in a common assembly. The aisle shall be enclosed at the ends and top.

Fluorescent lights and receptacles fixture shall be provided inside each panel with three (3)-way lighting switches.

Minimum thickness of steel for each part of panels shall be:

a. Parts of the enclosed and benchboard panel

Front plate	: 3.2 mm
Semi graphic plate	: 3.2 mm
Rear plate	: 2.3 mm
Side plate	: 2.3 mm
Ceiling plate	: 2.0 mm
Channel base	: 50x100x50x5 t mm
Common aisle plate	: 3.2 mm (checker plate)
Frame angle	: 50x50x4 t mm

b. Control desk

Sloping panel	: not exceed 2.3 mm
Other	: not exceed 2.0 mm

2. GRAPHIC AND MIMIC BUS PANELS

The graphic and mimic bus panels shall be in-stalled on the front of the enclosed panel and benchboard panel.

The graphic panel shall consist of the mosaic and acrylic resin sticking types.

The mosaic panel type shall be provided with a group of square pieces of mosaic size from 20x20mm to 50x50 mm square.

Equipment symbols and lines shall be engraved and finished in color lacquer on the surface of the mosaic.

Each equipment symbol shall display two (2)-kinds of color lights for operation conditions of equipment.

Mimic buses and equipment symbols shall be provided on the panel to form single line diagrams which will simulate actual electrical connections.

The mimic buses and symbols shall be made of approved metal finished in color lacquer.

The mimic buses shall be at least 10 mm wide and mounting bolts shall be concealed.

Sizes and colors of the graphic and mimic bus symbols, lines and buses shall be submitted on a 1/5 scale drawing for each color.

16.15.5 TESTS

1. FACTORY TESTS

The supervisory and control panels shall be completely assembled at the factory. The supervisory and control panels shall be subject, unless otherwise noted, to the following tests by the Contractor.

- a. Verification of construction
- b. Mechanical operation tests
- c. Electrical operation tests
- d. Temperature rise tests
- e. Withstand voltage tests
- f. Accessories and spare parts test

2. FIELD TESTS

After installation, the following tests shall be executed before energizing.

- a. Verification of construction
- b. Mechanical operation tests
- c. Electrical operation tests (Include operating auxiliary equipment under load)
- d. Withstand voltage tests

- e. Testing and setting up of all timers, alarm points, electrode length and protective relays

16.15.6 EQUIPMENT INCLUDED

The supervisory and control panels shall include necessary equipment as presented herein.

1. CONTROL TRANSFORMER

The control transformer shall have the following rating and features :

- a. Type : Indoor, dry molded resin insulated, built-in dead-front type
- b. Type of cooling : Natural air-cooled
- c. Number of phases : Single phase
- d. Rated frequency : 50 Hz
- e. Primary voltage : 220V
- f. Secondary voltage : 220V or 24V
- g. Average temperature rise : Not exceed 65 deg. C
- h. Power frequency
withstand voltage : 4 kV
- i. No-voltage tap changer
 - Primary : F230-R220-F210-F200 V

2. MOLDED CASE CIRCUIT BREAKERS

Circuit breakers shall be of molded case type with auxiliary switch, bolted in. Circuit breakers shall have an interrupting current value not less than 40,000A (asymmetrical value). If required, circuit breaker shall be furnished with motor operation for interlocking and operating.

3. INSTRUMENTS

Voltmeters, wattmeters, power factor meters and ammeters shall be not less than 110 mm square, 240 degrees from zero to full scale, $\pm 1.5\%$ of full scale accuracy, panel mounted type and shall be provided with external zero adjustment.

Watt-hour meter shall be of the pulse-counter, individual or group, non-reset, six (6) digit range type.

Hour meter shall be cased, panel mounted, non-reset, and of 9,999.9 hour range.

4. PHASE AND SEQUENCE SELECTOR SWITCHES

Phase and selector switches shall be the heavy-duty, rotary type, with the required number of positions and clearly marked to show each operating position.

5. PUSHBUTTON

Each pushbutton shall employ double break, silver-to-silver contacts. Operator shall be without guard and shall have a red button for alarm acknowledge. Pushbuttons shall be illuminated with transformer operated lamps.

6. CONTROL SWITCHES

Control switch shall have three positions of "ON", "OFF" and "NEUTRAL", and shall be of the momentary contact type with spring return to neutral position.

Control switch for the motor operation valve shall have four positions of "OPEN", "CLOSE", "NEUTRAL", and "STOP" pull out position with spring return to neutral position.

Control switches shall be of the wear-proof and arc-proof type with dust cover.

Emergency shut-down switch shall be of the momentary contact type with spring return to normal position, and shall have red handle to be pulled out. The switches shall be covered each by a transparent cover with magnet.

7. ANNUNCIATORS

The individual and the group annunciators shall be provided with automatic visual and audible alarms to indicate abnormal conditions in the water treatment plant.

Heavy faults shall be indicated by flicker lights and bell, and minor faults by flicker lights and buzzer.

Pressing the "BUZZER RESET" acknowledge pushbutton shall stop the flicker light, and silence the bell or buzzer.

The light shall go out when the alarm condition is removed and pressing the "LAMP RESET" pushbutton.

All annunciator lights shall be turned on by the "LAMP TEST" pushbutton regardless of normal condition.

Annunciator light shall have backlights and an engraved faultname with black letters on a white background.

At least 20% spare annunciators shall be provided at the site.

8. SIGNAL LIGHTS

Red signal light shall be used for "ON" or "OPEN" position, green light used for "OFF" or "CLOSE" position, and white light used for "MOVING" position of motor operating valve.

Color caps shall be made of glass or material which will not be softened by the heat from the lamps.

Each AC-signal light shall be provided with auxiliary transformer, and the DC-signal light shall be provided with external resistor.

9. GROUP SEQUENCE LIGHTS

The group sequence lights shall have a lamp inside a window which lights up to give information by the letters on the window. Wording shall indicate the operation sequence.

10. SEQUENCE CONTROLLER

All equipment shall be designed for nominal AC supply at 220 V \pm 10%, 50 Hz, single phase. Automatic voltage regulator shall be furnished to provide a constant voltage source for the sequence controller with the specified \pm 10% input voltage variation. Ambient temperature will be 0 deg.C to 45 deg. C, and all offered equipment must be suitable for operation at these temperatures.

All equipment shall be treated to prevent the growth of fungus or other living organisms and shall be completely solid state, unless otherwise specified.

Unless otherwise specified all active and passive elements shall be manufactured to industrial standard specifications.

Lightning protection shall be provided for all equipment furnished under this section.

A self checking system and battery for power failure shall be provided.

Two sets of programming loaders for programming shall be furnished.

Specifications of sequence controller shall be as follows :

- Program system : Stored program system
- Instruction : Basic four (Read, And, Or and Write)
- Computation functions : Timer computation, counter computation, step control, shift-register and logic control
- Computation system : Usually cyclic computation
- Input : Non-voltage contact
- Output : Contact

11. AUXILIARY RELAYS

Auxiliary relays shall be general purpose industrial types, and shall be the dust cover enclosed plug-in type.

12. ELECTRIC CLOCK

The electric clock shall be wall mounted, quartz type. The clock indicator shall be a digital or analog type with a suitable case.

13. TEST TERMINALS

Test terminals shall be furnished for the secondary circuit of the potential transformer and the current transformer. All matching test plugs shall be furnished. Test plugs and lead wires for each type of protective relay shall be furnished.

16.15.7 INSTALLATION

The supervisory and control panels shall be mounted on steel channels which are installed on the concrete floor. The channels shall run the full length of the switchgear and shall be installed level in all directions.

The supervisory and control panels shall be maintained in an upright position at all times. Lifting shall be only at the floorsills or the top mounted lifting angle.

The supervisory and control panels shall be protected against damage at all times. Any damage to the paint shall be carefully repaired using touch-up paint furnished by the switchgear manufacturer.

DIVISION 16 ELECTRICAL WORKS**SECTION 16.16 PANEL BOARD****16.16.1 GENERAL****1. GENERAL**

The Contractor shall furnish and install all panel boards as hereinafter specified and as shown on the drawings.

2. REFERENCES

The following standards or other internationally accepted standards or manufacturer's standards as approved by the Engineer are referred to.

IEC 60439	Low-voltage switchgear and controlgear assemblies
JIS H 3140	Copper Bus Bars
JIS C 8201-4-1	Low-voltage switchgear and controlgear -- Part 4: Contactors and motor-starters, Section 1: Electromechanical contactors and motor-starters
JIS C 8370	Molded Case Circuit Breakers (MCCB)
JIS C 8371	Residual Current Operated Circuit Breaker
JIS C 8374	Residual Current Sensing and Relaying Equipment
JEM 1265	Low-voltage metal-enclosed switch gear

16.16.2 SCHEDULE

The panel boards schedule will be specified in the Particular Specifications.

16.16.3 TYPE RATING AND CHARACTERISTICS

The type, ratings and characteristics of panel boards shall be as follows.

- a. Type : Indoor, metal-enclosed dead-front, self-supported or wall mounted type
- b. Number of phases : Three (3)-phase, four (4)-wire and DC circuit
- c. Rated frequency : 50 Hz
- d. Rated insulation voltage
 - Main circuit : 600V AC r.m.s.
 - Control circuit : 250V AC r.m.s.
- e. Rated operation voltage

- Main circuit : 280V AC and 100V DC
- Control circuit : 220V AC and 100V DC

f. Power frequency withstand voltage

- Main circuit : 2,500V AC r.m.s.
- Control circuit : 1,500V AC r.m.s.

g. Rated operating and control voltage

- DC : 100V \pm 25V
- AC (r.m.s.) : 220V \pm 22V 33V

16.16.4 CONSTRUCTION

All interiors shall be completely factory assembled with circuit breakers, bus bars and wire connectors. All wire connectors, except screw terminals, shall be of the anti-turn solderless type and shall be suitable for copper wire of the sizes indicated.

Interiors shall be so designed that circuit breakers can be replaced without disturbing adjacent units and without removing the main bus connectors and shall be so designed that circuits may be changed without machining, drilling, or tapping.

Branch circuits shall be arranged using double row construction except when narrow column panels are indicated. Branch circuits shall be numbered by the manufacturer.

Hinged doors covering all circuit breaker handles shall be included in all panel trims. Doors shall have semi-flush type cylinder locks and catches, except that doors over a 2.0 meter height shall have a vault handle and 3 point catch complete with lock, arranged to fasten the door at the top, bottom, and center. Door hinges shall be concealed.

Two keys shall be supplied for each lock. All locks shall be keyed alike; directory frame and card having a transparent cover shall be furnished on each door.

The trim shall be fabricated from steel. All exterior and interior steel surfaces of the panel boards shall be properly cleaned and finished with Muncell paint over a rust inhibiting phosphatized coating.

16.16.5 BUS BARS

Bus bars for the mains shall be copper. Full size neutral bars shall be included. Bus bar taps for panels with single pole branches shall be arranged for sequence phasing of the branch circuit devices.

Busing shall be braced throughout to conform to industrial standard practice governing short circuit stresses in panelboards.

Phase busing shall be full height without reduction. Cross connectors shall be copper.

Neutral busing shall have a suitable lug for each outgoing feeder requiring a neutral connection.

Spaces for future circuit breakers shall be bussed for the maximum device that can be fitted into them.

All bus bars shall be made of copper conforming to JIS H 3140, "Copper Bus Bar", Class C 1100 or equivalent.

16.16.6 TESTS

1. FACTORY TESTS

The panel boards shall be completely assembled at the factory. The panel boards shall be subject, unless otherwise noted, to the following tests by the Contractor.

- a. Verification of construction
- b. Mechanical operation tests
- c. Electrical operation tests
- d. Withstanding voltage tests

2. FIELD-TESTS

After installation, the following tests shall be executed before energizing.

- a. Verification of construction
- b. Electrical operation tests
- c. Withstanding voltage tests

16.16.7 EQUIPMENT INCLUDED

The panel boards shall include the following equipment.

1. CIRCUIT BREAKERS

Circuit breakers shall be the molded case type with auxiliary switch bolted-in. Circuit breakers shall have an interrupting current value not less than 40,000A (asymmetrical).

2. ELECTROMAGNETIC SWITCHES

The switch shall be three (3)-pole, 50 Hz, 600V AC. and two (2)-pole 250V DC magnetically operated, as shown on the drawings.

Each motor starter shall have 220V AC or 100V DC operating coil and three (3)- or one (1)- element overload relays. Auxiliary contacts shall be provided as shown on the drawings or as required.

Overload relays shall be adjustable and manually reset.

DIVISION 16 ELECTRICAL WORKS**SECTION 16.17 MOTORS****16.17.1 GENERAL****1. SCOPE OF WORK**

The Contractor shall furnish and install all motors as hereinafter specified and as shown on the drawings.

2. REFERENCES

The following standards or other internationally accepted standards or manufacturer's standards as approved by the Engineer are referred to.

JIS C 4003	Classification of materials for insulation of electrical machinery and apparatus
JIS C 4004	General Rules for Rotating electrical machines
JIS C 4210	Low-voltage three-phase squirrel - cage induction motors for general purpose
JEC 37	Induction machines
JEC 114	Synchronous machines

16.17.2 SQUIRREL CAGE INDUCTION MOTORS**1. TYPE AND RATING**

- a. Type : Horizontal or vertical, drip-proof or totally enclosed, fan cooled type
- b. Cooling method : Self-ventilation
- c. Number of phases : Three (3)-phase
- d. Rated frequency : 50 Hz
- e. Rated voltage
 - High voltage : 6,000V AC or 3,000V AC
 - Low voltage : 380V AC or 220V AC
- f. Class of rating : Continuous
- g. Class of insulation
 - High voltage : F class
 - Low voltage : E class or F class
- h. Limited temperature rise

- E class : 75 deg.C (resistance method)
- B class : 80 deg.C (resistance method)
- F class : 100 deg.C (resistance method)
- i. Ambient temperature : 45 deg.C
- j. Standard direction
 - of rotation : Clockwise when viewed from the opposite side to the coupling
- k. Voltage variation : 10% over and under the rated value, at the rated frequency
- l. Frequency variation : 5% over and under the rated value, at the rated voltage
- m. Momentary excess
 - current : 150% of rated current for not less than 15 seconds
- n. Momentary excess
 - torque : 160% of rated torque
- o. Overspeed : 120% of the maximum rated speed
- p. Power frequency withstand voltage (r.m.s.)
 - less than 1 kW: 500V + 2E (1,000V min.)
 - Less than 10,000 kW : 1,000V + 2E (1,500V min.)

2. CONSTRUCTION

Squirrel cage induction motors for exterior service shall be of weather proof design suitable for continuous service in a tropical environment.

Minimum output shall be as shown on the mechanical specification schedule and the mechanical drawings.

The motors for the driven equipment except pumps shall be capable of developing the motor power required by the units under all specified operating conditions without overload, and shall develop adequate starting torque for the driven equipment.

The motors for the driven pump shall have a rating that will not be exceeded with the pump operating at any point on its characteristic curve and in addition shall have a service factor of at least 1.15.

The motors shall be designed for full voltage starting. Locked-rotor current shall not exceed 600%.

All motors shall be run without injury in normal service, when under a load equal to the rated output, irrespective of a terminal voltage variation of 10% over and under the rated voltage, at the rated frequency.

Motor torque characteristics shall be equal to the requirements of the pumps being furnished. The motor shall have sufficient torque to start and synchronize with the discharge valve closed. Motor thermal capacity shall be sufficient to allow time for the discharge valve to open.

Stator and rotor cores shall be made of low loss, non-aging, electrical sheet steel with insulated laminations.

Stator coils shall be form wound, pre-insulated and fitted into open slots and adequately secured and braced to prevent movement during full voltage starting. Stator coils shall be form wound, of identical size, shape, insulation and number of turns.

In case motor output exceeds 100 kW, six resistance, Pt 100, 0 deg.C type temperature detectors shall be furnished in the stator winding between coil sides of different phases. The detectors shall be wired to an enclosed terminal block. The detector coil indicating the highest temperature at test shall be marked at the factory for connection to a stator temperature relay.

Bearings shall be sleeve type. Each bearing shall be furnished with bearing temperature relays.

Stator terminal boxes of motor output exceeding 100 kW shall be oversized for stress cone connections and differential protection transformers. A ground lug attached to the motor frame shall be mounted in the stator terminal box. The ground lug shall be suitable for the size wire shown on the drawings.

The motor having a rated output of not less than 5.5 kW shall be of such construction that the star-delta starter can be used, as required.

Space heaters shall be installed and arranged to be automatically energized when the motor is at rest and to automatically maintain a pre-determined motor temperature.

Motors shall be free of objectional noise and vibration. Maximum vibration at any speed or load shall not exceed two mils peak-to-peak.

3. TESTS

3.1 Factory Tests

The squirrel cage induction motors shall be completely assembled at the factory. The squirrel induction motors shall be subject, unless otherwise noted, to the following tests by the Contractor.

- a. Construction tests
- b. Measurement of resistance
- c. No-load tests
- d. Calculation of full load characteristics and breakaway torque

- e. Calculation of minimum starting torque
- f. Tests for starting input characteristic
- g. Temperature tests
- h. Withstand voltage tests
- i. Noise tests
- j. Vibration tests

16.17.3 SYNCHRONOUS MOTORS

1. TYPE AND RATING

- a. Type: Horizontal, drip-proof, bracket or pedestal mounted on a common steel base type
- b. Cooling method: Self-ventilation
- c. Number of phases: Three (3)-phase
- d. Rated frequency: 50 Hz
- e. Rated voltage: 6,600V AC or 3,300V AC
- f. Class of rating: Continuous
- g. Class of insulation: B class or F class
- h. Limits of temperature rise
 - B class: 80 deg.C (resistance method)
 - F class: 100 deg.C (resistance method)
- i. Ambient temperature: 45 deg.C
- j. Standard direction of rotation: Clockwise when viewed from the opposite side to the coupling
- k. Voltage variation: 10% over and under the rated value, at the rated frequency
- l. Frequency variation: 5% over and under the rated value, at the rated voltage
- m. Momentary pull-out torque: 150% of rated torque for not less than 15 seconds
- n. Overspeed: 120% of the maximum rated speed
- o. Power frequency withstand voltage (r.m.s)
 - less than 1 kW: 500V + 2E (1,000V min.)
 - less than 10,000 kW: 1,000V + 2E (1,500V min.)

2. CONSTRUCTION

Synchronous motors for exterior service shall be of weatherproof design suitable for continuous service in a tropical environment.

Synchronous motors shall be construction with unity power factor, with speed to match the pump to be driven. Motor frame structure of synchronous motor shall be either bracket type or pedestal type mounted on a common steel base.

Minimum output shall be as shown on the mechanical specification pump schedule.

The motors shall have a rating that will not be exceeded with the pump operating at any point on its characteristic curve and in addition shall have a service factor of at least 1.15.

Locked-rotor current shall not exceed 600%.

Optimum synchronizing speed is to be selectable over a limited range in the vicinity of 95% synchronous speed.

A system using timed random application of motor field excitation is not acceptable.

Motor torque characteristics shall be equal to the requirements of the pumps being furnished. The motor shall have sufficient torque to start and synchronize with the discharge valve closed. Motor thermal capacity shall be sufficient to allow time for the discharge valve to open.

All motors shall be run without injury in normal service, when under a load equal to the rated output, irrespective of a terminal voltage variation of 10% over and under the rated voltage, at the rated frequency.

Stator and rotor cores shall be made of low loss, non-aging, electrical sheet steel with insulated laminations. Stator coils shall be form wound, of identical size, shape, insulation and number of turns.

Stator coils shall be form wound, pre-insulated and fitted into open slots and adequately secured and braced to prevent movement during full voltage starting.

Six resistance, Pt 100, 0 deg.C type temperature detectors shall be furnished in the stator winding between coil sides of different phases. The detectors shall be wired to an enclosed terminal block. The detector coil indicating the highest temperature at test shall be marked at the factory for connection to a stator temperature relay.

Field pole windings shall be either of wire or strip copper, depending on electrical requirements. Pole bodies shall be well insulated with care taken to seal corners between pole-body insulation and flange.

Field windings shall be cemented with insulating compound to hold wires firmly against distortion from centrifugal force and to seal against the entrance of moisture.

Starting cage winding joints shall be phos-copper brazed-welded to maintain starting torques

throughout the life of the motors.

The rotating brushless excitation system shall include a direct connected three phase, AC generator feeding a full wave three phase diode bridge rectifier with the output applied to the field of the synchronous motor through a silicon controlled rectifier which is gated at the proper motor speed and phase angle by semi conductor operated logic circuitry to achieve maximum positive pull-in torque.

The rotating logic circuitry must further provide a means for energizing the motor field in the event the motor pulls into step under lightly loaded conditions through its reluctance torque (zero slip feature). It also must be capable of removing motor field at pull-out.

Bearings shall be sleeve and ring oiling type. Each bearing shall be furnished with bearing temperature relays.

Stator terminal boxes shall be oversized for stress cone connections and differential protection transformers. A ground lug attached to the motor frame shall be mounted in the stator terminal box. The ground lug shall be suitable for the size wire shown on the drawings.

Space heaters shall be installed and arranged to be automatically energized when the motor is at rest and to automatically maintain predetermined motor temperature.

Motors shall be free of objectional noise and vibration. Noise level shall be equal to or less than 85 decibels. Maximum vibration at any speed or load shall not exceed two mils peak-to-peak.

3. TESTS

3.1 Factory Tests

The synchronous motors shall be completely assembled at the factory. The synchronous motors shall be subject, unless otherwise noted, to the following tests by the Contractor.

- a. Construction tests
- b. Measurement of resistance
- c. No-load saturation characteristic tests
- d. Short-circuit characteristic tests
- e. Field current tests
- f. Starting characteristic tests
- g. Temperature tests
- h. Excitation equipment tests
- i. Withstand voltage tests
- j. Noise tests

k. Vibration tests

DIVISION 16 ELECTRICAL WORKS**SECTION 16.18 WIRE AND CABLE****16.18.1 GENERAL****1. GENERAL**

The Contractor shall furnish and install all wire, cable, and appurtenances as shown on the drawings and as hereinafter specified.

2. REFERENCES

The following standards or other internationally accepted standards or manufacturer's standards as approved by the Engineer are referred to:

VDE 0271	PVC insulated and sheathed control cables
JIS C 3001	Resistance of Copper Materials for Electrical Purposes
JIS C 3102	Annealed Copper Wires for Electrical Purposes
JIS C 3307	600V Polyvinyl Chloride Insulated Wires
JIS C 3342	600V Polyvinyl Chloride Insulated and Sheathed Cables
JIS C 3605	600V Polyethylene Insulated Cables and 600V Cross Linked Polyethylene Insulated Cables
JIS C 3606	High - Voltage Cross - linked Polyethylene Insulated Cables

16.18.2 MATERIALS

Wires and cables shall be of annealed, 98 percent conductivity at 20 deg. C, annealed copper.

16.18.3 WIRES AND CABLES**1. 35 kV and 11kV CABLES**

All cable used for 22 kV circuits shall be Cross-Linked Polyethylene insulated and Polyvinyl Chloride sheathed power cable type XLPE with single or three conductors. Conductors more than 60 mm square shall be used.

2. 6.6 kV AND 3.3 kV CABLES

All cables used for 3.3 kV and 6.6 kV circuits shall be Cross-Linked Polyethylene insulated and Polyvinyl Chloride sheathed power cable type XLPE, with single or three conductors. Conductors more than 22mm square shall be used.

3. 380V MAIN-LINE CABLE

All cables used for 380V circuits shall be Cross-Linked Polyethylene insulated and Polyvinyl Chloride sheathed power cable type XLPE with single, two, three or four conductors.

4. 380V AND 220V CABLES

Cable used for three-phase motor and single motors shall be Polyvinyl Chloride insulated power cable type 0.6/1 kV with two or three conductors. Conductors more than 3.5 mm square shall be used.

5. 220V CABLES

Cable used for lighting and single phase motor shall be Polyvinyl Chloride insulated and sheathed cable type 0.6/1 kV. Conductors more than 2.0 mm square shall be used.

6. CONTROL CABLES

All cables used for 220V AC and 100V AC control circuits shall be Polyvinyl Chloride insulated and sheathed cable type 0.6/1kV. Conductors more than 2.0 mm square shall be used.

7. INSTRUMENT SIGNAL CABLES

All cables used for 220V instrument signal circuits shall be Polyvinyl Chloride insulated and sheathed cable with copper-tape shielding type CVV-S. Conductors more than 2.0 mm square shall be used.

8. COMMUNICATION CABLES

All cables used for communication line shall be Polyethylene insulated and Polyvinyl Chloride sheathed cable with copper-tape shielded type CPEV-S. Conductors more than 1.2 mm (diameter) shall be used.

9. WIRES

Wire used for grounding and electrical construction shall be Polyvinyl Chloride insulated wire type IV, and MYA-600 Volt. Conductor more than 2.0 mm square shall be used.

16.18.4 INSTALLATION

Under all wire and cable installation work between terminals, any wire and cable connection work at any points except terminals will not be permitted. Wire and cable which have no connection parts shall be used for their installation work between terminals.

All wire and cable connection work shall be only permitted at terminal board provided with equipment.

Three (3) - single conductor cables comprising one three-phase circuit shall be laid without spacing.

All conductors shall be carefully handled to avoid kinks or damage to insulation.

Lubricant shall be used to facilitate wire pulling. Lubricants shall be approved for use with the insulation specified.

Finishing of terminals of all high-voltage cables and low-voltage cables having a section over 14 mm square shall be made by using terminal finish materials and fittings.

Connections of each terminal of equipment shall be done with solderless terminals, and cables shall be marked by identification marks on bands or tags fitted every 20 m to sheathes.

Each core wire of high-voltage and low voltage cables shall be identified with a color index.

Inlet cables to the panels shall be firmly secured with proper support so that excess stress will not be imposed on the joint.

The gaps in the cable hole of the panel wells, etc. shall be filled with putty or other materials to prevent entry of moisture and other foreign matters.

Wire used for power circuits shall be color coated as follows :

For three (3)-phase, four (4)-wire circuits

phase A	: red
phase B	: blue
phase C	: yellow
neutral	: black
ground	: green

For single-phase, two (2)-wire circuits

phase	: as phase color
neutral	: black
ground	: green

Cable work to be undertaken in the pit, which is to be constructed under another contract, shall include separators, supports and others, all made of hot-dipgalvanized steel. Such fittings shall be firmly fixed to the pit to hold securely the cables and others.

DIVISION 16 ELECTRICAL WORKS

SECTION 16.19 CONDUIT, BOXES, AND FITTINGS

16.19.1 GENERAL

1. GENERAL

The Contractor shall furnish and install all conduit boxes and fitting as hereinafter specified and as shown on the drawings.

2. REFERENCES

The following standards or other internationally accepted standards or manufacturer's standards as approved by the Engineer are referred to.

JIS C 8305	Rigid Steel Conduits
JIS C 8309	Pliable Metal Conduits
JIS C 8330	Fittings for Rigid Metal Conduits
JIS C 8340	Boxes and box covers for rigid metal conduits
JIS C 8350	Fittings for Pliable Metal Conduits
JIS G 3132	Hot-rolled Carbon Steel Strip for Pipes and Tubes

16.19.2 MATERIALS

1. CONDUIT

Conduit tubes shall be comply to JIS-C-8305 for "Thick rigid steel conduit tubes and thin rigid steel conduits tube".

Power and control cables shall use thick rigid steel conduit tubes, and lighting cables shall use thin rigid steel conduit tubes.

The inside and outside surfaces of conduit tubes shall be given rust-preventive treatment by hot-dip galvanizing.

2. FLEXIBLE CONDUIT

Flexible conduit shall be used to JIS-C-8309 for "Class 2 PVC Covered Flexible Metal Conduit".

The "Class 2 PVC covered flexible metal conduit" shall be wound with a uniform 4 layers as installed by employing the combination of materials prescribed below.

Exterior cover : PVC layer

- Outside layer : Metallic strip
- Intermediate : Metallic strip
- Inside layer : Non-metallic strip

3. BOXES AND FITTINGS

The pull boxes and fittings shall be fabricated from hot-dip galvanized steel of 1.6 mm or more thickness with hot-dip galvanized cover and stainless screws.

The pull boxes and fittings which will be installed outdoors and installed in basement rooms of buildings shall be fabricated from stainless steel of 2.0 mm or more thickness with stainless steel cover and screws.

Cast iron boxes and fittings shall be galvanized with cast galvanized covers and stainless screws.

Outlet boxes shall be of hot-dip galvanized steel square and octagonal, and of sufficient size to accommodate all the required conductors enclosed in the box.

Pull boxes shall be of sufficient size to accommodate the connected conduits and enclosed conductors. Boxes 300 mm square and smaller shall have gasketed screw type covers. Large boxes shall have bi-parting gasketed hinged doors with latch mechanisms, handles and cylinder locks complete.

All boxes shall be painted.

4. FLEXIBLE CONDUIT FITTINGS

Liquid tight, flexible metal conduit shall have an interlocked, hot-dip galvanized steel core, with an abrasion-resistant, liquidtight, polyvinyl chloride covering.

16.19.3 INSTALLATION

Rigid steel conduits shall be provided for all exposed and embedded installations.

PVC conduits shall be provided for installations in corrosive areas.

All conduits for power and control cables shall use thick rigid conduits. Conduits more than 22 mm electrical trade size shall be used.

The sectional area of a conduit shall be, at least, 2.5 times the total sectional area of cables to be put in.

Radius of curvature of conduits shall be over 6 times of inside diameter thereof and the bending angle shall not exceed 90 degrees.

Bending of a conduit shall have less than three-90 degree bends in any one run. Pull boxes shall be provided as directed or required.

Conduits and boxes shall be fitted securely to structures. Fitting conduits to a place without access for inspection shall not be permitted. All piping shall be symmetrical and either vertical, horizontal or parallel to structure parts.

For connecting conduits, couplings shall be used, tightly screwed.

No cable shall be pulled into the conduit system until it is complete in all details; in the case of concealed work, until all rough plastering or masonry has been completed; and in the case of exposed work, until the conduit system has been completed in every detail.

The ends of all conduits shall be tightly plugged to exclude dust and moisture while the buildings are under construction.

All conduits and fittings on exposed work shall be secured by means of metal clips and back plates.

Conduit supports shall be spaced at intervals 1.5 meter or less, as required to obtain rigid construction.

Single conduits shall be supported by means of one-hole pipe clamps in combination with one-screw back plates to raise conduits from the surface. Multiple runs of conduits shall be supported on trapeze type hangers with steel horizontal members and threaded hanger rods.

Conduit hangers shall be attached to structural steel by means of a beam of channel clamps. Where attached to concrete surfaces, concrete inserts of the spot type shall be provided.

All conduits on exposed work shall be run at right angles to and parallel with the surrounding wall and shall conform to the form of the ceiling. No diagonal runs will be allowed. Bends in parallel conduit runs shall be concentric. All conduits shall run perfectly straight and true.

Conduits terminating in pressed steel boxes shall have double locknuts and insulated bushings.

Conduits terminating in gasketed enclosures shall be terminated with conduit hubs.

For connecting a flexible conduit with another metal conduit or equipment, connectors shall be used to secure a tight mechanical and electrical connection.

The radius of curvature of conduit shall be over 6 times the inside diameter, and shall be laid in such a manner that it can be replaced easily.

For a cable branching out from a cable duct, flexible conduit or rigid conduit shall be used for protection thereof.

Flexible conduit shall be used for all motor terminations and other equipment with pull box.

Vertical conduits, 4 m or longer shall have a drain fitting.

Expansion and deflection fittings shall be used where conduits cross building expansion joints.

Pressed steel boxes shall be used for concealed work. Exposed boxes and fittings shall be cast metal.

DIVISION 16 ELECTRICAL WORKS

SECTION 16.20 ELECTRIC FLEXIBLE CONDUIT

16.20.1 GENERAL

1. GENERAL

The Contractor shall furnish and install all electric flexible conduit as hereinafter specified and as shown on the drawings.

2. REFERENCES

The following standards or other internationally accepted standards or manufacturer's standards as approved by the Engineer are referred to.

JIS K 6723	Plasticized Polyvinyl Chloride Compounds
JIS K 6922-2	Plastics – Polyethylene (PE) moulding and extrusion materials -- Part 2: Preparation of test specimens and determination of properties
JIS K 6761	Polyethylene Pipes for General Purposes
JIS K 6923	Plastics -- Polystyrene (PS) Moulding and Extrusion Materials
JIS K 7202-2	Plastics -- Determination of hardness -- Part 2: Rockwell hardness

16.20.2 MATERIALS

Electric flexible conduit shall consist of corrugated hard polyethylene, and shall have the following features:

- a. Density : 0.95 g per cu cm
- b. Vicat softening point : 120 degree
- c. Torsional resistance : 150 kg per cm
- d. Hardness : 66
- e. Size : 30 - 200 mm

16.20.3 INSTALLATION

Proper location of underground cables and others shall be approved by the Engineer before execution of burying work.

Electric flexible conduit shall be used, unless otherwise specified, for underground cable installation.

Pilot wire shall be provided inside flexible conduit in the course of its production and shall be connected with the cable pilot wire to pull the cable into the conduit.

Electric flexible conduit shall be installed from ground level more than 0.6 m depth irrespective of the size of conduit. If conduit is under pressure, more than 1.2 m depth.

Electric flexible conduit shall be laid carefully so as to prevent soil, sand and water entering conduit through the end mouth.

When two or more conduits shall be laid in parallel, the respective conduits shall be arranged with 50 mm distance (diameter 30 mm and 50 mm), 70 mm distance (diameter 80 mm, 100 mm and 150 mm), 100 mm distance (diameter 200 mm).

Filling shall be used with backfilled soil.

Joining conduit shall consist of straight joining, bellmouth, spare cap and waterproof wall sealing compound.

Cables shall be pulled into the conduit by utilizing the pilot wire previously accommodated in the conduit.

Electric flexible conduit shall be Corrugated Hard Polyethylene Pipe.

At the important locations of underground conduit, concrete sign poles shall be provided for indication of such locations.

The buried indication sheet for underground high-voltage cable shall be continuously installed from 20 cm to 40 cm above the buried electric flexible conduit.

Manholes and handholes shall be built of reinforced concrete, and be water-tight. At a corner of the bottom thereof, a sump shall be provided.

On the walls of man-holes, support fittings shall be fitted rigidly so as to support cables and joints securely.

When a man-hole exceeds 1.4m in depth, a ladder shall be provided.

Exposed surfaces of the walls of hand-holes and man-holes shall be finished with mortar.

Underground structures and obstacles shall be investigated prior to excavation in order not to damage them, or to take necessary measures.

In backfilling, proper tamping shall be done made so as not to cause any settlement.

Spare flexible conduits shall be located nearest to the access openings to facilitate future cable installations.

The Contractor shall use excavation machinery with caution in areas containing existing underground conduit systems and others.

DIVISION 16 ELECTRICAL WORKS

SECTION 16.21 LIGHTING SYSTEM

16.21.1 GENERAL

1. GENERAL

The Contractor shall furnish and install all lighting fixtures and accessories as hereinafter specified and as shown on the drawings.

2. REFERENCES

Kazakhstan Standards shall be referred to, if applicable, or the following standards or other internationally accepted standards or manufacturer's standards as approved by the Engineer are referred to.

JIS C 8106	Fluorescent lamp luminaires for commercial, industrial and public lighting
JIS C 8108	Ballasts for Fluorescent Lamps
JIS C 8110	Ballasts for High Pressure Mercury Vapour Lamps and Ballasts for Low-Pressure Sodium Vapour Lamps
JIS C 8303	Plugs and Receptacles for Domestic and Similar General Use
JIS C 8304	Small Switches for Indoor Use
JIS C 8370	Molded Case Circuit Breakers (MCCB)
JIS C 8371	Residual Current Operated Circuit Breakers

16.21.2 SCHEDULE

The lighting system schedule will be specified in the Particular Specifications.

16.21.3 FIXTURES, LAMPS AND ACCESSORIES

1. LIGHTING FIXTURES AND LAMPS

All lighting fixtures, lamps and accessories shall be for operation on 220V, 50 Hz service.

All fixtures and lamps shall be at the numbers and types shown and specified. All fixtures and lamps installed shall be new, and all shall operate on completion of the job.

All fixtures and lamps shall be left in a clean condition, free of dirt and defects, before acceptance by the Engineer.

The schedule of types of lighting fixtures indicates the types of fixtures and types of mounting to be provided. Generally when a manufacturer's name is used, the luminaire as manufactured by him is to

be used.

Where alternative fixtures are proposed, the quality of the alternate fixture and other necessary data shall be submitted for approval before an order is placed with a supplier.

2. MERCURY VAPOR FIXTURES

Mercury vapor fixtures shall be complete with integral mounted ballast of the proper size and type recommended by the manufacturer of the fixture, and acceptable to all applicable codes. The fixtures shall be complete with a deluxe white lamp of wattage scheduled.

Ballasts for mercury vapor fixtures shall be for operation on 220V, 50 Hz, with high-power factor, constant input power type.

3. EMERGENCY LIGHTS

Emergency lighting shall be automatically lighted at power supply interruption with 40W lamps by batteries.

4. SWITCHES

Wall switches shall be of the indicating, toggle action, flush mounting, quiet type, rated 10A at 250V or as specified on the drawings.

Watertight switches shall be 10A, 250, mounted in a cast aluminum box with gasketed cover or as specified on the drawings.

5. RECEPTACLES

Wall receptacles shall be the duplex grounding type, 250V, 20A, three (3)-pole, three (3)-wire or as specified on the drawings.

Watertight receptacles shall be general purpose receptacles enclosed in gasketed, cast iron housings with spring loaded gasketed cover.

Special purpose receptacles shall be as shown on the drawings.

6. OUTLET FITTINGS

At all outlets of whatever kind for all systems, there shall be provided a suitable fitting which shall be either a box or other devices especially designed to receive the type of device to be mounted thereon.

At all outlets on concealed conduit work, galvanized pressed steel outlet boxes shall be provided. These boxes shall in all cases be especially designed for the apparatus required and in all cases where such boxes are not available on the market, special boxes shall be made by the Contractor without additional expense.

Exposed boxes used for switches and receptacles shall be cast type; those for lighting outlets as required by the fixtures.

Boxes and fittings in wet areas shall be of waterproof construction.

16.21.4 LIGHTING PANEL BOARD

Lighting panel board shall be the dead-front, factory-assembled, bolt-in circuit breaker type; interior shall be enclosed in a steel panel, surface-mounted with knockouts.

Lighting panel board shall have the following ratings :

- a. Rated insulation voltage : 600V AC
- b. Rated frequency : 50 Hz
- c. Number of phases
 - AC : Three(3)-phase, four(4)-wire
 - DC : Two (2)-wire
- d. Rated operation voltage
 - AC : 380/220V
 - DC : 100V
- e. Insulation level : 2,500V R.M.S. (One minute)

Interior shall have solderless, anti-turn connectors and shall be constructed so that branch circuit breakers can be replaced without disturbing adjacent units or resorting to field drilling and tapping.

Bus bars and connecting drop shall be copper. Neutral bar shall be full-sized and shall have one terminal screw for each branch circuit; main bus bar shall be full-sized for entire length. Indicated spaces shall have cross connections for the maximum sized device that can be fitted.

Door in trim shall have concealed spring hinges and shall have cylindrical lock. Trim shall have circuit directory pocket. All trim and cabinet of surface-mounted panel shall be phosphate treated, primed and finished with baked enamel.

The number of circuit breakers and the ampere ratings shall be as shown on the drawings.

The cover plate shall be given a priming coat and two coats of high grade baked gray enamel. Panelboard shall carry the UL seal of approval. All breakers controlling fluorescent lighting circuits shall be equipped with handle lock-off devices.

DC magnet switch shall be operated by no-voltage relay at AC power supply interruption until return of normal AC power.

DIVISION 16 ELECTRICAL WORKS

SECTION 16.22 LIGHTNING PROTECTION SYSTEM

16.22.1 GENERAL

1. GENERAL

The Contractor shall furnish and install a complete Lightning Protection system as shown on the drawings and as hereinafter specified.

2. REFERENCES

Kazakhstan Standards shall be referred to, if applicable, or the following standards are referred to.

JIS A 4201	The protection of Structures Against Lightning
JIS C 3101	Hard-drawn Copper Wires for Electrical Purposes
JIS C 3102	Annealed Copper Wires for Electrical Purposes
JIS H 3100	Copper and Copper Alloy Sheets, Plates and Strips

16.22.2 SYSTEM DESIGN

The system shall consist of air terminals, roof and down conductors (main conductors) and branch conductors, grounding and bonding of equipment. The system shall be totally exposed as required to meet the approval of the Engineer and specifications for the type of building or structure.

Air terminals shall consist of solid copper rod with a tapered point 0.61 meter in height, spaced at intervals exceeding 7.6 meters. Minimum height of air terminals shall be such as to bring the tip not less than 0.254 meter above the object to be protected, with spacings of less than 7.6 meters recommended.

Main conductors shall be copper cable, of the grade ordinarily required for industrial electrical work normally designated as being 98 percent conductivity when annealed, and shall size not less than 35 mm square.

Branch conductors used for bonding equipment shall be copper cable not less than 50 mm square.

16.22.3 MATERIALS

Materials used in the installation of the Lightning Protection System shall be as approved by the Engineer. Prior to making the installation, a complete list of materials, catalog data and shop drawings shall be submitted for approval.

In the event any items of material or equipment contained in the schedule fail to comply with the specification requirements, such items shall be rejected.

The system furnished under this specification shall be the product of a manufacturer regularly engaged in the production of Lightning Protection Systems and shall be the manufacturer's latest design.

16.22.4 GROUNDING

Each downlead cable shall terminate at a ground rod. Sizes shall be as shown on the drawings. Ground rods installed for the Electrical System shall have a common ground with the Lightning Protection System.

DIVISION 16 ELECTRICAL WORKS

SECTION 16.23 GROUNDING SYSTEM

16.23.1 GENERAL

1. GENERAL

The Contractor shall furnish and install all grounding systems as hereinafter specified and as shown on the drawings.

2. REFERENCES

Kazakhstan Standards shall be referred to, if applicable, or the following standards or other internationally accepted standards or manufacturer's standards as approved by the Engineer are referred to.

JIS C 3101	Hard-drawn Copper Wires for Electrical Purposes
JIS C 3102	Annealed Copper Wires for Electrical Purposes
JIS C 3307	600V Grade Polyvinyl Chloride Insulated Wires
JIS H 3100	Copper and Copper Alloy Sheets, Plates and Strips

16.23.2 WIRE AND CABLE

The wire and cable used for the wiring shall be as hereinafter specified.

- a. 500V PVC-Insulated Power Cable (NYM-500 Volt)
- b. 600V Grade Polyvinyl Chloride Insulated Wire (IV)
- c. 1000V PVC-Insulated Power Cables (NYA-1000 Volt)

16.23.3 MATERIALS

Wire shall be of annealed, 98% conductivity, hard drawn copper and cable shall be of annealed, 98% conductivity, soft drawn copper.

16.23.4 GROUND PLATES

Ground plates shall be copper plate of 1.5 mm or more thickness and 900 mm x 900 mm square or equal.

The connections between the ground plates and grounding wires shall comply connected by brass-welding with electrolytic corrosion-proof treatment.

16.23.5 GROUNDING RODS

Ground rods shall be copper clad steel rods, 14 mm or more in diameter, 3.0 meter long and with pointed and chamfered tops. Grounding rods shall be equipped with couplings and driven bolts, and shall be driven to the depths and number of rods needed to obtain the desired resistance.

Ground rod clamps shall be cast copper alloy, and shall tightly grip the rod and cable. The high strength silicon bronze U-bolts, nuts and lock-washers shall make positive corrosion resistant ground connections.

16.23.6 GROUNDING CONNECTORS

Grounding connectors shall be cast copper alloy interlocking clamps equipped with silicon bronze bolts, nuts and lockwashers or interlocking lugs with allen head set screws and one-hole tongues. Grounding connectors shall be corrosion resistant and provided for cable to flat surface connections on equipment and structural steel.

16.23.7 GROUND ELECTRODS MARKERS

The marker for buried ground plates and rods shall be installed to construction wall near each electrode.

Each marker shall be made of brass or stainless steel, and shall have written down the bury position, depth, resistance and date etc.

16.23.8 INSTALLATION

Various ground works shall be grounded independently of and separately from the common ground. Grounds of the following equipment shall be done separately from the common ground.

- a. Lightning arrester
- b. Lightning rod
- c. Instruments for instrumentation and communication equipment

The ground electrode shall be separated 2.0 m or more from other steel frames and pipes as far as possible.

Three auxiliary ground rods for measuring of ground electrods resistance shall be driven to the depths needed to be measured by grounding tester.

For the above measurement a grounding terminals board shall be installed.

All electrical equipment shall be connected to the nearest available grounding rods. The protecting conduits shall be bonded to the grounding conductor at both ends.

The Contractor shall not allow the grounding connections to be painted. If the connections are painted, they shall be disassembled and remade with new fittings.

All equipment enclosures, panel, motor, transformer and conduit systems, exposed structural steel, and similar items shall be grounded.

A grounding wire and cable shall be run in all electric power conduits. The cable rack and control station shall be grounded by a separate green colored, insulated, grounding conductor.

Although all metallic conduits shall be grounded, they shall not be used to provide grounding for motors or other electrical equipment.

Connections shall be made by means of approved grounding clamps.

The Contractor shall exercise care to ensure good ground continuity, in particular, between the conduit system and equipment frames and enclosures. Where necessary, jumper wires shall be installed.

16.23.9 TESTS

The Contractor shall test the ground resistance of the system. All test equipment shall be provided by the Contractor and approved by the Engineer. Dry season resistance of the system shall not exceed two (2) ohms. If such resistance cannot be obtained with the system as shown, the Contractor shall provide additional grounding as instructed by the Engineer, without additional payment.

DIVISION 16 ELECTRICAL WORKS

SECTION 16.24 CABLE TRAY AND DUCTS

16.24.1 GENERAL

1. GENERAL

The Contractor shall furnish and install all cable racks and ducts as hereinafter specified and as shown on the drawings.

2. REFERENCE

The following standard or other internationally accepted standards or manufacturer's standards as approved by the Engineer is referred to.

JIS H 8641 Zinc Hot Dip Galvanizing

16.24.2 MATERIALS

1. CABLE TRAY

Cable rack material shall be hot-rolled mild steel sheets, not less than 2.0 mm in thickness.

Cable racks, hangers, rods, brackets, separators, etc., shall be hot-dip galvanized steel with 400g/m² zinc volume on one-side.

Concrete inserts for ceiling hangers and wall mountings shall be made of a stainless steel.

Beams of cable rack shall be spaced at intervals 0.15 meter or less.

2. CABLE DUCTS

Cable duct material shall be hot-rolled mild steel sheets, not less than 2.3 mm in thickness, with cable supports, separates, reinforcement and duct covers with stainless steel screws.

Outside and inside of the duct shall be finished by painting after the hot-dip galvanizing.

Other materials shall be the same as the above Sub-Section "1. CABLE RACKS".

16.24.3 INSTALLATION

1. CABLE TRAY

Cable rack lengths shall be not less than 3 meters, and connections shall be with splice plates.

The vertical spacing of cable racks shall be installed at a maximum of 3 meters.

Cable rack supports shall be spaced at intervals 1.5 meter or less, and against swing supports as required to obtain rigid construction.

Each cable rack end shall be connected by a grounding bond with the grounding terminals.

A high-location of cable racks shall be provided with a cat walk along the cable racks for maintenance purposes.

Signal cables and communication cables shall be separated from power cables on the cable rack by separators.

The width of cable rack branches and bends shall be more than 10 times the total cable diameter on the cable rack.

Holes made by the Contractor in the wall or slab shall be filled up with insulation compound.

2. CABLE DUCTS

Installation of cable ducts shall be in the same manner as stated in Sub-Section "1. CABLE RACKS".

DIVISION 16 ELECTRICAL WORKS

SECTION 16.25 SCADA SYSTEM

16.25.1 GENERAL

1 GENERAL

This specification is provided for consideration against standard products and systems and where advantages or cost savings might be realized by alteration of the specification the contractor shall propose such changes as part of a complete alternative offer in addition to that specified.

2 DESCRIPTION OF WORKS

The works Distributed Control System (DCS) shall follow the international Standards Organization (ISO), Open Systems Interconnect (OSI), reference model guidelines. All central system hardware and software devices shall be interconnected using a bus topology data highway. The communications protocol used shall be non-proprietary and meet the requirements of the ISO.

The system shall provide efficient and safe operation of the process plant by detecting alarm and error conditions, alerting the operator to these conditions, monitoring all important system parameters and providing facilities for plant optimization. The system will allow operators, technicians and engineers to issue commands to change system parameters, start and stop equipment, provide configuration tools and operate diagnostic facilities from Operator Workstations (OW) and Engineers Terminal (ET), after successful log on by security password.

For each abnormal condition, plant failure, plant unavailable or failure to respond to a command within a given period, the DCS shall provide the appropriate alarm. Printed and archived alarms shall be time and date stamped for occurrence and acceptance. Alarms, logs and reports shall be output to separate printers at the MCR. Each LCR shall be provided with a common alarm, logging and report printer, alarms shall be in red. The ability to generate alarms within the system software based upon digital and / or analogue events and set points shall be provided.

Intelligent Input Output Processors (IOPs) shall provide plant interface facilities and shall control, monitor and store plant input/output data and linked to the main system servers over the plant data highway.

Specific alarm, monitoring and control input / output requirements shall be determined from the particular control specifications and the Drawings.

3 REFERENCE

ISO 9075 (BS 6964) - Structured Query Language (SQL)

BS 5515 - Documentation of Computer Based Systems

4 QUALITY ASSURANCE

- 1.All equipment shall be suitable for installation and continuous services in the ambient conditions at the job site.
- 2.All equipment of a similar type shall be supplied from a single manufacturer to ensure common spares, operations and maintenance procedures.
- 3.All hardware and software proposed shall have been successfully proven in a similar water application for a period of at least two years, and be from established and reputable suppliers.

5 SUBMITTALS

A. Functional Design Specification (FDS)

The Functional Design Specification (FDS) shall be submitted to the Engineer and approved before manufacture and purchasing commences. The system vendor and/or contractor shall include the following material as a minimum :

1. Description of the design and design criteria
2. Details of associated equipment.
3. Functional Design Specification
4. Quality Plan
5. Outline of acceptance test procedures
6. Implementation program for manufacture, installation and commissioning with particular reference to interface with existing equipment.
7. Manufacturers literature for each item of equipment supplied.

B. Contractor's Drawings

The Contractor shall submit general and detailed dimensioned arrangement drawings, schematics and wiring diagrams of all major items of Plant for the Engineer's approval. Manufacture of an item of Plant shall not commence until the associated drawings have been approved in writing by the Engineer.

C. Instruction Manuals

These manuals shall include but not limited to the configuration of data base, reports, logs and screen displays.

16.25.2 PRODUCT

1 Master Station/Central System - Hardware

A. Computer

The system shall support hardware and software interconnectivity to other networks in accordance with the ISO Open System Interconnect reference model.

Engineers terminals and plant Operator Workstations (OW) shall be RISC based and shall be similar throughout.

Each Operator Workstation shall be a personal computer based upon the latest Intel Pentium microprocessor. Nominal processor speed shall be no less than 3 GHz and the personal computer shall operate with zero wait states. The PC bus shall be 64 bit and shall be a EISA/PCI bus. All expansion cards shall be compatible with the computer bus speed and type. Each PC shall be provided with at least 2048 megabytes of random access memory (RD-RAM).

The case shall be tower style with a minimum of five drive bays. At least three drive bays shall be externally accessible from the front of the computer case. The case shall be provided with sliding door covers over all of the drive bays to prevent dust migration into the drive.

The motherboard shall be equipped with a minimum of seven 32 bit expansion slots, of which one shall be a combined EISA/PCI slots, one shall be a PCI local bus slots, and the remaining shall be EISA slots. A minimum of three serial ports and two parallel ports shall be provided. All ports shall be clearly labeled. The power supply shall be a minimum of 350 watts.

The hard disk drive shall be internally mounted in each of the PC case. The hard disk shall have a minimum of 40 GB storage capacity each. Another same capacity hard disk shall be provided in each PC for main hard disk backups. The hard disk controller shall write to two hard disks simultaneously. Each drive contains the same information at all times, which provides a backup in case a drive fails (Mirroring).

A three-year manufacturer's on-site warranty service contract shall be included with each personal computer. Warranty services from the ISS directly in lieu of warranty services from the computer manufacturer shall be unacceptable.

B. Redundancy

The DCS shall be supplied with dual redundant servers and suitable proven software to ensure high system availability and to prevent loss of service or data.

C. Visual Display Unit (VDU)

All visual display units shall be 525 mm color monitor screens, capable of displaying information in alphanumeric, bar histogram, graphical and mimic diagram formats. Monitors shall simultaneously display a minimum of 256 colors from a palette of 16 million colors and be non - interlaced, low radiation, flat screen with no discernible flicker. Display of characters shall be legible and stable on a shadow mask tube, having a resolution of not less that 1280 x 1024 pixels and a refresh rate of not less

than 50 Hz. The units shall include all the necessary picture controls to adjust the sharpness, contrast and position of the image.

D. Keyboard

The master station keyboards shall be of the standard QWERTY pattern with Russian key, separate from the VDU, low profile and have non-reflecting surfaces and keys of low intensity to reduce unwanted reflections.

E. Logging / Alarm / Report Printers - Continuous Feed

These printers shall be used for logging of system wide events and alarms shall comply with the following:-

- Print speed : 20 pages per minute
- Paper feed : A4 with auto sheet feeder mechanism and minimum 250 sheet paper tray.
- Resolution : 600 DPI
- Character set : Full ASCII.
- RAM : 32 MB

F. Color Printers (Laser)

These printer shall be used for the production of color screen dumps and reports and shall have a sufficiently sized buffer memory such that system performance will not be degraded when the color printer is operational and comply with the following:-

- Print speed : 8 pages per minutes full color graphics.
- Colors : Compatible with VDU graphics.
- Paper feed : A3 and A4 size
with auto sheet feeder mechanism and minimum 50 sheets per tray.
- Resolution : 600 DPI.
- RAM : 64 MB

G. Audible Alarm

An audible alarm shall be provided which is initiated by any fault condition arising and silenced on operator acceptance of all fault conditions. An alarm mute function shall be provided to silence the audible alarm without accepting any fault conditions. It shall be possible in the engineer's mode to enable/disable this audible alarm.

H. Data Storage

A hard disk historical data system with removable optical or disk media for archive and backup shall be provided.

The historical data system shall store all alarms with the time of occurrence for one month and the daily average, total, maximum and minimum with time of occurrences for all analogues connected to the system, in addition to their value at the set logging intervals. All events shall be archived in a first in first out buffer for a period of one month.

A high speed back up device with removable media, such as streaming tape cartridge or optical disk, shall be provided for each server, suitable for backing up the whole system on a weekly basis. Archiving shall be fully automatic with non archived data being overwritten.

Data selected for archive shall be written to removable media which shall be sized to support at least one month's worth of archive data.

I MIMIC PANEL

Where required a modular mimic diagram shall be provided. The Mimic will be configured to display the status of all principal items of plant in the area covered.

No part of the mimic panel display area shall be below 600 mm or above 2100 mm from the floor.

All layout details and dimensions, including main construction, colors, symbols, line diagrams, legend text and indications, shall be agreed with the Engineer.

The mimic diagram driver shall be housed in either the mimic diagram enclosure or a separate enclosure. In either case the driver shall consist of modules mounted in standard 19 inch card frames. The mimic driver shall consist of a client device directly connected to the data center LAN.

The panel shall indicate alarm status (amber) and status (red or green) in the graphic display. The contractor shall prepare this graphic display to indicate all processes as shown on the drawings and the particular specification. The contractor shall submit at least three (3) different versions of the simulated color graphic to final approval by the Engineer.

Mosaic Tile

The face of the mimic diagram shall comprise a mosaic of precision formed tiles, which shall clip into a supporting grid to form a robust construction of flush and neat appearance. The tile faces shall have a durable, scratch-resistant non-reflective finish. The background color of the mimic diagram tiles shall be to the approval of the Purchaser. The face dimensions of tiles shall be subject to approval by the Engineer.

The face of the tile mosaic shall be engraved and/or printed or painted to provide a diagram. The printing or painting shall be durable throughout the lifetime of the equipment.

The mimic diagram face and supports shall be rigidly held in a robust floor mounting frame. The surround to the mosaic tile area and the ends of the frame shall be enclosed in decorative panelling to provide a high quality aesthetic finish. The complete construction shall be formed into an enclosed panel, with a access to enable the ready replacement of defective components and the rearrangement of tiles. Tiles and components shall be replaceable without disturbance to the surrounding areas of the mimic face.

Wiring troughs or clips shall be provided at the rear of the mimic diagram to enable wiring to electrically driven components to be neatly dressed and supported. Flexible wiring of adequate length shall be used to enable electrically driven components to be relocated on the mimic diagram without the necessity for rewiring.

All illuminated indications shall use high radiance, light emitting diodes (LED's). Either single peep-through or multiple-element/planar types shall be used, as appropriate. The illuminated area shall have even intensity across the whole face. All LED's shall have a wide viewing angle in excess of 60 degrees, without significant change in perceived luminosity.

A 20% spare capacity shall be provided (equipped) within the mimic driver and the wiring to the mimic board to allow for future modifications. The spare capacity shall be evenly distributed.

All driver outputs shall be protected against overload and short-circuit.

Lamp test facilities shall be provided such that operators can initiate the test from their workstation positions. This facility shall ensure that both the mimic LED's and the driver circuitry are exercised.

J. Un-interruptible Power Supply (UPS) System

The Contractor shall supply a UPS system with sufficient capacity to maintain power to the supplied equipment, its peripherals and process critical instrumentation on a mains power failure for a minimum period of 30 minutes.

In the event of power failure, the master central system shall be supported by the un-interruptible power supplies specified.

The central system equipment shall be programmed to degrade gracefully once UPS power is exhausted or execute a shutdown routine after a preset time from the original mains failure.

The UPS systems shall be monitored by an and a fault in the UPS system shall be accorded the highest priority status.

The Functional Design Specification shall detail modes of failure and process shutdowns and itemize signals to be supported by UPS.

Power distribution from the UPS in the control room area shall be via floor plate mounted sockets, the

design of which will be such as to prevent inadvertent connections of non-system hardware, for example cleaning equipment.

2 CENTRAL SYSTEM SOFTWARE FUNCTIONS

A. General

The Contractor shall be responsible for supplying complete software packages to enable the Plant to operate as stated in this specification. Provision must be made for the adding of further software tasks as and when required. All software functions shall be user friendly with instruction and messages to aid the operator. The contractor shall make available all standard software functions even if not specifically detailed in the specification.

The computers shall utilize a real time multi-tasking and networked operating system with a proven track record in real time distributed process control applications.

It is a requirement that the system be supported by on line configuration and editing of all mimic displays and database.

The system shall be capable of supporting the allocation of plant to zones and these zones may be allocated for the attention of particular OWs

Each Operator Workstation and Engineers Terminal shall be a high performance RISC system with disk storage for all local area and frequently used graphics displays. High resolution, multi screen graphics, (minimum 1280 x 1084 pixels 256 colour) is required. Operational mimics and other graphics shall be presented in an industry standard GUI format. A minimum of four active windows should be displayable concurrently. Both text and graphics shall re-size automatically to accommodate changes made to the size of a window. Operator interface shall be via low profile minimum 102 key keyboard with associated mouse or track ball pointing device. The system shall be designed to minimize the operators use of the keyboard. All major functions shall be accessible on-screen through use of the mouse or track ball.

An Operator Workstation shall be provided for each process area control center and be connected to the plant data highway. Functionality shall be identical to that of the Main Control Room OWs allowing full access to all system functions at the authorized access level. Operator system entry for each area will be Password coded with different levels of entry depending on the level of authority of the operator. Development and Systems level entry passwords will be provided for the MCR and Engineer workstations. Each action taken by any operator at any level of entry, or, at any operator terminal shall be log file recorded, and time and date stamped. Log in and out time and dates will be printed on the control room event logging printer.

VDU mimics will display dynamic colour details of flow rates and pressures, pump status, well levels,

alarms, treatment dosing rates, electrical power supplies and other general treatment and plant status conditions. Commands via the operator terminals, will operate in a GUI working environment using a mouse or track ball pointing device, all requests and commands shall be via icons, whether menu linked or linked to plant control actions. A permanent dynamic alarm banner shall be displayed at the bottom or top of each operator screen. Each control action will be routed through a series of confirmation routines.

The complete system database shall be available to each operator terminal offering pre-configured reports per process area. These reports shall be available for printing in graph or tabular format, dynamic trend displays shall also be available for all analogue flow, level and pressure values. Custom, as well as pre-configured reports and trends shall be available to a higher level of entry. A color A4 size screen dump printer shall be provided for graph and trend prints.

An operator Help utility shall be provided offering help linked to the particular action being carried out by the operator at that time. At least one help screen per screen page shall be available. This facility shall be pre-configured with an option for updating by operators via a password entry. Typical information available shall consist of guides of actions to take under particular plant conditions, general process information and help in operating the telemetry system itself.

B. Display Facilities

The displays shall be user configurable, with the user being able to construct any desired symbol for display. Any display shall appear (excluding historical recall) within 3 seconds of selection and the displayed data shall be updated from the database as information is recovered from the IOPs. Alarms shall typically appear within 3 seconds of being received into the central system database.

The Contractor shall configure all display pages as fully as possible. However, facility must be incorporated to permit easy construction and modification of the display pages by using a standard library of shapes and symbols. The library shall be added to and modified by the user as required.

The initial application software shall provide for the display pages listed below and any pages necessary for the system to function as a complete entity.

1. Mimic Displays.
2. Alphanumeric configuration pages for the complete I/O and IOP's.
3. Graphic Displays.
4. Trend Displays.
5. Alarm Summary tables with date and time.
6. Alert Summary with date and time.
7. Event logs of past 72 hours with date and time.

8. Tabular display of data.
9. Inset windows showing an analogue trends may be mixed with mimic displays. In such a display the main mimic and inset trend shall all be live with automatic display updates.
10. Pan and zoom facility with automatic de-cluttering on zoom out.

Indexing of information and menus shall be presented in the form of active windows on the screen while the mimics etc. are still available for view.

No display or function shall effect the logging / monitoring of data. It shall be possible for the master station terminal and auxiliary terminals to perform different tasks within the displays simultaneously.

The system shall support full Pan and Zoom graphic display facilities.

C. Plant Monitoring and Plant Alarms.

The operator shall be able to monitor all of the information at all workstations. He shall be able to view active plant information on a series of VDU based graphical and tabular displays.

On occurrence of a plant alarm, the following shall occur at the master station:

1. Alarm message displayed in the alarm message area of the screen.
2. The audible alarm shall sound
3. The appropriate section of the display page shall change colour and flash.
4. A full message shall be written on the alarm page.
5. The full alarm message shall be printed on the alarm printer
6. The full alarm message shall be recorded, stored on disk and automatically archived on a daily basis

The operator shall acknowledge the alarm by pressing an Accept Alarm key or Icon. This action shall stop all associated alarm messages and displays flashing, however the display shall remain in the alarm state fixed color to indicate an accepted alarm. When all outstanding alarms have been acknowledged the audible alarm shall be silenced.

Once the alarm has cleared the messages/displays will return to normal the alarm message shall stay recorded on the event/alarm log and an alarm cleared message shall also be recorded.

If the alarm clears before being acknowledged the sequence of events shall continue as above except the message shall change to indicate a cleared alarm.

An audible alarm silence function shall be provided to enable an operator to silence the audible alarm without acknowledging all alarms. On occurrence of any subsequent alarm the audible alarm shall sound.

For multiple bit points (where 2 or more inputs are combined to function as one point) the assignment of status/alarm levels shall be on the combined signals.

Each signal within the configured system shall be capable of being assigned an alarm based on the following:

- 4 levels per analogue (Lo Lo, Hi Hi, Lo and Hi)
- rate of change
- deviation from setpoint or other control parameter

A minimum of four alarm priorities shall be provided so that those requiring immediate attention may be separated from alarms of lower priority. An audible alarm shall sound for alarms requiring operator action. It shall be possible to acknowledge alarms from any operator station provided the operator is logged on to an approved access level.

Typical alarm assignments are as follows:

- Critical Alarm - An alarm that requires immediate operator action.
- Non Critical alarm - An alarm that requires operation action but not necessarily immediate action.
- Operator Guide Alarm - An alarm that provides information to the operator.
- Event - A low priority condition which is recorded.

The alarm software shall produce an alarm summary which will show all currently active alarms in priority and chronological order.

D. Plant Control

The system shall support a high security plant control facility. This should be password based and work on a select, check-back and execute philosophy of operation.

E. Data Archiving

Continuous process (analogue) data, digital event states, alarms and operator actions shall be archived to a removable read/write optical disk system. The archive media shall be sized to store logged analogue data, at a maximum sample rate of 15 minutes, for a period of 15 months. Data recording shall be on dual media. The archive system shall generate an alarm when a file is 90% full.

Analogues will be stored at a rate selected by the operator in the range 1 minute to 1 hour. The operator shall have the facility to select the way in which an analogue is stored, the system will provide any combination of the following:

1. Instantaneous value.
2. Average value.

3. Maximum value.
4. Minimum value.
5. Not stored.

Maximum, minimum and average values shall be calculated over a period set by the operator in the range 15 minutes to 24 hours, the default shall be 1 hour.

The logging of new data and reception of alarms must be carried out at the same time as the operator is viewing archived data. Any alarms received must be displayed as an overlay on the visual display unit.

F. Data Archiving

Continuous process (analogue) data, digital event states, alarms and operator actions shall be archived to a removable read/write disk system. The archive media shall be sized to store logged analogue data, at a maximum sample rate of 15 minutes, for a period of 15 months. Data recording shall be on dual media. The archive system shall generate an alarm when a file is 90 percent full.

G. Mimic Displays

The Contractor shall configure all the mimics to provide total detailed coverage of the monitoring and control of plant as detailed in this specification. It is expected that display modifications will be required in the future and therefore the ability to change the displays without programming skills is essential.

Instrumentation shall be displayed using ISO standard symbols. For mimic configuration it shall be possible to call up a library of standard symbols representing items (e.g. pumps, valves) and add new symbols to the library. Building mimics shall be simple and be achieved by using a mouse or tracker ball pointing device. The mimic displays shall consist of the following pages:

1. A general diagram covering the whole of the system on a single screen with key data.
2. A general block diagram for each site or area of site showing the plant displayed on a series of single screens with key data.
3. Mimic of the plant and instrumentation connected to each IOP displayed on as many screens as necessary.

H. Tabular Representation of Data.

It shall be possible to put any data into a tabular format, with the data entered in row or columns. The user shall be able to add headings to any of the rows or columns and store the table as a blank for later use.

I. Trend Displays

It shall be possible to plot dynamically updated real time data and archived data on a line graph to

represent analogue or digital information. Each graph shall be capable of displaying 4 plots overlaid on a graph of different colors and line texture. By the graph there shall be a key relating each color to its function. The horizontal axis shall be time based and user selectable in minutes, hours, days, weeks, etc. together with a start time.

The vertical axis shall be scaled in units to suit the individual readings and be displayed in the color of the selected reading. To avoid cluttering the vertical axis scale shall be changed by selecting the individual display. The vertical axis shall be automatically scaled for each selected point between limits entered by the user.

The display of the data shall also be available in tabular form.

J. Manually Entered Data

Some data will need to be entered into the system manually via the keyboard. This data will fall into three types.

1. Constants which will be changed infrequently. This data may have time and date associated with it e.g., unit cost of power.
2. Variables which will mainly be the results of laboratory testing. This data will need to have a time and date entered manually with the data.
3. Maintenance related comments.

K. Manually Corrected Data

The system shall allow an operator to manually correct false data via the keyboard. This data shall include a marker to enable modifications to be highlighted.

L. Reports

There shall be a real time spreadsheet facility supplied and installed by the contractor in the master station. The users shall be able to transfer data from either the archive system or live data to the spreadsheet. The user shall be able to produce daily, weekly, monthly and annual reports using any data and a mixture of formats (tables, graphs, summaries, spreadsheets). Typical reports would be:

Power consumption and costs.

Effluent Quality

Total Flows

Failures of Plant

Maintenance Schedules

It shall be possible to configure and store blank templates for later use, facilities for editing stored templates shall be provided.

M. Input Tables

Each Input shall have a table covering every characteristic of the input. This data shall be automatically sent to the appropriate locations when the user has completed entering or modifying data into the table. The contractor shall compile all input tables as indicated in the input/output schedules, plus any other I/O to enable the complete and optimum monitoring and control of the plant. The user shall be able to modify, amend or create new tables. The Contractor shall ensure all possible characteristics are included in the table including the following.

Point Identity

Point Description

Point Type

Point State

Point Range

Point Units

Status/alarm and priority levels

Alarm set points - high, low, out of range high/low

Log interval - time between logs

Log type - average, total, etc.

Log in IOP - for communications failures

N. Output Tables

Each output shall have a table covering every characteristic of the output. This data shall be automatically sent to the appropriate locations when the user has completed entering or modifying data into the table. The contractor shall compile all output tables as indicated in the Input / Output schedules, plus any other I/O to enable the complete and optimum monitoring and control of the plant. The user shall be able to modify, amend or create new tables. The Contractor shall ensure all possible characteristics are included in the table including the following.

Point Identity

Point Description

Point Type

Point State

Point Range

Point Units

O. Profiling

From an average, typical or manually entered plot it shall be possible to set an exception profile whereby readings within an upper and lower level are acceptable. The user may select for the system to alarm if the reading is outside the profile and / or highlight such exceptions as part of a report and so reduce the need to examine all data to ensure acceptability. The number of exceptions shall be logged.

P. Data Manipulation

It shall be possible to perform simple mathematical functions on any data, including the following functions:

1. Addition.
2. Subtraction
3. Multiplication
4. Division
5. Square Root

It shall be possible to log, display or use in a control loop the resultant data.

Q. Database Query Facilities

The system shall support the use of database relationships and wild card characters to provide database query facilities. It shall be possible to easily configure queries and save them for future use.

R. Downloading IOP Configuration

It shall be possible to download configuration to the IOP's from the Engineers Terminal. This facility shall be in addition to any local programming of the IOP.

S. Diagnostics

The system shall have on-line diagnostic facilities to report system faults as they occur. A set of off-line diagnostic routines shall be supplied for more extensive fault diagnosis.

T. Access Levels

The functions available on the system shall be fully flexible so as to allow users access levels to be customized by the System Operator to suit individual user requirements.

Access to management and engineering levels shall be restricted by user selectable passwords or keyswitch. The security systems shall be based on a set of privileges which may be granted or denied to individual uses by the System Operator.

U. Control Loop and Sequence Programming

The method of programming will depend upon the Contractor's systems requirements. However, the following standards shall be followed:

1. All programs shall be written such that they lend themselves easily to alterations and additions.
2. Good programming practice shall be followed using structured programming techniques. All programs shall be tidy in format and logical to follow, and shall be accompanied by flow diagrams. Programs should be extensively annotated with comments and be self-documenting.

The system shall be supplied with programs that use a high level language for the master station.

V. Program - Documentation

As part of the requirements of this specification full documentation is required as below :

1. Software User Manuals
2. Database Point Allocation Table.
3. Complete program listing, flow charts for all sequences and control routines.
4. Application Software Source Code.
5. End User License Agreements.

3 Future Expansion

The system hardware, application software and database shall be sized to accommodate a total of 50 percent increase in signal capacity and up to 100percent increase in an individual zone.

Sufficient plug in modules shall be provided and wired to terminals ready to accept future signals of up to 10 percent for each IOP.

Each IOP shall be able to accept at least two more I/O cards without requiring replacement of the original equipment.

4 IOP - Hardware

Each IOP shall be mounted in an IP52 enclosure and constructed to allow easy replacement and maintenance of cards. Plant. Mounting shall be of the 475 mm rack type. Particular attention shall be given to the ability of the IOP and its enclosure to withstand the harsh gases prevalent in certain areas of a Sewage Treatment

Input/output cards shall be mounted in a card rack where any slot can be used for any type of card.

Each IOP shall form a network node and shall be linked to the data highway through dual redundant communications interface adapters.

The IOP shall be an intelligent device that can collect data, generate alarms, perform process and

control functions and communicate with other IOPs on a peer to peer basis.

The program and data held within memory shall remain intact and error free if all external power is removed from the IOP for a minimum period of two weeks.

The Contractor shall supply batteries for each IOP with sufficient capacity to maintain full power to the IOP for 8 hours after a power failure. The UPS system shall be integral to the IOP. The batteries shall be of a sealed maintenance free type.

All field connections shall be made in terminal strips located for easy access. These terminals shall be clearly marked and identified. Terminals carrying voltages in excess of 24 volts shall be fully shrouded. All terminals shall be of the 'flip up' isolator type with test points.

A hand held programmer, shall be provided for local display of signals, programming and fault diagnosis.

IOP's shall be equipped with RS232/485 links for interconnection to standalone control systems and standard plant packages.

Connection to other devices will use Modbus ASCII or RTU protocol as standard. Details of other protocols available should be included within the tender. Each controller shall support peer to peer communications.

LED's indicating status of input and output digital signals shall be provided on the input/output cards.

IOPs shall be configured such that a single IOP or IOP module failure will not interrupt or degrade plant monitoring and control functions. IOP failure shall be alerted to the operator at the highest alarm priority.

5 IOP - Software

The IOP shall be capable of processing locally input plant information before broadcasting it on the data highway to reduce transmission overheads.

Total internal scan time interval for all inputs and outputs in an IOP shall not exceed 100 ms.

There shall be two pairs of alarm settings for each analogue input, one an alarm warning of a possible fault, the other warning that the input is outside a valid range of readings.

The IOPs shall have sophisticated in built control facilities to permit control loop configuration using simple building blocks. These blocks shall sequence control, three term control and other control routine components as required by the Specification. The IOP shall be capable of routine signal processing including integration, summation, subtraction and totalisation of one or more inputs. Control loops shall incorporate deviation and rate of change alarms, bump-less transfer facility, set

point and output high and low limits.

The IOP shall be capable of executing sequential control logic. Programming of sequential control shall be by means of vendor supplied high level function block language or ladder diagram format as apart of an integrated package.

The IOP's shall have standalone capability, able to continue monitoring plant and executing control loops if the communication link to the master station fails. In the event of such a failure the IOP shall log all alarms and required analogues until all the total memory is filled. When the communication link is restored the IOP will automatically upload the logged data to the data archiving system.

The IOP's shall have a watchdog function and full self-diagnostics capable of detecting and reporting faults to the master station and displayed locally.

The Contractor shall program the IOP's fully under this Contract. It shall be possible to modify the programs remotely by downloading from the Engineers Terminal. It shall also be possible to change the program locally, using the portable programmer unit if necessary.

6 Data Communications Links

Communication Standards

Transmission of data shall conform to a recognized CCITT standard. The data transfer system shall be self monitoring such that any equipment or line failure shall be displayed at both ends.

Site Data Highway

The system shall use a data highway to transfer data between the master station and local PLC. The system shall be capable of transferring data even if the highway is broken downstream or one or more local PLCs are non-functioning.

Fiber Optic Communication

The system shall use the Fiber Optic Communication Network to transfer data between the master station and the local PLCs.

Leased or Private Cable

The system shall have the ability to use leased or private cables to transfer data between the master station and the local PLCs. The modems used should be PTT approved.

Radio Network

1. General

All radio equipment shall comply with the appropriate local recommendations and shall have been

approved for licensing by the Frequency allocation authority. Additionally the equipment shall comply with the most recent edition of the appropriate National and International Standards Specifications.

The radio system shall be of the following type :

- Frequency : UHF/VHF as allocated by Frequency Allocation Authority
- Base Mode : Full duplex
- Outstation Mode: Two frequency Simplex
- Channel Spacing: 25 kHz

2. Radio Transmitters/Receivers

Transmitter/receiver radio units shall be single units without standby facilities. These units shall have sufficient battery back up for the system to function for 2 hours in the event of mains failure. Provision for this may be from the main outstation battery back up supply. The units may be either wall mounted or incorporated within the outstation enclosure, whichever is preferred.

3. Base Station Radio Transmitter/Receivers

Base station transmitter/receiver radio units shall be of a dual main/standby type with auto changeover of the duty units. The Contractor shall supply within the tender document and explanation of how this changeover shall be accomplished. An alarm signal shall be transmitted to the Master Control Center when a changeover occurs. The base station shall be provided with power supply equipment, including nickel cadmium battery and 220 volts 50 Hz ac mains fed battery charger and have sufficient battery back up to allow for the system to operate for 8 hours in the event of mains failure and capable of automatically recharging the battery to full capacity within 24 hours while the radio equipment continues to operate at full duty.

4. Aerials and Aerial Structures

The Contractor shall supply and install all aerials and aerial support structures and shall provide typical drawings to show how each type of aerial is to be mounted.

The base stations shall have omnidirectional aerials plus any associated duplexers.

UHF outstations shall have a single 12 or more element , yagi aerial with a gain of 12 dB with respect to a half wave dipole on the corresponding Base Station. Any VHF outstations shall have 8 or more element yagi VHF aerials planned on the corresponding Base Station.

The Contractor shall supply and install all necessary low loss coaxial down leads for connection for the radio unit and lightning protection for the aerial system.

5. Insulation and Withstand High Voltage

An electrical insulation for each unit between AC supply input terminal and GND shall be 10MΩ or more.

An electrical insulation for the panel between AC supply input terminals and GND shall be 5MΩ or more.

All equipments shall be taken withstand high voltage test of AC 600V for 1 minute.

6. Lightning conductors

Contractor shall provide adequate lightning conductors on antennas and others if necessary to protect the equipment of these communication systems.

Lightning Arresters shall also be provided to protect them from lightning shock current.

7. Radio status Indication and Alarm

Following operation status shall be provided on the panel of radio equipment:

This system is consist of duplex radio equipment as

A: transmitter/receiver and B : transmitter/receiver.

1) Indicators:

- Transmitter active (Available of Use)
- Transmitter A or B selection
- Transmitter A or B alarm (One side)
- Transmitter A or B phase lock/unlock of the loop
- Transmitter A or B alarms (Both side)
- Receiver A or B status indication of the selector
- Power supply unit A or B failure
- Receiver A or B alarm
- Main power supply indicator

2) Switches:

- A and B power supply unit ON/OFF or Auto
- Select A or B side transmitter or Auto
- Select A or B side receiver or Auto
- Simulate A or B side transmitter alarm to initiate automatic switchover.

3) Alarms:

- A side alarm condition
- B side alarm condition
- AC power failure

7 Inputs/Outputs

A. All process I/O and plant interface boards shall comply with the following:

1. Plant wiring termination's shall accommodate up to 0.9 mm diameter conductors, terminals shall be of the test disconnect type to permit ease of signal isolation and loop monitoring for commissioning and maintenance purposes.
2. Hot (powered) replacement of I/O boards shall be possible without special tools.
3. Provision to power two wire loop powered transmitters.

a. Digital Inputs

All digital inputs shall be optically isolated.

All alarm and state indications shall be from dry contacts or 60 Vdc wet contacts. An isolated +24V dc supply shall be provided to source the opto-isolated inputs when connected to dry contacts, adequate filter circuits and software de-bounce techniques will be necessary. Contact operation shall be as follows :

Alarms In the healthy condition the contacts shall be closed with the relay coil energized; in the alarm condition the contacts shall be opened with the relay de-energized.

States Contacts shall be open with relay coil de-energized in the off (logic '0') condition, and closed in the on (logic '1')condition.

Two bit Digital One contact shall close when the plant is in one state and a second contact shall close when the plant is in the opposite state.

B. Analogue Inputs

Independently configured channels in the range 4 - 20 mA, 1-5 V dc, 0-1 V dc, 0-5 V dc, 0-10 V dc or +/-10 V dc. All analogues shall be screened and segregated from other cables. The signal ground shall be separate from the system ground. Input impedance shall be greater than 1 Mohm. ADC conversion at ten times per second shall be 12 bit, system accuracy + 0.2 percent of span.

C. Digital Outputs

All digital outputs shall be optically isolated.

All control circuits shall operate from a 24V dc supply. The contact will be normally open and

energized to close when an action is initiated. Outputs shall be either open-collector or volt-free contacts as follows:

- Open collector : 100 mA at 35 V dc.
- Contact : 2A at 60V dc or 120 VA (resistive)
0.5A at 60V dc or 120 VA (inductive).

D. Analogue Outputs

In general all analogue outputs shall be 4-20 mA or 1-5 V dc, selectable, and drive a maximum loop impedance of 600 ohms. The signal ground shall be separate from the system ground. DAC conversion shall be 10 bit, system accuracy + 0.2 percent of span.

E. RTD Input

Capable of receiving 10-ohm Copper or 100-ohm Platinum Resistance Temperature devices directly without external transmitter. Conditioned signal must be capable of being directly accessed by the on board IOP controller without external intervention.

F. Pulse Input

Capable of receiving a zero based pulse or rectangular wave or sinusoidal wave form with amplitude of 4-6 or 21.6-27 volts and rate of 0 to 5000 pulses per second for totalizing, frequency counting and period determination.

8 Power Supply Requirements

A. Operating and Protection Power Supplies

All power supplies provided by the Contractor shall conform to the followings:

1. Be comprised of standard available units.
2. Be fitted with adequate input/output fuse protection.
3. Power supplies to be fitted if applicable with short circuit protection and current limiting facilities.
4. All power supplies to be selected such that they are de-rated to allow for future expansion to improve the reliability, and help increase the MTBF of the units. With all the expansion described in this specification the loading on the power supplies shall not exceed 75 percent of their total capacity.

9 Environment Conditions

A. Temperature and Humidity Range

The equipment shall be installed in an environment having a temperature range of 16°C to 30°C and a relative humidity of 10 to 90 percent (non condensing).

The Contractor will use, where required, fans, heaters, and air conditioning units to maintain a correct working temperature for his equipment.

All parts of the equipment shall be constructed of materials or treated to prevent the formation of mold, fungus or any corrosion over the temperature and relative humidity ranges specified.

B. EMI / RFI Noise Immunity

The Plant to be provided shall be adequately protected against interference from the use of the radio transmitters, at any point external to the equipment housings, and no malfunction of the Plant shall result from this cause.

Responsibility for the correct and reliable operation of the Plant shall rest with the Contractor, who must ensure that the Plant is adequately protected against the ingress of radiated, mains-borne signal-borne interference.

C. Generated Interference

The Contractor shall ensure that the DCS, instrumentation and communications equipment conforms to relevant standards for noise emissions.

16.25.3 EXECUTION

1 TOOLS

The Contractor shall include for the supply of all spanners, key, special tools, gauges and all other electronic and calibration tools required for the efficient installation, commissioning and operation of the plant.

2 TRAINING

A. The system supplier shall conduct training courses at four levels for personnel selected by the Employer. Training shall be provided at maintenance, plant operator, programmer, and management (administrative) levels and shall be conducted by personnel employed by the system supplier familiar with the system supplied that have experience and training in developing and implementing instructional courses.

B. The entire cost of the complete training program, except per diem expenses for the Employer personnel to attend the maintenance training program, shall be the responsibility of the system supplier and shall be included in the contract price.

C. The system supplier shall submit information on the training program for approval prior to shipment of the equipment. This submittal shall include a course outline, time required, course schedule, sample workbook and instructor qualification information for each level.

D. The supplier shall make a workbook on each course available to every person taking any of the four courses listed herein. The workbook shall be of sufficient detail so at a later date a trainee could review in detail the major topics of the course.

E. The training times shall be scheduled by the Employer in advance with the Supplier so as to minimize disruption to the Employer's work schedules.

F. Maintenance Training:

1. Training shall be provided for six of the Employer's personnel at the system supplier's facility on routine preventive and emergency maintenance of all system components. The training program shall be divided into two segments and shall consist of at least five (5), eight (8) hour working days in length each.
2. The maintenance training program shall be developed for personnel that have electronics maintenance and repair experience and a general knowledge of computer systems, but shall not assume any familiarity with the specific hardware furnished. As a minimum, the following subjects shall be covered:

System Architecture and Layout

Hardware Components.

Module Switch Settings (Configuration Switches)

I/O Modules

Power Supplies.

Data Highway:

Programmer connection

IOP programming and diagnostic techniques

Battery replacement and recording.

PC and workstation Familiarization and maintenance:

Troubleshooting

Disassembly

Cleaning

Component Replacement

Reassembling

G. Operator Training:

1. Training shall be provided for at least ten of the Employer's personnel on the operation of system hardware and software and shall consist of a least twenty (20) eight (8) hour days in

length. The training program shall include an additional session to be held six months after start-up. The second session shall consist of a least five (5) eight (8) hour working days in length. At a minimum, the following topics shall be covered:

Power-up, bootstrapping and shutdown of all hardware devices.

Interpretation of all standard displays.

Appropriate actions for software and hardware error occurrences.

Use of operator interface displays and keyboards

Use of printer including replenishment of supplies

Manual data entries

Creation and editing of graphic operator display screens.

H. Programmer Training:

1. Training shall be provided for at least four of the Employer's personnel at the Employer's facility on the high level applications software. The training program shall consist of at least five (5) eight (8) hour working days in length and shall include at the following topics in addition to the operator training:

Loading of any required software into the system

Data base creation and editing.

Configuration of printed report formats

Creation and editing of tabular and graphic operator interface display screens.

Diagnostic routines.

SCADA and System interface requirements.

2. The programmer training shall be conducted using equipment and software furnished hereunder and shall be developed for personnel with a general familiarity of computer operation and high level application programs, but shall not assume any familiarity with the specific hardware or software furnished.

I. Management Training:

1. Training shall be provided for at least four of the Employer's personnel at the Employer's facility covering topics on hardware and software. A special emphasis shall be placed on the functional characteristics of the major components of the system. The training shall consist of two (2) eight (8) hours working days in length and shall cover at a minimum the following topics:

System architecture

- Hardware components
- Software capabilities
- Operator interface description
- Operator interface displays.
- Report generation including printer operation
- SCADA information available for configuration.

2. The management training shall be conducted for the Employer's designated personnel who need a basic understanding of system functions and operations.

3 WORKS TEST (Master Station And IOPs)

Before dispatch from a manufacturer's works each item of plant hardware, software and its components shall be tested in accordance with the relevant specification or code issued by the British Standards Institution. In the absence of such a specification or code these tests shall be performed in a manner subject to the approval of the Engineer, and witnessed and approved by the Engineer or his representative.

4 WORKS SYSTEM TESTS

The equipment will be generally inspected to ascertain compliance with the Specification (FDS), satisfactory finish, workmanship etc. and relevant functional tests shall be carried out with simulated inputs/outputs as necessary.

If simulated inputs/outputs are necessary then the simulation equipment shall be provided by the Contractor as part of the Works unless otherwise agreed.

The works system tests shall take place according to the program detailed by the Contractor.

In the event of testing and/or inspection being carried out at a Sub-Contractor's works, the Contractor's representative shall accompany the Engineer or his representative if the Engineer attends such tests.

Any surface coating applied prior to the initial inspection of Plant or equipment shall be considered sufficient reason for its rejection. Where any attempt to conceal defects is discovered the works may be rejected.

A Test Plan shall be produced by the Contractor. The plan shall indicate a logical step by step schedule comprising step, action and reaction, e.g.:

- Step 1 Action : Simulate high level
- Reaction : Tank Symbol Change Color

1. Hardware Tests

All hardware including spares shall be required to pass an agreed preliminary hardware performance test to ensure known hardware operability before software testing begins.

2. Functional Testing

Functional testing using the system software shall be comprehensive. Simulation of the inputs and responses from Plant operation shall be as realistic a reproduction as possible of Site conditions.

3. System Diagnostics

The means of fault detection and diagnostics provided by the system software shall be validated. This will involve making provision for including a sufficient variety of faults and out-of-range conditions in the system to ensure the detection processes are adequately tested.

5 DEMONSTRATION WORKS TESTS

The Engineer shall have the option not to attend these original factory tests but to witness a repeat of these tests as a demonstration of the final correct operation of the system.

Alternatively the Engineer can instruct the Contractor to carry out the witness tests on a Self Certification basis.

6 WORK TEST RESULTS

Three copies of all tests certificates, log sheets, performance curves, etc. relating to the tests at manufacturer's works shall be dispatched to site before the Engineer has approved such certificates etc. in writing.

7 FACTORY ACCEPTANCE TEST

The Factory Acceptance Tests shall include items 1 to 2 inclusive.

8 COMMISSIONING

The Contractor and any appropriate conversant customer Engineers shall be present when his equipment or installation is commissioned.

Tests to be carried out during commissioning shall include operating the equipment in a variety of modes and sequences to prove its satisfactory operation to the contractors Project Manager prior to initializing the formal Site Acceptance Tests.

9 SITE ACCEPTANCE TESTS

The Engineer shall have the option to attend the Site Acceptance Tests before setting to work.

1. Master Station Tests

These tests shall be carried out after commissioning to an agreed specification. This shall include operating the equipment in a variety of modes and sequences as determined by the agreed specification (SAT document).

2. IOP Tests

These tests shall be carried out either during commissioning or at another time as determined by the Engineer.

The tests shall include operating the equipment in a variety of modes and sequences as determined by the agreed specification (SAT document).

10 SETTING TO WORK

After commissioning and Site Acceptance Tests (when the latter is included) the equipment shall be set to work by the Contractor in agreement with the Engineer. Setting to work means connecting to the master station but not repeating Site Acceptance Tests.