40300 LOW-VOLTAGE SWITCHGEAR

The Contractor shall furnish and install low-voltage switchgear as hereinafter specified and as shown on the drawings.

The existing receiving panel board and wiring in the chlorination house shall be removed and carried to the directed place by the PMO/Engineer after operating the low-voltage switchgear for new power receiving.

a) Low-voltage switchgear
b) Removal of the existing power receiving panel board and wiring.

40301 References

The following standards are referred to;

a)	IEC 158	:	Low-voltage control gear.
b)	IEC 439	:	Low-voltage switchgear and control gear assemblies.
c)	IEC 947	:	Low-voltage switchgear and control gear.
d)	BS 5486	:	Low-voltage switchgear and control gear assemblies

40302 Schedule of Low-Voltage Switchgear

Schedules of low-voltage switchgear which shall be furnished and installed are shown in the following Table.

TABLE 3 LOW-VOLTAGE SWITCHGEAR

IDENTIFICATION	LVS-MAIN	LVS-OB LVS-P	LVS-OB LVS-L
Number of Panels	1	1	1
Type	Indoor, self-standing, dust and vermin proof front and rear doors with front access.		
Location	Operation Building		
Number of phases	Three(3)-phase, four(4)-wire		
Rated Bus Current (A)	600	400	400
MCCB and Other Equipment Included	As shown on the Drawings and the Specification		

40303 Construction

The main switchboard shall be constructed, fully wired, and checked out at the factory and shall be required a minimum of installation work on site.

The low-voltage switchgear shall be made for simplified servicing, replacement and maintenance throughout without major dismantling.

The enclosures shall be suitable for containing circuit breakers, magnet-contractors, capacitors, auxiliary relays, terminals, wirings, nameplates and other necessary devices and parts.

Doors shall be provided with handles and locks. It shall be free from damage when it is opened and closed frequently. Hinges shall have sufficient strength, and doors shall be equipped with door stoppers.

Wiring shall be branched at terminals. More than 3 leads shall not be connected to one terminal. Full safety precautions shall be provided in all cases.

Provisions for power and control cables entries shall be made at the bottom.

All bus-bars and bus-bar connections shall consist of high conductivity copper. The bus-bars shall be clearly marked with the appropriate phase and neutral colours.

All wiring within the panel shall be enclosed in PVC duct, wiring insulation being coloured according to the colour code. Where single core cables are used, special care shall be taken to prevent hysteresis.

A high conductivity copper earthing bar shall be provided for the full length of the low-voltage switchgear and all parts and earthing terminals of units shall be bonded to this bar.

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

a)	Bottom plate	1.5 mm
b)	Ceiling plate	1.5 mm
c)	Partition plate	1.5 mm
d)	Side and rear plate	2.0 mm
e)	Roof plate	2.0 mm
f)	Front door plate	3.0 mm

40304 Equipment Included

The low-voltage switchgear shall include the necessary equipment presented herein, which shall include but not be limited to the following.

a)	Moulded Case Circuit Breakers	1 lot
b)	Magnet Contractors	1 lot
c)	Instruments and Relays	1 lot
d)	Phase and Sequence Selector Switches	1 lot
e)	Control Switches	1 lot
f)	Signal Lamps	1 lot
g)	Auxiliary Relays	1 lot
h)	Control Transformers	1 lot
i)	Annunciators	1 lot
j)	Test terminals	1 lot
k)	Fuses	1 lot
l)	Static Capacitors	1 lot
m)	Fluorescent lamp fixtures with switch	1 lot

n)	Terminal Blocks	1 lot
o)	Space Heater with Thermostats	1 lot
p)	Other Necessary Devices	1 lot

40305 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 floor skills 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.

40306 Tests

The factory tests and field tests of the low-voltage switchgear shall be applied as the "40116 Tests" of the specifications.

40307 Accessories and Spare Parts

The following accessories and spare parts shall be furnished for operation and maintenance of emergency power generator system. Said accessories and spare parts shall include the following but not be limited.

(1) Testing Equipment

All portable type testing equipment for maintenance shall be furnished.

	Item	Qty	Measuring Range	Accuracy
a)	AC Voltmeter	1	0–300/750V	± 0.5%
b)	AC Ammeter	1	0–1/5/10/20	± 0.5%
c)	DC Voltmeter	1	0–10/30/150/300V	± 0.5%
d)	DC Ammeter	1	0–1/3/10/30A	± 0.5%
e)	DC Ammeter	1	0–10/30/150/300mA	± 0.5%
f)	Wattmeter	1	1/5A, 240V	± 0.5%
g)	Circuit Tester	2	DC 0.3–1200V, 8 steps	± 2.0%
			DC 12uA–1.2A, 6 steps	± 2.0%
			AC 3–1,200V, 6 steps	± 3.0%
			2 k – 20M, 3 steps	± 3.0%
h)	Clip–on Ammeter	1	0–100/600 mA	
			0–3/15/60/300A	± 2.5%
i)	Insulation Resistance			
j)	Tester	1	500V, 1000M	± 10%
k)	Earth Tester	1	0–10/100/1000	± 5%
l)	Noise Level Meter	1	30–130 dB (A)	
m)	Transceiver	1set		
n)	Slide Type Voltage Regulator	1set	1 Ø. 0–300V, 30A Max	
o)	Transformer	1	3kV/240V, 5kVA for power frequency withstand voltage test, enclosed type with bushing and casters	
p)	Earth Leakage Breakers	1	AC. 100 – 400 V	
q)	Tester	1	AC.5–50 mA, AC 300V–600V	
r)	Phase Rotation Detector	1	With phase–failure check	
s)	Illuminance Meter	1	60–2,000/20,000 lux ± 0.3/3 lux	
t)	Tachometer	1	Non–touch type	
u)	Steel Locker	3 Sets	for container testing equipment about 1,000W x 2,000H x 500D with glazed door and shelves	

(2) Accessories

a) Two (2) Sets of voltage detectors, 600V
b) Two (2) Sets of grounding short bar devices
c) Two (2) Sets of insulation gloves
d) Four (4) Sets of maintenance caps
e) One (1) Set of yellow rope (20m) for keep out with stand pipe
f) One (1) Tool set for maintenance

Tool Name	Quantity	Remarks
Screw drivers	6	Tip size 4mm x 150mm to 9mm x 250mm with case
Phillips type screwdrivers	3	No.1 to No.3 with case
Open end wrenches	6	6mm to 24mm with case
Ring wrenches	6	45deg. offset 8 to 24mm with case
Adjustable wrenches	2	24mm x 20mm, 55mm x L450mm
Combination plier	1	Cutting capacity 2.6mm x L200mm
Adjustable plier	1	Max. Opening 45mm x L250mm
Side cutting plier	1	Cutting capacity 3.2mm x L200mm
Needle nose plier	1	Cutting capacity 1.2mm x L160mm
Diagonal cutting plier	1	Cutting capacity 1.8mm x L160mm
Connector crimpers	2	Plier type 2.5mm2 - 16mm2
Wire stripper	1	Plier type
Tweezers	2	Two (2)-kind of sizes
Scissors	1	
Soldering iron	1	With iron stand and solder
Knife	1	Folding type
Hammers	1	Weight 1bs x L300mm
Plain files	6	Six (6)-kind of sizes
Combine files	6	Six (6)-kind of files
Sand papers	10	
Tape measures	2	30 m, 3 m
Vernier calipers	1	With gap and depth gage
Psychrometer	1	With psychrometer chart
Hygro-thermograph	1	With carts and ink for 3-months
Hand mirror	2	With case
Binoculars	2	With case
Pen Light	2	
Jewelers screw drivers	1 set	
Container	1 set	

(3) Spare Parts

a)	Each type two (2)	Complete sets of protect relays "UV" and "2E"
b)	Each type one (1)	Complete set of molded case circuit breakers
c)	Each type two (2)	Complete sets residual current sensor and relay
d)	Each type two (2)	Complete sets of electro-magnetic switches
e)	Each type 500%	Pieces of light bulbs and fuses
f)	Each type three (3)	Pieces of color caps for signal lamp
g)	Each type three (3)	Complete sets of signal lamps and annunciator lamps
h)	Each type two (2)	Complete sets of change over switches

i)	Each type two (2)	Complete sets of control switches
j)	Each type one (1)	Complete set of space heater
k)	Each type two (2)	Complete sets of terminal blocks
l)	Each type One (1)	Complete sets of ammeter, voltmeter
m)	Each type two (2)	Complete sets of test terminals
n)	One (1)	Lot of other necessary spare parts recommended by the manufacturer

40400 EMERGENCY POWER GENERATOR SYSTEM

40401 Work to be Performed

This Specification shall cover the design, manufacturing, testing and delivery of the following systems for installation complete with necessary auxiliary devices, supervision of construction and field testing.

Two(2) existing generator sets and wiring in the chlorination house shall be removed and carried to the directed place by the PMO/Engineer after operating the low-voltage switchgear for new power receiving.

a) Generator
b) Diesel Engine with Common Steel Bed
c) Generator Control Panel
d) Battery System
e) Fuel Oil System
f) Engine Cooling System
g) Silencer and Exhaust System
h) Cabling necessary to complete all the above works
i) Piping necessary for all the above, complete
j) Foundation work
k) Removal and translocation works of existing generators sets and wiring

40402 References

The following standards are referred to:

a) IEC 34 : Rotating electrical machines.
b) IEC 622 : Sealed nickel-cadmium prismatic rechargeable single cells.
c) ISO 3046 : Reciprocating internal combustion engines performance
d) BS 5414 : Reciprocating internal combustion engines performance
e) BS 6115 : Specification for sealed nickel-cadmium prismatic rechargeable single cells
f) JIS C 4402 : Thyristor Rectifier for Floating Charge
g) JIS C 4004 : Generator Rules for Rotating Electrical Machines.
h) MS 45-1985 : For diesel engine lublicating oil(for API services CD)

40403 Schedule of Emergency Power Generator System

Schedule of all systems which shall be furnished and installed under this Contract are summarized in the following Tables.

TABLE 4-1 GENERATOR

IDENTIFICATION		G-OB
Number of unit	:	1 set
Type	:	Open screen protected, air-cooled type
Shape of field	:	Salient-pole type or cylindrical type
Exciting system	:	Self-excited, brushless
Rated output	:	150 kVA Continuous full-load operation
Over load capacity	:	110% (60 min.)
Rated voltage	:	415/240 V
Rated frequency	:	50 Hz
Number of phases	:	3-phases, 4-wire system
Power factor	:	0.8 (lagging)
Efficiency	:	Not less than 92 %
Revolutions	:	1,500 rpm
Stator and rotor insulation class	:	F-class or higher
Equipment included		
- Brushless excitor	:	1 set
- Space heater	:	1 set
Other necessary equipment	:	1 set

TABLE 4-2 DIESEL ENGINE

IDENTIFICATION		DE-OB
Number of unit	:	1 set
Type	:	Land use, direct injection, water cooled, non-supercharged, 4-cycle vertical, 6-cylinder
Output	:	215 ps Continuous full-load operation
Overload capacity	:	110% (30 min.)
Starting system	:	Electric motor(DC 24V)
Fuel oil	:	Light diesel fuel
Lubricating system	:	Forced lubrication with heat pump
Revolutions	:	1,500 rpm
Fuel consumption	:	Not more than 200/g/ps-h
Speed variation	:	100-0-100% load
- Transient	:	Not more than 10 %
- Permanent	:	" 5 %
Equipment included	:	As shown on the drawings and the specifications

TABLE 4-3 GENERATOR CONTROL PANEL

IDENTIFICATION		GCP-OB
Number of Panels	:	1
Type	:	Indoor, Front and Rear Doors
Rated Voltage	:	415/240V
Rated Bus Current	:	400A
Major Equipment Included		
- MCCB (motorized)	:	1 set
- PT	:	3 set
- CT	:	6 set
- AVR	:	1 set
Other Equipment Included	:	As shown on the Drawings and the Specifications

TABLE 4-4 BATTERY SYSTEM

IDENTIFICATION		B-OB and BC-OB
Number of Equipment	:	1 set
Application	:	Generator starter and control
Type of Panel	:	Metal-enclosed, battery built-in type
Rated operation voltage		
- Input	:	400V AC, Three-phase, 50 Hz
- Output	:	24V DC
Location	:	Operation Building
Battery		
- Type of Cell	:	Nickel-Cadmium Alkaline High Rate Type
	:	(ah, sba 6001)
- Battery Capacity	:	Min. 120 AH
- Battery Discharge Rate	:	5 H
- Number of Cells	:	21
Major Equipment Included		
- Transformer	:	Three-phase, dry type
- Battery Charger	:	50 A
- Silicon Dropper	:	50 A
- Silicon Rectifier	:	50 A
Other Equipment Included	:	As shown on the Drawings and the Specification

TABLE 4-5 FUEL SYSTEM

EQUIPMENT		Q'TY	DESCRIPTIONS
Fuel storage tank	:	1 set	Outdoor type 2,000 liters
Fuel service tank	:	1 set	Indoor type 300 liters
Hand pump	:	1 set	0.2l/stroke with fuel service tank
Piping	:	1 lot	As required on the Drawings and the Specifications
Fuel oil level switch	:	1 set	Indoor, explosion proof type
Fuel oil level switch	:	1 set	Outdoor, explosion proof type

TABLE 4-6 ENGINE LUBRICATION SYSTEM

EQUIPMENT		Q'TY	DESCRIPTIONS
Lubricating oil pump	:	1 set	With machine
Lubricating oil cooler	:	1 set	With machine
Piping	:	1 lot	With machine

TABLE 4-7 ENGINE COOLING SYSTEM

EQUIPMENT		Q'TY	DESCRIPTIONS
Cooling water service tank	:	1 set	Indoor type 1,000 litters
Circulating pump	:	1 set	With machine
Piping	:	1 lot	As shown on the Drawings and the Specifications

TABLE 4-8 SILENCER AND EXHAUST SYSTEM

EQUIPMENT		Q'TY	DESCRIPTIONS
Silencer	:	1 set	Residential type with steel support 85 db by outside
Expansion joint	:	1 set	SP bellows, steel flange
Piping	:	1 lot	As shown on the Drawings and the Specifications
Heat insulation	:	1 lot	

40404 Emergency Generator

(1) *General Requirement*

Emergency generator shall consist of generator, generator control panel, battery system and diesel engine with auxiliary equipment.

The emergency generator shall be the standard product, as modified by these specification, of a manufacturer regularly engaged in the production of this type of equipment. The emergency generator to be furnished shall be a standard production model expect as modified by these specifications, of proven ability, and shall be designed, constructed and installed in accordance with the best practice and methods.

(2) Diesel Engine

The diesel engine shall be a model which has been satisfactory for the operation in similar service at the same rating and speed for at least two(2) years.

The diesel engine shall be of the vertical-in-line, full-injection, heavy duty rating, arranged for direct connection to an alternating current generator.

The engine shall be four stroke cycle and shall have a rotative speed of 1,500 rpm.

The engine speed shall be governed by a hydraulic, isochronous governor or approved equal, which shall have manual adjustment for speed drop, speed setting and load limit. The governor shall be capable of maintaining the frequency constant within plus or minus 0.3 % for any constant load between 1/4 and 4/4 generator rating.

After any sudden load change of not more than 25 % of rated load, the governor shall re-establish stable operating conditions in not less than 4 seconds. Stable operation is operation at a frequency that is constant within plus or minus 0.3 % of rated frequency. The maximum change of frequency during the 4 seconds surging period shall not exceed 3.5 cycles.

The diesel engine shall be furnished for battery system. Starting shall be accomplished by a 24 volt electric starter.
The emergency generator shall be accommodated by rigidly mounted on the frame by anti-vibration rubbers.

(3) Generator

The generator shall be of open, bracket type and especially designed for direct connection to the diesel engine, and shall be for 3 phase, 4 wire, 50 Hz. 415/240 volt operation.

The generator shall be of the revolving field type and shall have a kW rating at 80 % power factor which will absorb the full rating of the engine.

With a load corresponding to 100% (power factor :less than 0.4) of rated current applied at rated voltage and frequency, the instantaneous voltage variation factor shall be less than 25% and shall be restored to -3% of the final voltage within 2 seconds.

The generator shall be free from mechanical faults when operated at 120% of rated

speed for 1 minute under no-load and non-excited condition.

Wave form shall be closely similar to sine curve at rated voltage and frequency under no load. Wave form distortion shall be less than 10%.

The generator shall be normal even when operated for 30 minutes at rated frequency and power factor and at 110% of rated output.

(4) Generator Control Panel.

The specifications for the "40300 LOW-VOLTAGE SWITCHGEAR" shall be applied.

(5) Battery

The battery shall be of the Nickel-Cadmium, Alkaline type, especially designed for diesel engine cranking service and control power source.

The battery shall be of a capacity as recommended by the battery manufacturer for cranking the engine being furnished, for the necessary break-away current as required and spinning current for five consecutive starts of fifteen seconds of cranking on each start without being recharged and with the ambient temperature of 40 degrees C.

The capacity for control power source shall be included in the total capacity of battery.

a)	Type	:	Nickel-Cadmium, Alkaline,
b)	Float charging voltage	:	1.45 V/cell
c)	Boost/Equalizing charging voltage	:	1.6 V/cell
d)	Battery temperature	:	25 degrees C
e)	Final voltage	:	0.9 V/cell

(6) Battery Charger

There shall be furnished an automatic battery charger for charging the Nickel-Cadmium Alkaline battery being supplied, and which shall be the solid state constant voltage type incorporating a self-protecting current limiting feature for

protection against low battery volts and short circuits.

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

The battery and charger panels shall include necessary equipment as presented herein, which shall include but not be limited to the following.

a)	Molded case circuit breakers	1 lot
b)	Electromagnetic switches	1 lot
c)	Instruments and protection relays	1 lot
d)	Phase and sequence selector switches	1 lot
e)	Control switches	1 lot
f)	Annunciators	1 lot
g)	Auxiliary relays and timers	1 lot
h)	Signal lamps	1 lot
i)	Test terminals	1 lot
j)	Terminal blocks	1 lot

(7) Auxiliary Equipment

The emergency power generator facility shall include necessary equipment presented herein, which shall include but not be limited to the following.

a) Pumps Built-in

The cooling water pump and the lubricating pump shall be built in the engine body.

b) Fuel Storage Tank

-	Capacity	:	2,000 litters
-	Material	:	Structural rolled steel.
-	Accessory device	:	Fuel receiving pipe and valve, fuel piping joint, fuel level gauge, mist pipe, maintenance hole, stop valves

c) Fuel Service Tank

-	Capacity	:	300 litters
-	Material	:	Structural rolled steel.
-	Common supporting bench	:	Steel angle frame with ladder
-	Accessory device	:	Fuel piping joint, fuel level gauge, float level switch(explosion-proof), hand fuel pump, mist pipe, stop valves and others

The hand fuel pump shall be suitable for handling diesel fuel and shall be capable of pumping fifteen liters per minute at a suction lift of three meters.

d) Cooling Water Service Tank

-	Capacity	:	1,000 litters
-	Material	:	Structural rolled steel.
-	Common supporting bench	:	Steel angle frame
-	Accessory device	:	Water piping joint, water level gauge, float level switch, ball-tap, stop valves and others

e) Exhaust System

There shall be included an exhaust silencer having a high degree of attenuation equal to not less than 25 decibels. The silencer shall be the standard model of a manufacturer regularly engaged in the manufacture of engine exhaust silencer and shall be of the multiple type.

f) Devices Equipment

All accessory devices including the following items shall be equipped with engine body.

- Tachometer generator
- Lubricating oil pressure gauge and oil thermometer
- Cooling water pressure gauge and thermometer
- Cooling water solenoid valve
- Exhaust thermometer
- Turning device of the flywheel
- Other necessary equipment

40405 Installation

If the Contractor does not have a qualified engine and generator serviceman on the job during the installation, the PMO/Engineer may direct him to provide the service of a factory representative to give the necessary instructions to insure a proper installation.

Anchor bolts shall be provided and installed in accordance with engine manufacturer's recommendations.

40406 Piping

Field fuel and cooling water piping shall be galvanised steel pipe of sizes shown on the drawings. Galvanised coating on the inside and outside of pipe with zinc shall conform to ISO 1459 and ISO 1461. Exhaust piping shall be light weight, black steel.

The entire exhaust system which is installed in the field, except the flexible section, but including exhaust silencer, shall be covered with insulation of a non combustible type and jacketed with an aluminum jacket. The insulation shall be a refractory fiber pipe covering or approved equal, held in place with stainless steel banding and covered with a 0.5 mm aluminum jacket, secured with screws and jacketing lapped a minimum of 75 mm. Fittings and flanges shall be insulated with refractory fiber pipe covering material cut to fit. Flexible section of the exhaust system shall be protected by suitable metal guards to prevent personal

injury from a burn if in contact with bare flesh.

All connections to the engine shall be made with flexible metal hose of an approved type.

40407 Tests

(1) Factory Tests

The emergency power generator set shall be factory tested after completely assembled at the factory. The emergency power generator set shall be subject, unless otherwise noted, to the following tests by the Contractor.

a) Mechanical inspection
b) Electrical inspection
c) Full load operation tests
d) Governor performance tests
e) Voltage and frequency regulation tests
f) Automatic shutdown devices actually stopped tests
g) Temperature rise test with exciting apparatus.
h) Insulation resistance measurement with exciting apparatus.
i) Over speed test.
j) Calculation of the efficiency.
k) Power frequency withstand voltage tests
l) Accessories and spare parts.
m) Acoustic noise level tests

(2) Field Tests

After installation of all equipment has been completed and as soon as conditions permit, the unit shall be subject to an acceptance test under actual operating conditions to determine that the operation is satisfactory without overheating of any part, and to insure that the unit is free from excessive vibration throughout the entire range of speed and load.

Before running the field test, the Contractor shall submit for the PMO/Engineer's approval a copy of the proposed log sheet, on which will be recorded the load and all corresponding temperatures and pressures as well as total quantity of fuel consumed during the test.

The test shall consist four hours of operation with the available load up to the rated capacity of the generator unit. Reading shall be taken and recorded at 30 minute intervals over the four hour test period.

The items of field test shall be executed in the same manner as the factory tests.

40408 *Tools, Accessories and Spare Parts*

The following tools, accessories and spare parts shall be furnished for operation and maintenance of emergency power generator system. Said tools, accessories and spare parts shall include the following but not be limited.

(1) Tools

a)	One	(1)	Set of Lead wire & terminals for testing the voltage and current circuits
b)	Three	(3)	Pieces of bar type thermometer (0 – 600°C)
c)	One	(1)	Set of Clearance gauge
d)	One	(1)	Set of deflection gauge
e)	One	(1)	Set of fuel test pump with pressure gauge
f)	One	(1)	Set of hand time rotameter
g)	One	(1)	Set of standard disassembly and re–assembly tools for engine and generator
h)	One	(1)	Set of wing pump
i)	One	(1)	Set of hand–operated chain hoist, 0.5 ton
j)	One	(1)	Set of tools box
k)	One	(1)	Lot of necessary accessories recommended by the manufacturer

(2) Accessories for Battery

a)	One	(1)	Set of maintenance tools
b)	One	(1)	Set of portable DC voltmeter(0–3V, 1.0 class)
c)	One	(1)	Set of Syringe hydrometer (1.1–1.3)
d)	Three	(3)	Sets of vent mounted thermometer (0–100 deg.C)
e)	One	(1)	Set of mixing tank
f)	Three	(3)	Sets of funnel (made of synthetic resin)
g)	Three	(3)	Sets of bottle (made of synthetic resin)
h)	One	(1)	Set of requisite quantity of potassium hydroxide with 10% extra
i)	One	(1)	Set of sufficient quantity of distilled water first filling up
j)	One	(1)	Set of Steel locker for containing accessories 1 set

(3) Spare Parts for Emergency Power Generator System

a)	Each type 500%	Pieces of fuses
b)	Each type 500%	Pieces of lamp bulbs
c)	Each type One(1)	Set of lamp holders
d)	Each type One(1)	Set of magnetic contractors
e)	Each type Two(2)	Sets of auxiliary relays
f)	Each type One(1)	Set of timer relays
g)	Each type One(1)	Set of thermal relays
h)	Each type One(1)	Set of change over switches
i)	Each type One(1)	Set of control switches
j)	Each type Three(3)	Sets of fuel jet valves
k)	Three (3)	Sets of piston rings & oil rings
l)	Three (3)	Sets of inspiration valves
m)	Three (3)	Sets of discharge valve
n)	Three (3)	Sets of nozzles & Springs for fuel valve
o)	Three (3)	Sets of plunger liner valve, spring for fuel pump
p)	Each type One(1)	Set of spring packings, pins, bolts/nuts
q)	One (1)	Set of painting materials
r)	One (1)	Set of lubricants
s)	One (1)	Lot of necessary spare parts recommended by the manufacture

(4) Spare Parts for Battery System

a)	Each type One(1)	Set of molded case circuit breakers
b)	One (1)	Phase complete set of SCR rectifiers
c)	One (1)	Unit complete set of silicone dropper and electromagnetic
d)	Each type One(1)	Set of resisters and condensers
e)	Each type 500%	Pieces of fuses
f)	Each type 500%	Pieces of light bulbs
g)	Each type two(2)	Complete sets of auxiliary relays
h)	Each type two(2)	Complete sets of timers
i)	Each One (1)	Complete set of change over switches
j)	Each One (1)	Complete set of control switches
k)	One (1)	Set of container boxes
l)	One (1)	Lot of other necessary spare parts recommended by the manufacturer

40500 MOTOR CONTROL CENTERS AND LOCAL CONTROL PANELS

The Contractor shall furnish and install all motor control centers, auxiliary relay panels and local control panels as hereinafter specified and as shown on the drawings.

The existing panels and wiring for the transmission pump and booster pumps shall be removed as directed by the PMO/Engineer. The old panels and wiring shall be removed only after installing the new motor control center, local control panels and wiring. The schedule for changing the control panels, etc. shall be approved by the PMO/Engineer to ensure the pump operation without undue delay.

40501 References

The following standards are referred to.

a) IEC 70	:	Power capacitors
b) IEC 158	:	Low-voltage switch gear and control gear
c) IEC 439	:	Low-voltage switch gear and control gear assemblies
d) BS 5486	:	Low-voltage switch gear and control gear assemblies

40502 Schedule of Motor Control Center, Auxiliary Relay Panels and Local Control Panels

Schedule of all motor control centers, auxiliary relay panel sand local control panels which shall be furnished and installed under this Contract, are summarized in the following Tables.

TABLE 5-1 MOTOR CONTROL CENTER

Identification	MCC-FIL	MCC-CHE	MCP-CHL	MCC-TRP
Number of Panels:	3	2	2	1
Type :	Single type			
Location :	Operation Building			
Rated Bus Current :	600A			
Compartment units :	As shown on the Drawings and the Specifications			
Control Transformer:	1	1	1	1
Other Equipment Included :	As shown on the Drawings and the Specifications			

TABLE 5-2 AUXILIARY RELAY PANELS

Identification		AUX-FIL	AUX-CH
Number of Panels	:	1	1
Type	:	Indoor, Front and rear doors	
Location	:	Operation Building	
Other Equipment Included	:	As shown on the Drawings and the the Specifications	

TABLE 5-3 LOCAL CONTROL PANELS (1/2)

Identi-fication	Qty	Type *1	Form *2	Location	Application	Remarks
LCP-RW1	1	OD	PS	Receiving tank	Raw water flow meters	*3 & w/telephone
LCP-RW2	1	OD	PS	Rapid mixing tank	Raw water flow meter & flush pumps	*3
LCP-FIL1	1	ID	PS	Basement-floor of filter	Plant water pumps	
LCP-FIL2	1	ID	PS	Basement-Floor of filter	Air scouring	
LCP-FIL3	1	ID	PS	Filter	Filtration & washing	
LCP-FIL4	1	ID	WM	Filter	Exhaust fans	

Notes
*1 ID = Indoor, OD = Outdoor,
*2 PS = Pipe Stand, WM = Wall Mounted
*3 This panel shall include a receptacles (4P30A, 3P15A), terminals and switches for receptacles.

TABLE 5-4 LOCAL CONTROL PANELS (2/2)

Identi-fication	Qty	Type *1	Form *2	Location	Application	Remarks
LCP-AL1	1	ID	WM	Chemical buil.	Alum mixers	
LCP-AL2	1	ID	PS	Chemical buil.	Alum dosing pumps	
LCP-LM1	1	ID	WM	Chemical buil.	Lime mixers	
LCP-LM2	1	ID	PS	Chemical buil.	Lime dosing pumps	
LCP-LM3	1	ID	PS	Chemical buil.	Lime injector pumps	
LCP-LM4	1	ID	WM	Chemical buil.	Receptacle	*3
LCP-CHL1	1	ID	WM	Chlorine buil.	Booster pumpx3	
LCP-CHL2	1	ID	WM	Chlorine buil.	Booster pumpx2	
LCP-CHL3	1	ID	WM	Chlorine buil.	CGDIAx3	*3
LCP-CHL4	1	ID	WM	Chemical buil.	Receptacle	
LCP-TRP1	1	ID	WM	Pump station	Ansecourtios pump	
LCP-TRP2	1	ID	WM	Pump station	Receptacle	*3

Notes
*1 ID = Indoor, OD = Outdoor,
*2 PS = Pipe Stand, WM = Wall Mounted
*3 This panel shall include a receptacles (4P30A), terminals and switches for receptacles.

40503 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.

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.

Interlocks shall be provided to prevent openings of the compartment door when the circuit breaker or switch is closed. An interlock bypass 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 and outgoing 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.

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.

(2) Auxiliary Relay Panels

The auxiliary relay panels shall include auxiliary relays, timers and other devices for automatic controls, link-up controls and manual controls of each motor and others.

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

(3) Local Control Panels

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

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.

Local control panel shall be fabricated of heavy gauge steel not less than 2.0 mm thick and shall be of rigid construction.

Ammeters, control switches, push buttons, signal lamps, selector switches and annunciators shall be panel front mounted and receptacle and terminals shall be panel

inside installed.

Door for maintenance shall be provided with key- locking. All fastening devices shall be stainless steel.

40504 Equipment Included

The motor control centers, auxiliary relay panels and local control panels shall include necessary equipment presented herein, which shall include but not be limited to the following.

(1) Motor Control Center and Auxiliary Relay Panels

a)	Molded case circuit breakers	1 lot
b)	Motor starters (Direct on line)	1 lot
c)	Motor starters (Star-delta)	1 lot
d)	Motor starters (Reactor)	1 lot
e)	Instrument transformers	1 lot
f)	Earth leakage relays	1 lot
g)	Zero-phase sequential current transformers	1 lot
h)	Motor protection relays	1 lot
i)	Static capacitors	1 lot
j)	Instruments and protection relays	1 lot
k)	Phase and sequence selector switches	1 lot
l)	Control switches	1 lot
m)	Push button switches	1 lot
n)	Alarm annunciators	1 lot
o)	Signal lamps	1 lot
p)	Auxiliary relays and timers	1 lot
q)	Test terminals	1 lot
r)	Space heater with thermostats	1 lot

(2) Local Control Panels

a)	Molded case circuit breaker	1 lot
b)	Ammeter	1 lot
c)	Instrumentations	1 lot
d)	Change over switches	1 lot
e)	Control switches	1 lot
f)	Push button switches	1 lot

g)	Signal lamps	1 lot
h)	Annunciators	1 lot
i)	Auxiliary relays	1 lot
j)	3P+E 30A receptacle	1 lot
k)	Space heater and thermostat	1 lot
l)	Terminal blocks	1 lot

40505 Installation

The installation of motor control centers, auxiliary panels and local control panels shall be applied as the "40300 LOW-VOLTAGE SWITCHGEAR, 40305 Installation" of the specifications.

40506 Tests

The factory tests and field tests of all motor control centers, auxiliary relay panels and local control panels shall be applied as the "40100 GENERAL, 40116 Tests" of the specifications.

40507 Accessories and Spare Parts

The following accessories and spare parts shall be furnished, which shall include but not be limited to the following.

(1) Accessories for local control panels

a) Two (2) Complete sets of portable tough-rubber sheath cable (10 mm2-4C, 10 m length) with winding pulley and connectors

b) Four(4) Complete sets of portable tough-rubber sheath cable (4 mm2-3C, 30 m length) with winding pulley and connectors

c) Two (2) Complete sets of portable metal- enclosed switchboard with ELB 4P 50AF, terminals and receptacles 3P+E 30A, 2P+E 15A

(2) Spare parts for motor control centers and auxiliary relay panels

a)	Each type two (2)	Complete sets of MCCB for each motor 5.5 kW and less
b)	Each type One (1)	Complete set of MCCB for each motor 30 kW and more
c)	Each type two (2)	Complete sets of ELCB
d)	Each type three(3)	Complete sets of electro-magnetic switches for each motor 5.5kW and less with thermal relays
e)	One (1)	Complete set of electro-magnetic switches for 30kW star-delta starter with thermal relay
f)	Two(2)	Complete set of electro-magnetic switches for 75kW with thermal relay
g)	One (1)	Complete set of electro-magnetic switches for 30kW star-delta starter with thermal relays
h)	Each type two (2)	Complete sets of residual current sensors and relays
i)	Each type one(1)	Complete set of control transformer
j)	Each type 500%	Pieces of fuses
k)	Each type 500%	Pieces of lights bulbs
l)	Each type three(3)	Complete sets of signal lights
m)	Each type five(5)	Complete sets of control switches
n)	Each type five(5)	Complete sets of changeover switches
o)	Each type five(5)	Complete sets of push button switches
p)	Each type twenty(20)	Complete sets of auxiliary relays
q)	Each type three (3)	Complete sets of timers and hour meter
r)	Each type five (5)	Complete sets of space heater with thermostats
s)	Each type five (5)	Complete sets of terminal blocks.
t)	Each type ten (10)	Pieces of spare name plates and tag plates
u)	Two (2)	Large steel lockers with glazed door and shelves for keeping all spare parts specified
v)	One(1)	Lot of other necessary spare parts recommended by the manufacturer

(3) Spare Parts for local control panels

a)	Each type three(3)	Complete sets of change over switches
b)	Each type three(3)	Complete sets of control switches

c)	Each type three(3)	Complete sets of push button switches
d)	Each type 500%	Pieces of fuses
e)	Each type 500%	Pieces of light bulbs
f)	Each type three(3)	Complete sets of annunciator and signal lights
g)	Each type two (2)	Complete sets of space heater with thermostats
h)	Each type two (2)	Complete set of receptacles
i)	Each type ten(10)	Pieces of blank name plats
j)	One (1)	Lot of other necessary spare parts recommended by the manufacturer

40600 INSTRUMENTATION

40601 Work to be Performed

This Specification shall cover the design, manufacturing, testing and delivery of the following systems for installation complete with necessary auxiliary devices, supervision of construction, field testing and instruction.

The Contractor shall furnish and install all instrumentation as hereinafter specified and as shown on the Drawings. Equipment shall include at least the following:

The existing equipment and wiring in the chlorine building shall be removed as directed by the PMO/Engineer.

a) Flow measuring equipment
b) Level measuring equipment
c) Chlorine gas leakage detectors
d) Panel mounted instrumentation equipment
e) Removal of the existing equipment and wiring

40602 References

The following standards are referred to.

a)	ISO 3966	:	Measurement of fluid flow in closed conduits Velocity area method using Pitot static tubes
b)	ISO 5167	:	Measurement of fluid flow by mean of orifice plates, nozzles and Venturi tubes inserted in circular cross-section conduits running full
c)	BS 1042	:	Measurement of fluid flow in closed conduits
d)	JIS Z 8762	:	Measurement of Fluid Flow by means of Orifice Plates, Nozzles and Venturi Tubes

40603 Schedule of Instrumentation

Schedules of all instrumentation which shall be furnished and installed under this Contract are summarized in the following Table.

TABLE 6-1 FLOW MEASURING DEVICES

TAG	Q'ty	TYPE	PIPE SIZE (mm)	APPLICA-TION	LOCATION	DIFFERENTIAL PRESSURE (Less than)	MEASURING RANGE (m3/H)
FaT-2	1	Annubar Tap	800	Raw Water Flow	Flow Meter Chamber	550 mmH2O	0-90,000
FaT-5	1	Annubar Tap	800	Raw Water Flow	Flow Meter Chamber	170 mmH2O	0-50,000
FoT-6	1	Orifice Plate	600	Filtered Water Flow	Flow Meter Chamber	800 mmH2O	0-60,000
FaT-7	1	Annubar Tap	900	Filtered Water Flow	Flow Meter Chamber	800 mmH2O	0-120,000
FaT-8	1	Annubar Tap	800	Filtered Water Flow	Flow Meter Chamber	170 mmH2O	0-50,000
FaD-15	1	Annubar Tap	200	Air Flow	Filter Basement	15 mmH2O	0-2,500
FoD-16	1	Orifice Plate	350	Backwash Water Flow	Filter Basement	3,000 mmH2O	0-750
Fg-17	1	Turbine Type	150	Plant Water Outlet Flow	Chemical Build.		

Note:
*1 : Each flow meter "FaT-2, FaT-5, FaT-7" and "FaT-8" shall include Fa, Ft, Fmf, Id, and all pressure piping.
*2 : Flow meter "FoT-6" shall include Fa, Ft, Fmf, Id, and all pressure piping.
*3 : Flow meter "FaD-15" shall include Fa, Fmf, Id, and all pressure piping.
*4 : Flow meter "FoD-16" shall include Fo, Fmf, Id, and all pressure piping.
*5 : Flow meter "Fg-17" shall incorporate the 6-digits counter.

TABLE 6-2 LEVEL MEASURING DEVICE

TAG	Q'TY	TYPE	APPLICATION	LOCATION	MEASURING RANGE
LTfg-1,2	2	Flange 80 mm	Clear Water Reservoir Level	ClearWater Reservoir Meter Room	0-6.0 m
LTfg-3,4	2	Flange 80 mm	Lime Solution Tank Level	Chemical Building	0-2.5 m
LTfg-5,6	2	Flange 80 mm	Alum Solution Tank Level	Chemical Building	0-2.5 m
ER-RW	1	Electrode x 3	Over Flow Level	Receiving Tank	As required
ER-FIL1 to 6	6	Electrode x 3	Filter Water Level	Filter Units	As required
ER-ET -1,2	2	Electrode x 5	Elevated Tank Level	Chemical Building	As required
ER-FEP	1	Cable Float Type Level Swich x1	Filtered Water Effluent Pit Level	Filter Basement	As required

*1 : Each level transmitter shall include a sluice valve and piping.

TABLE 6-3 CHLORINE GAS DETECTOR

TAG	Q'TY	TYPE	APPLICATION	LOCATION	MEASURING RANGE
CGD-1,2	2	Non Regent Type	Chlorine Gas Leakage	Container Room	0-3 ppm
CGD-3	1	Non Regent Type	Chlorine Gas Leakage	Chlorinator Room	0-3 ppm

TABLE 6-4 LOCAL PANEL MOUNTED EQUIPMENT

TAG	Q'TY	TYPE	APPLICATION	LOCATION	MEASURING RANGE(m3/H)
FI-2-2	1	Wide Angle	Raw Water Flow	Receiving Tank "LCP-RW1"	0-90,000
FI-5-3	1	Wide Angle	Raw Water Flow	Receiving Tank "LCP-RW1"	0-50,000
FI-5-2	1	Wide Angle	Raw Water Flow	Rapid Mixing Tank "LCP-RW2"	0-50,000
FId-15-1	1	Direct Indicator	Air Scour-ing Flow	Filter Basement	0-2,500
FId-16-1	1	Direct Indicator	Filtered Water Flow	Filter Basement	0-750
LI-3,4	2	Wide Angle	Lime Solution Tank Level	Chemical Building "LCP-LM2"	0-2.5 m
LI-5,6	2	Wide Angle	Alum Solution Tank Level	Chemical Building "LCP-AL2"	0-2.5 m

TABLE 6-5 MONITOR AND CONTROL PANEL MOUNTED EQUIPMENT

TAG	Q'TY	TYPE	APPLICATION	MEASURING RANGE
SQ-1-1 to 3	3	Square Root	Raw Water Flow	
FI-1-1 to 5-1	5	Moving Coil	Raw Water Flow	
FQ-1-1	1	6-Digit	Raw Water Flow	
SQ-2	1	Square Root	Raw Water Flow	
FQ-3-1	1	6-Digit	Raw Water Flow	
FR-3-1	1	Three(3)-Pen	Raw Water Flow	0-60,000
SQ-5	1	Square Root	Raw Water Flow	
FQ-5-1	1	6-Digit	Raw Water Flow	
SQ-6 to 8	3	Square Root	Filtered Water Flow	
FI-6-1 to 9-1	4	Moving Coil	Filtered Water Flow	
FQ-6-1 to 9-1	4	6-Digit	Filtered Water Flow	
FR-7-1	1	Three(3)-Pen	Filtered Water Flow	0-120,000
SC-10-1 to 11-1	2	V/I	Distribution Flow	
FI-10-1 to 11-1	2	6-Digit	Distribution Flow	
FQ-12-1 to 13-1	2	6-Digit	Distribution Flow	
SQ-13-1	1	Square Root	Distribution Flow	
FA-13-1	1	H/L	Distribution Flow	
FI-13-1 to 14-1	2	Moving Coil	Distribution Flow	
FR-14-1	1	Three(3)-Pen	Distribution Flow	0-200,000
LA-1 & 2	2		Clear Water Tank Level	

TABLE 6-5 MONITOR AND CONTROL PANEL MOUNTED EQUIPMENT(Cont'd)

TAG	Q'TY	TYPE	APPLICATION	MEASURING RANGE
LIA-1-1 & 2-1	2	Bar-graph	Clear Water Tank Level	0-6 m
LR-3-1	1	One (1)-Pen	Clear Water Tank Level	0-6 m
LA-3 & 4	2	H/L	Lime Solution Tank Level	0-2.5m
LI-3-1 & 4-1	2	Moving Coil	Lime Solution Tank Level	
LA-5 & 6	2	Moving Coil	Alum Solution Tank Level	0-2.5 m
LI-5-1 & 6-1	2	Moving Coil	Alum Solution Tank Level	
WA-1 & 2	2	L/LL	Chlorine Weight	
WI-1-1 & 2-1	2	Moving Coil	Chlorine Weight	0-2,000 kg
ADDER	2	2-Input	Raw Water Flow	
SUB	1	2-Input	Raw Water Flow	
ADDER	2	2-Input	Distribution Flow	
SUB	1	3-Input	Filtered Water Flow	
SUB	1	2-Input	Filtered Water Flow	
R-TREND	1	Three-Pen	Trend Recorder	0-100 %
Q-TREND	1	6-Digit		
Selector	1	30-Input 3-Output	For Trend Recorder	
PWS	2		24V DC Power Supply	
DST	2	Terminal Type	4-20 mA and 1-5 VDC	
Volt-meter	1	Wide Angle	Power Receiving	0-600V AC
Ammeter	1	Wide Angle	400V Main	0-750A AC
kW-meter	1	Wide Angle	400V Main	As required
PF-meter	1	Wide Angle	400V Main	-50%-0-50%
KWC	1	6-Digits	400V Main	
Volt-meter	1	Wide Angle	Generator	0-600V AC
Ammeter	1	Wide Angle	Generator	0-400A AC
kW-meter	1	Wide Angle	Generator	As required
PF-meter	1	Wide Angle	Generator	-50%-0-50%
F-meter	1	Wide Angle	Generator	45-50-55 Hz
KWC	1	6-Digits	Generator	
Running Hour meter	1	6-Digits	Generator	
Volt-meter	1	Wide Angle	Battery	0-35V DC
Ammeter	1	Wide Angle	Ansé Cortios	0-200A AC
COS	23	Two (2) position	For Recorder	4-20mA DC

40604 General Requirements

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

Standard input and output signals shall be 4 to 20 mA DC (milliampere direct current) or 1 to 5 volts DC electronic. Zero based signal transmission will not be allowed.

Electric equipment shall be designed for operation at 230V 50 Hz. single phase and DC 24 V.

All instrumentation shall be designed with selected materials and painted to fully withstand the installation environment, and shall also be designed for easy maintenance and inspection. All instrumentation shall provide interchangeability of common device and parts.

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

All transmitters shall be provided with floor or wall stands with waterproof type terminal boxes.

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

Location	Temperature (C)	Humidity (%)
Outdoor use	40 or less	95 or more
Indoor use	35 or less	95 or more

Lightning 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 maintained free and self-restoring.

Instruments shall be housed in a suitable metallic case, properly grounded.

40605 Flow Measuring Devices

Flow measuring devices for the raw water flow and the clear water flow shall consist of

i) flow meter orifice or annubar type sensor,
ii) flow transmitter,
iii) manifold assembly, and
iv) direct flow indicator. Each item shall be as follows:

(l) Flow meter Orifice (Fo)

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

Orifice plate shall be designed and manufactured in accordance with the following conditions:

a) Type : Concentric, corner–tapes type
b) Overall
c) Accuracy : ±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 plate tab shall identify the upstream edge and the bore diameters.

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

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.

(2) Annubar Type Sensor (Fa)

The annubar type flow sensor with transmitter shall be furnished and installed as shown on the Drawing.

The flow sensor shall be of the averaging pitot differential pressure type as specified hereinafter.

The flow sensor shall consist of four basic parts :

a) High pressure sensor with four impact ports facing upstream,
b) Interpolation tube to average the pressure sensed by the impact ports,
c) Single low pressure sensor facing downstream, and
d) Instrument head to transmit these pressures to a secondary device.

The flow sensor shall be of a cross-sectional shape (diamond) so that the flow separation occurs at a fixed point resulting in a stable flow coefficient over a wide range of Reynolds Numbers independent of pipeline pressure. Flow sensor accuracy shall be ± 1.0 %.

The flow sensor and instrument head shall be made of Type 316 stainless steel.

The flow sensor mounting configuration shall be flanged mounted as shown on the Drawings.

The flow sensor shall be provided with two (2) vent chambers and copper connecting piping. Each vent chamber shall be properly sized and have a vent valve. Vent chamber and vent valve shall be made of stainless steel.

(3) Flow Transmitter(Ft)

The flow differential pressure shall be converted to a DC signal directly proportional to the measurement, and shall be designed and manufactured in accordance with the following conditions:

a) Type — Diaphragm sensing type
b) Accuracy — ± 0.5 % of full scale

c) Working pressure 100 kg/cm2

The transmitter shall have an immersion proof type housing.

The material of the diaphragm shall be type 316L stainless steel. The transmitter shall be mounted with manifold assembly on 50 mm standing stainless steel pipe, schedule 40 having a heavily gusseted stainless steel plate base, minimum thickness of 10.0 mm.

(4) Manifold assembly(Fmf)

A manifold assembly shall be provided complete with two (2) Type 316 stainless steel shut-off valves and a Type 316 stainless steel by-pass needle valve, a head test pipe, two(2) air vent valves, and two(2) male quick connect couplings for connection to a portable manometer.

The manifold assembly shall be connected to a transmitter mounted on the pipe.

(5) Direct Flow Indicator(Id)

Direct flow indicator shall be provided at tapping pipes led to flow transmitters for backup or direct indication. 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 ±2.0 % 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.

The meter shall be equipped with connection pipes with cock and meter tube protection covers.

Sectional type flow meters shall be installed as shown on the Drawings. The meters shall be provided with the complete set and ready to operation. Suitable protection for the meter tubes shall be provided.

Direct flow indicator shall be designed for an easy-to-read and linear to flow scale for direct, continuous reading in flow units (m3/H).

The indicator shall be mounted on 50 mm in diameter stainless steel pipe, schedule 40 having a heavily gusseted stainless steel plate base, minimum thickness of 10.0 mm.

40606 Level Measuring Devices

The following types of level measuring devices shall be specified herein and such devices shall be complete with all necessary apparatuses.

(1) Flange Type Level Transmitter (LTfg)

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 flanged type
b) Accuracy : ±0.5 % of full scale

The transmitter shall be the immersion proof type. The material of diaphragm shall be type 316L stainless steel, and housing shall be type 316 stainless steel.

A valve assembly shall be provided complete with Type 316 stainless steel shut-off valves 80 mm dia. and drain valve, a head test pipe, air vent valve, and male quick connect couplings for connection to a portable manometer.

(2) Electrode 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.

The holder cover shall be provided and the fitting shall be flanged type.

(3) Mercury type Level Switch

Level switches shall consist of a PVC encased, rigid, eccentrically- weighted float housing for a mercury switch actuator, of design which can withstand occasional submergence under 20 meters of water.

Mounting brackets and anchor bolts shall be stainless steel.

Number and configuration of level switches shall be as required for the control system specified above, and shall be suited for installation in the sump pit and others of dimensions shown.

40607 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 : Non reagent, semiconductor sensing
b) Measuring range : 0-3 ppm
c) Accuracy : Within ± 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. 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 230V by power supply unit.

40608 Panel Mounted Instruments

The instrumentation meters, equipment and other necessary devices to be equipped on the monitor and control panel, and shall conform with the specifications set forth under the following items and shall be supplied, installed and complete with all necessary parts and accessories.

(1) Indicators (I)

a) Bar–graph type

Bar–graph type shall have the accuracy of ±0.5% of full scale and scale shall be at least 100 mm length. Zero and span adjustment shall be provided. Bar–graph type indicator shall have high and low alarm.

b) Wide Angle Type

Indicator shall have the accuracy of ±1.5% of full scale and scale shall be at least 100 mm length or 240 degrees from zero, not less than 95 mm square. Zero and span adjustment shall be provided.

c) Moving Coil Type

Moving coil type shall have the accuracy of ±1.5% of full scale and scale shall be at least 100 mm length from zero. Zero and span adjustment shall be provided.

(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 ±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.

(3) Integrator (Q)

Integrator shall be designed and manufactured in accordance with the following conditions:

a) Type, : Proportional integration
b) Accuracy, : ± 1.0%
c) Indication (Counter) : 6 digits, no rest

(4) 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 ± 3% of full scale and repeatability shall be ± 0.5% of full scale.

(5) Adder or Subtraction (ADD or SUB)

The adder or subtraction 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 signal 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 ± 0.5% of full scale.

(6) Square Root Extractor (SQ)

Square root extractor shall be provided for measuring flow rate. In case the flow transmitter is equipped with a square root extractor, it is not required to provide the extractor in the panel. The accuracy shall be ± 0.5% of full scale.

(7) Arrester (Ar)

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

(8) 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 ±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.

(9) Distributors

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 ± 0.2% of full scale.

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

40609 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 PMO/Engineer. Local electrical shutoffs for power supplies to field instrumentation shall be provided.

All piping including to and from field instruments shall be provided with test tees, shutoffs and disconnect unions as shown.

It shall be the responsibility of the Contractor to check the Electrical Drawings to ensure that the wiring and power availability is sufficient, and if not, to provide all additional facilities necessary at the Contractor's 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, chlorine gas detectors and others.

40610 Tests

The factory and field tests of instrumentation shall be applied as "the 40100 GENERAL, 40116 Tests" of the specifications.

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 ± 2% of the actual flow within the specified range as computed from the differential manometer readings taken during tests.

40611 Accessories and Spare Parts

The following accessories and spare parts shall be furnished, which shall include but not be limited to the following.

(1) Accessories

a) One (1) set of portable type instrument checkers for adjustment and maintenance.

The checker shall have following functions.

Measuring range		
- Voltage(mV)	:	DC.0-15/30/50/100/300/500/1,000
- Current (mA)	:	DC.0-15/30/50
- Resistance (Ω)	:	0-10, 0-100
Signal generating range with output adjustment volume		
- Voltage(mV)	:	DC.0-15/30/50/100/300/500/1000
- Current (mA)	:	DC.0-15/30/50
- Resistance	:	Equivalent resistance of pt.100 resistance bulb
Accuracy	:	± 0.5% of full scale
Accessories	:	Each lead wire

b) One (1) tool set for mechanical instruments.

This set shall include but not be limited to the following.

Tool Name	Quantity	Remarks
Canvas kit bag	1	
Single ended wrenches	2	7/16 and 1/2 inches for range adjustment
Phillips type screwdriver	2	No.1, 2
Screwdriver	2	6mm x 100mm, 4mm x 100mm
Vewller's screwdriver	1	No.3, standard
Screwdriver	1	2.5mm x 35mm
Tweezers	1	
Offset socket wrenches	1	For drain plug
Tape measure	1	Stainless steel, 2m, take up
Allen wrenches(metric system)	7	1.5, 2, 2.5, 3, 4, 5 and 6mm
Allen wrenches(inch system)	6	5/64, 3/32, 1/8, 9/64, 5/32, and 1/4 inch
Side cutting pliers	1	6-inch
Adjustable wrench	1	6-inch
Pliers	1	
Scissors	1	
Exchange bit Vewller's screwdriver	1	3mm x 35mm, standard
Set of exchange bit	1	No.0 and No.1(Phillips type) 1mm x 35mm (Standard)
Double ended wrenches	4	1/4"x5/16",6mmx7mm, 8mmx9mm, 10mmx12mm

Tool Name	Quantity	Remarks
Screwdriver	1	1.5mmx12mm, for adjustment of pen movement
Screwdriver	1	3.3mm
Alignment pin(NO.8&14) adjustment	2	For control mechanism
Nozzle cleaning wire (with case)	1	
Others	1 lot	

c) One (1) tool set for electrical instruments.

This set shall include but not be limited to the following.

Tool Name	Quantity	Remarks
Canvas kit bag	1	
Round nose chain pliers with site cutters	1	6-inch, with insulated grip
Scissors	1	
Set of exchange bit (with case)	1	No.0 and No.1(Phillips type) 1mmx35mm (Standard)
Tweezers	1	
Exchange bit Vewller's screwdriver	1	3mmx35mm (Standard)
Vewller's screwdriver	1	No. 3 (Standard)
Phillips type screwdriver	1	No.1 4mmx100mm
Phillips type screwdriver	1	No. 2
Exchange bit box-driver	1	M3x0.5, M3x0.6
5 pcs. of plain file	1	Bastard cut
Tape measure	1	1m, take up
T117 sparkle solder	1	1mm dia. x 1m
PVC tape	1	13mm wide, 10m
Electric soldering iron stand	1	
Type 4S soldering iron	1	230V, 25W
Adjustable Wrench	1	4-inch
Diagonal cutting nipper	1	With insulated grip
Lead wires with clips	4	Each red, yellow, pink and black
Allen wrenches	2	M2.3 and M3 x 0.5
Others	1 lot	

d) One (1) tool set for instruments adjustment.

This set shall include but not be limited to the following.

Tool Name	Quantity	Remarks
Canvas kit bag	1	
Spanner 1/4"x5/6"	1	For amplifier mounting and restrictor mounting
Single ended spanner 7/16"	1	For span adjustment
Screwdriver 1.5mmx12mm	1	For adjusting pen pressure, movement and zero point
Screwdriver 3.3mm	1	For driving element, and movement hub screws
Single ended spanner 1/2"	1	For span adjustment
Screwdriver 2.5mmx35mm	1	For reset, flappers and zero adjustment
Tweezers	1	
Allen wrench 1/4"	1	For tightening
Nozzle cleaning wire (with case)	1 set	For cleaning pen-tip, nozzle and restrictor
Socket wrench	1	For driving element, and movement hub screws
Alignment pin for link 40mm	1	For centering the movement
Alignment pin for link 20mm	1	For centering the movement
Allen wrench, 5/64	1	For ration adjustment
Allen wrench, 3/32"	1	For controller and A/M transfer set screw
Allen wrench, 1/8"	1	For instrument vector mechanic clamp screws
Allen wrench, 9/64"	1	For replacement of force motor
Allen wrench, 5/32"	1	For Normal/Reverse operation of controllers
Spanner, 1/8"x3/6"	1	For link adjustment
Others	1 lot	

e) Two(2) Steel locker switch glazed doors and shelves

(2) Spare Parts for Flow Measuring Equipment

a) One (1) Complete set of flow transmitters(Ft) and(Fmf)
b) Each size five (5)-m of piping material
c) One (1) Lot of other necessary spare parts recommended by the manufacturer

(3) Spare Parts for Level Measuring Equipment

a) One (1)	Complete set of flange type level transmitters (LTfg)
b) Each type two (2)	Complete sets of electrode type level switches
c) One (1)	Pieces of flict level switch
d) Each type one(1)	Complete set of level switch relay
e) Ten(10)-m Length	of electrodes with connectors and spacers
f) One (1)	Lot of other necessary spare parts recommended by the manufacturer

(4) Spare Parts for Chlorine Gas Leakage Detector

a) One (1)	Complete set of chlorine gas leakage detector (CGD) and receiving meter(Cl2IA)
b) One (1)	Complete set of power supply unit
c) Each type 500%	Pieces of fuses
d) Each type 500%	Pieces of light bulb
e) One (1)	Lot of other necessary spare parts recommended by the manufacturer

(5) Spare Parts for Panel Mounted Instrument Equipment

a) Two (2)	Complete sets of balance type indicator
b) Three(3)	Complete sets of wide angle type indicator
c) Two (2)	Complete sets of moving coil type indicator
d) One (1)	Complete set of one-pen type recorder (R)
e) (500)	Rolls of recording papers
f) Each color (200)	Pieces of ink cartridges
g) Each color (3)	pieces of recording pen
h) Each Three (3)	Sets of string
i) Each Three (3)	pieces of syringe
j) Five (5)	Set of check pins
k) One (1)	Complete set of totalizer(Q)
l) Two (2)	Complete sets of alarm units (A)
m) One (1)	Complete set of square root extractor(SQ)
n) Five (5)	Complete sets of arresters
o) One (1)	Complete set of power supply unit (PWS)
p) Five (5)	Complete sets of distributors (DST)
q) Each type 500%	Pieces of fuses
r) Each type 500%	Pieces of light bulb
s) Each type ten (10)	Pieces of spare nameplates and tag plates
t) One (1)	Lot of other necessary spare parts recommended by the manufacturer

40700 MONITOR AND CONTROL PANELS

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

40701 References

The following standards are referred to.

a)	IEC	439	:	Factory-built assemblies of low-voltage switchgear and control gear
b)	IEC	492	:	Factory-built assemblies of low-voltage switchgear and control gear

40702 Schedule of Monitor and Control Panel

Schedule of all monitor and control panels which shall be furnished and installed under this Contract are summarized in the following Table.

TABLE 7 MONITOR AND CONTROL PANELS

IDENTIFICATION		MCP-OB
Number of Panels	:	3
Type	:	Self-standing, metal-enclosed rear door type
Graphic	:	All graphic with mimic bus
Location	:	Operation building
Major Equipment Include		
- Equipment Included	:	See the SECTION 9 904
- Instrument Equipment	:	See the SECTION 5 TABLE 8-5, 8-6
- Exchange for intercom	:	1 set with terminal board and power supply unit
- Electric Clock	:	1
- Annunciator	:	1 lot
Other Equipment Included	:	1 lot

NOTES *1 : Modification of all graphic panel layout shall be required as directed by the PMO/Engineer without an additional cost to the Employer.

40703 Construction

The monitor and control panel shall be provided for monitoring of process condition as shown on the Drawings. The panel construction shall comply with Clause 40300 "LOW-VOLTAGE SWITCHGEAR".

Rear door shall be hinged to provide access to panel wiring and maintenance.

The graphic panel shall consist of the acrylic resin sticking types. Equipment symbols and lines shall be engraved and finished in color lacquer on the surface of the acrylic resin. 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 power supply 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.

Sizes and colors of the graphic symbols, lines and mimic buses shall be submitted on a 1/5 scale drawing for each color.

Fluorescent lights shall be provided inside each panel with lighting door switches.

Minimum thickness of steel for each part of panels shall be:

a)	Front plate	:	3.0 mm
b)	Semi graphic plate	:	3.0 mm
c)	Rear plate	:	2.0 mm
d)	Side plate	:	2.0 mm
e)	Ceiling plate	:	2.0 mm
f)	Channel base	:	50x100x50x5 t mm
g)	Frame angle	:	50x50x4 t mm

40704 Equipment Included

The monitor and control panels shall include necessary equipment as presented herein.

a)	Control transformers	1 lot
b)	Molded case circuit breakers	1 lot
c)	Instruments	1 lot
d)	Phase and sequence selector switches	1 lot
e)	Control switches	1 lot
f)	Push button switches	1 lot
g)	Auxiliary relays and timers	1 lot
h)	Signal Lamps	1 lot
i)	Alarm annunciators	1 lot
j)	Group sequence lamps	1 lot
k)	Instrumentation	1 lot
l)	Exchange with terminal board and power supply unit	1 lot
m)	Electric clock	1 lot
n)	Fluorescent lamps and door switches	1 lot
o)	Test terminals	1 lot
p)	Terminal blocks	1 lot

40705 Installation

The monitor 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 panels and shall be installed level in all directions.

The monitor and control panels shall be maintained in an upright position at all times. Lifting shall be only at the floor sills or the top mounted lifting angle.

The monitor 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 panel manufacturer.

40706 Tests

The factory rest and field tests of the monitor and control panels shall be applied as the "40100 GENERAL, 40116 Tests" of the specifications.

40707 Spare Parts

The following spare parts shall be furnished for monitor and control panels.

a)	Each type 500%	Pieces of fuses
b)	Each type 500%	Pieces of light bulbs
c)	Each type ten(10)	Complete sets of signals and annunciator lamps
d)	Each type three(3)	Sets of graphic symbols
e)	Each size and color 5 m	Length of graphic lines
f)	One (1)	Set of mimic bus lines adhesive
g)	Each type ten(10)	Complete sets of auxiliary relays
h)	Each type five(5)	Complete sets of timers
i)	Each one (1)	Complete set of bell and buzzer
j)	Each type two(2)	Complete set of change over switch
k)	Each type two (2)	Complete sets of control switches
l)	Each type five(5)	Complete sets of terminal blocks
m)	Each type ten(10)	Pieces of spare nameplates
n)	Each ten (10)	Pieces of spare annunciator plates
o)	One (1)	Lot of other necessary spare parts recommended by the manufacturer

40708 Operation System

(1) General

All essential and desirable operation system shall be provided to all equipment and facility installed under this contract. Said operation systems shall include the following but not be limited.

The work specified hereinafter shall include to design furnish and test all operation system with satisfactory and also include the services for start-up, adjustment, instruction and maintenance of all systems.

Safety operation shall be performed by the system of overload protections and alarms in buzzers and flickering annunciators so as to avoid faulty operation.

(2) Priority on Control Way

The priority on control way of all equipment shall be as follows unless specified.

a) First priority of control shall be given to the local control panel near equipment for normal operation or test operation during maintenance "RUN-STOP" or emergency operation "STOP".

b) Second priority of control shall be given to the monitor and control panel in the control room of operation building.

c) Third priority of control shall be given to the auxiliary relay panels or the motor control centers in the electric room of the operation building.

d) When the change-over switch of the motor control center is set at "NORMAL" and the change-over switch of the local control panel is set "LOCAL", equipment shall be operated only by the local control panel and any panel cannot operate the equipment.

e) When the change-over switch of the local control panel is set at "REMOTE" and the change-over switch of the low-voltage switchgear or the motor control center is set "TEST", equipment shall be operated only by the low-voltage switchgear or motor control center in the electric room of operation building.

f) When the change-over switch of the local control panel is set "REMOTE", and equipment shall be operated only by the monitor and control panel in the monitoring room, of operation building.

g) When the change-over switch of the local control panel is set at "REMOTE" and the change-over switch of the motor control center is set "NORMAL", equipment shall be operated only by the monitor and control panel in the operation building.

(3) Motor Starting Conditions

All motor starting systems shall be designed to ensure the following so that motors

begin to run in safety.

a) All relays and devices for protection of motor shall be not functioned.

b) Molded case circuit breaker of motor control center shall be closed.

c) In case of large capacity motor switch a star-delta starting or reactor starting systems, other motors with star-delta starting or reactor starting systems controlled from all motor control centers will not be started. Interlocks shall be incorporated to prevent simultaneous starting.

d) In case of pumps, the level of pump suction pit will not be lower.

e) All starting conditions shall be ready to run motor.

(4) Re-starting After Power Failure

In power failure, all motors shall be disconnected from power lines by a control system unless specified. After power recovery, they shall be started again in manual operation one by one.

(5) Operation System

Operation system for the following loads shall be functioned in the modes of "Manual", "AUTO" and others, which shall be specified hereinafter and as shown on the following Table and the Drawings.

TABLE 7 OPERATION MODES AND CONTROL LOCATIONS

Name of Panel	--LVS, GCP, MCC--			----------LCP----------					--MCP--
Name of COS	R/T,	M/A,	CS	R/L,	M/A,	D/S,	1/2,	CS	CS
Flush pumps :	O	–	O	–	–	–	–	O	–
Plant water pumps :	O	–	O	–	O	–	O	O	–
Air-scouring blowers :	O	–	O	–	O	–	O	O	–
Alum mixers :	O	–	O	–	O	–	–	O	–
Lime mixers :	O	–	O	–	O	–	–	O	–
Alum dosing pumps :	O	–	O	–	–	O	–	O	–
Lime dosing pumps :	O	–	O	–	–	O	–	O	–
Lime booster pumps :	O	–	O	–	O	–	O	O	–
Chlorinator booster pumps :	O	–	O	–	O	O	–	O	–
Anse courtios pump :	O	–	O	O	O	–	–	O	O
Outdoor lighting :	O	O	O	–	–	–	–	–	O
Emergency generator :	O	O	O	–	–	–	–	–	O
Static capacitors :	O	–	O	–	–	–	–	–	O

Notes

"R/T" : The detail of COS "R/T" is "Remote-Test"

"R/L" : The detail of COS "R/L" is "Remote-Local"

"M/A" : The detail of COS "M/A" is "Manual-Auto"

"1/2" : The detail of COS "1/2" is "NO.1-NO.2"

"D/S" : The detail of COS "D/S" is "Duty-Standby"

"CS" : The detail of CS "CS" is "Run-Stop" or "On-Off"

"O" : The operation mode shall be applied.

"–" : The operation mode is not applied.

40800 LIGHTING AND COMMUNICATION SYSTEM

40801 Work to be Performed

Hereinafter specified the Specification shall cover the design, manufacturing, testing and delivery of the following lighting and communication systems for installation complete with necessary auxiliary devices, supervision of construction, field testing, start-up and instructions work.

a) Lighting system for filter
b) Outdoor lighting system
c) Intercommunication System
d) Public-address system
e) Removal and re-installation of existing radio telephony system

40802 References

The following standards are referred to.

a)	IEC	82	:	Ballasts for tubular fluorescent
b)	IEC	188	:	High-pressure mercury vapour lamps.
c)	IEC	262	:	Ballasts for high pressure mercury vapour Lamps.
d)	IEC	268	:	Sound system equipment
e)	IEC	400	:	Lamp holders for tubular fluorescent lamps and starter holders.
f)	IEC	838	:	Miscellaneous lamp holders.
g)	BS	4533	:	Luminaries
h)	JIS C 8106		:	Luminaries for Fluorescent Lamps

40803 Schedule of Lighting and Communication Systems

Schedule of lighting system and communication system which shall be furnished and installed under this Contract are summarized in the following Tables.

TABLE 8-1 LIGHTING PANEL AND FIXTURES

Location		---Lighting--- Panel	Fixture	----Outdoor(HF250W)--- "A"	"B"	"C"	"D"	Photo-switch
Filter	:	1Nr	1lot	-	-	-	2	-
Raw water intake	:	-	-	-	1	1	-	-
Sedimentation basin	:	-	-	1	1	2	-	-
Work shop	:	-	-	-	1	-	1	-
Waste basin	:	-	-	-	-	2	-	-

TABLE 8-2 COMMUNICATION SYSTEMS

	Ex-change	Power amplifier	Terminal board	Speaker (I)	(J)	Hand-set (G)	(H)	Tele-phone
Operation buil.	: 1	1	With exchange	3	3	6	2	3
Chemical buil.	: -	-	TB-CHE	2	-	-	2	-
Chlorine buil.	: -	-	TB-CHL	-	-	-	1	-
Filter	: -	-	TB-FIL	1	-	-	1	-
Filter(LCP-FIL3)	: -	-		-	-	1	-	-
Work shop 1	: -	-	TB-WS1	2	-	2	-	-
Raw water (LCP-RW1)	: -	-	-	-	-	1	-	-
Office & work shop	: -	-	TB-OW	2	-	-	2	-
Clear water reservoir	: -	-	TB-CWR	-	-	-	1	-
Disused chlorine house	: -	-	TB-DH	-	-	-	1	-
Work shop 2	: -	-	TB-WS2	-	-	-	1	-
Pump station	: -	-	TB-PS	1	-	-	1	-
Staff house	: -	-	TB-SH	-	-	-	1	-

Notes : Number of terminals of all terminal boards shall be incorporated with 20-pairs.

40804 Lighting System Equipment

(1) Light Fittings and Lamps

Light fittings shall except where otherwise specified be power factor compensated

by means of phase capacitors. Where earthing of light fittings is necessary, it is to be effected without using chains or other rigid supports as conductors. All light fittings shall be cleared and the installation in complete working order before handing over and shall be provided with lamps/tubes. 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.

(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 230V, 50 Hz, with high-power factor, constant input power type.

(3) Emergency Lights

Emergency lighting shall be automatically lighted at power supply interruption with versatile AC/DC lamps by an incorporated Alkaline battery.

(4) Light Switches

Light switches shall be 10 A according to the load switched. They shall be suitable of switching inductive loads and mounted in pressed steel boxes on adjustable grids. They shall be installed at a height of 1,200 mm above finished floor level. Watertight switches shall be 10A, 250V, mounted in a cast aluminum box with gasketed cover.

(5) Receptacles

Wall receptacles shall be the duplex grounding type, 250V, 15A, three (3)-pole, three (3)-wire or as specified on the drawings. Water tight receptacles shall be general purpose receptacles enclosed in gasketed, cast iron housings with spring loaded gasketed cover.

(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, galvanised 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.

(7) *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	:	Three(3)-phase, four(4)-wire
d)	Rated operation voltage	:	400/230V
e)	Insulation level	:	2,500V r.m.s. (One minute)

Interior shall have solder less, 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.

40805 Intercommunication System

An intercommunication system shall be means by which the exchange interconnects between distributed hand-sets in the Treatment Plant, called the exchange.

The intercommunication system shall consist of an exchange, hand-sets, power supply unit and terminal boards.

The function of intercommunication system shall include hands-free and fully duplex hand-set operation, press to talk for high noise areas, privacy mode to refuse incoming calls, call transfer/forwarding, camp on busy and busy call-back, conference and personal number calls.

The exchange shall be a microcomputer-based intercommunication system.

Power supply of the exchange shall be AC 230 volt, 50Hz., and DC 24 volt. If AC power supply is failed, the exchange automatically transfers to DC 24 volt power.

(1) Exchange

a)	Type	:	Microprocessor based inter-communication type
b)	Speech method	:	Hand-set conversation and/or hands-free
c)	Line capacity	:	24 lines
d)	Link capacity	:	2 lines
e)	Wiring system	:	2-wire system,
f)	Transmission band		
	- Base band	:	200- 5 kHz.
	-FM carrier band	:	15 -35 kHz.
g)	Service signal tones	:	Calling, busy, dial, privacy, paging pre-announcement and holding tones
h)	Power source	:	AC 230 V and DC 24 V back-up
i)	Accessories	:	Power supply unit, terminal board

(2) Hand-set (G,H)

a)	Type	:	Hands-free and fully duplex hand-set operation, desk/surface mounted (G) and wall mounted (H)
b)	Microphone	:	Omni directional electric condenser microphone
c)	Microphone sensitivity	:	-70 dB
d)	Speaker	:	Dynamic type, input level 0.6W
e)	Input/output impedance	:	600 ohms, balanced
f)	Dialing code	:	Amplitude modulated pulse number code system
g)	Frequency response	:	200-7,500 Hz.
h)	Wiring system	:	Non-polar 2-wire system
i)	Accessories	:	Lead cable

(3) Telephone set (K)

a)	Type	:	Mauritius telephone company's standard, desk/surface-mounted
b)	Accessories	:	Lead cable

40806 Removal and Re-installation of Existing Radio Telephony System

The following existing radio telephony system shall be re-installed in the new operation building after cleaning, checking, repairing and replacing any defective parts if any.

(1)	Radio	1 set
(2)	Antenna with support	1 set
(3)	Coaxial cable	1 set
(4)	Power supply system	1 set

The following newly lighting arrester system for antenna shall be furnished and installed by this Contract.

(1)	Newly lightning arrester	1 set
(2)	Newly grounding system	1 set

40807 Public-Address System

The public-address system enables the control room of the operation building to communicate selectively with individual 5-zones or all-call entire Treatment Works.

The public-address system shall consist of a power amplifier, paging microphone and loudspeakers.

The power amplifier shall have a power output of 120 watts r.m.s. peak, solid state type and suitable housing type for setting on the desk.

Power supply of the power amplifier shall be AC 230 volt, 50Hz., and DC 24 volt. If AC power supply is failed, the power amplifier automatically transfers to DC 24 volt power.

(1) Power Amplifier

a)	Type	:	Desk-top
b)	Output power	:	60W r.m.s
c)	Selector switch	:	5 circuits
d)	Frequency response	:	40-16,000 Hz.
e)	Output impedance	:	100V/330 ohm
f)	Input	:	Microphone, cassette recorder, radios, paging, chime and auxiliary
g)	Line output	:	600 ohms, balanced
h)	S/N	:	60 dB at 20-20,000 Hz.
i)	Power supply	:	AC 230V (DC 24V back-up)
j)	Accessories	:	Desk for installation

(2) Paging Microphone

a)	Type	:	Desk-top, dynamic type
b)	Output level	:	-76 dB at 1 Hz.
c)	Frequency range	:	200-10,000 Hz.
d)	Output impedance	:	600 ohms at 1 Hz. unbalanced
e)	Switch	:	Short-off type with locking lever
f)	Accessories	:	Shielded cable with phone plug

(3) Loudspeaker (I)

a)	Type	:	Wall mounting box type
b)	Output	:	3 Watt
c)	Impedance	:	3,300 ohms
d)	frequency	:	100-10,000 Hz.
e)	Accessories	:	Attenuator, support

(4) Loudspeaker (J)

a)	Type	:	Reflex horn, outdoor mounted type
b)	Input	:	10 Watt
c)	Impedance	:	8 ohms
d)	frequency	:	320-9,000 Hz.
e)	Material	:	Aluminum
f)	Accessories	:	Attenuator, supports(stainless steel)

40808 Tests

The tests of lighting system, intercommunication and public address systems shall be applied as "40100 GENERAL, 40116 Tests" of the specifications.

40809 Accessories and Spare Parts

The following accessories and spare parts shall be furnished, which shall include but not be limited to the following.

(1) Accessories for Lighting System

a)	Each one(1)	Set of ladders, height 3 m, 6 m
b)	Two (2)	Sets of stepladders, height 3 m
c)	Ten (10)	Complete sets of watertight type portable lights with battery

d)	Three (3)	Sets of watertight portable hand lamps with tough-rubber sheath cable 5 m with reel and receptacle sets
e)	Two (2)	Sets of extend tough rubber sheath cable (4mm2 – 4C, 30m) with portable reel and receptacle set (4P20A x 2)

(2) Spare Parts for Lighting System

a)	Each type two(2)	Complete sets of lighting fixtures type "F" and "E"
b)	Twenty (20)	Pieces of 40W fluorescent lamps
c)	Each type two(2)	Pieces of receptacles
d)	Each type five(5)	Sets of wall switches
e)	One (1)	Set of containing box for spare parts

(3) Spare Parts for Outdoor Lighting System

a)	One (1)	Set of special stepladder for changing of out door lighting fixture lamp
b)	Five (5)	Pieces of mercury vapor lamps 250W
c)	Each type one(1)	Complete set of mercury vapor ballast
d)	Two (2)	Sets of photo switches
e)	One (1)	Set of containing box for spare parts

(4) Spare Parts for Intercommunication System

a)	Three (3)	Complete sets of hand-set
b)	Two (2)	Pieces of terminal block

(5) Spare Parts for Public Address System

a)	Two (2)	Complete sets of speakers 3W

40900 WIRING SYSTEM

40901 Work to be Performed

The Contractor shall furnish and install all necessary wiring, system with necessary auxiliary devices, field testing, supervision of wiring and start-up work as shown on the drawings and as hereinafter specified.

a) Cabling Wiring System
b) Conduits System
c) Electric Flexible Conduit System
d) Cable Racks and Duct System
e) Earthing System
f) Tests

Wiring system specified herein shall apply to the following works:

(1) *Cable Wiring System*

a) AC 400/230V main power cable wiring for power receiving from CEB's power transformer on the pole, to the low-voltage switchgear(LVS-OB) in the electric room of the operation building.

b) AC 400/230V power and lighting distribution cable wiring for new and existing buildings from LVS-OB in the electric room of the operation building to each building.

c) Power and control cable wiring for the emergency power generator system in the operation building between the generator panel, LVS-OB, and the monitor and control panel(MCP-OB).

d) Incoming wiring of telephone cables from the telephone company to the Operation Building.

e) Communication cable wiring, from the exchange in the (MCP-OB) to terminal boards of each Buildings.

f) Power and control cable wirings, between(LVS–OB), the motor control centers(MCC), the auxiliary relay panels and (MCP–OB).

g) Power supply and control cable wiring in the generator room.

h) Power supply and control cables of the Anse Coutios transmission pump from (MCC–TRP) to the existing pump station and modification works of the pump station.

i) All communication cable wirings, intercom, public address system and telephone for new and existing buildings from the operation building to each building.

j) Power supply and control cables of all electrical wiring, motors, local control panels, lighting, instrumentation equipment, electrodes, communication equipment and others.

k) All existing wirings shall be removed and modified as required by the PMO/Engineer.

(2) Conduits system

The Contractor shall furnish and install all necessary rigid steel conduits, PVC conduits, boxes and flexible steel conduits with exposed and embedded installations, painting, supervision for installation and field testing.

(3) Electrical flexible conduits system

a) Underground piping with cable man–holes for 400V main cable from the CEB pole to the electric room in the operation building.

b) Underground piping with cable man–holes for all kinds of cables from the electric room in the operation building to the new buildings and existing buildings.

c) All underground piping with cable man–holes and hand–holes between each building and each outdoor lighting.

d) Underground piping with cable man-holes and hand-holes for all kinds of cables from each building to the local control panels and outdoor lighting.

(4) Cable racks and duct system

a) Cable duct and cable pit for power and control cables in the electric room and the generator room of the operation building.

b) Cable racks for power and control cables of local control panels, motors and others in the chemical building.

c) Cable racks for power and control cables of local control panels, motors and others in the filter pipe gallery.

d) Cable racks for power and control cable of local control panels, motors, and others in the chlorination building.

(5) Earthing system

a) Electrodes and necessary wiring for 400/230V equipment
b) Electrodes and necessary wiring for communication equipment
c) Electrodes and necessary wiring for instrumentation equipment.
d) Electrodes and all wiring for auxiliary ground electrodes.

40902 Reference

The following standards are referred to:

a)	IEC 227	:	Polyvinyl chloride insulated cable and cords with circular conductors and a rated voltage not exceeding 750V
b)	IEC 614	:	Conduit for electrical installations
c)	BS 4607	:	Non-metallic conduits and fittings for electrical installations
d)	BS 4808	:	L.F. cables and wires with PVC insulation and PVC sheath for telecommunication

e)	BS 6004	:	PVC-insulated Cables (non-armored) for electric power and lighting
f)	BS 6099	:	Conduits for electrical installations
g)	JIS C 3307	:	600V Grade Polyvinyl Chloride Insulated Wires
h)	JIS C 3605	:	600V Polyethylene Insulated Cables and 600V Cross Linked Polyethylene Insulated Cables
i)	JIS C 8305	:	Rigid Steel Conduits
j)	JIS C 8309	:	Flexible Metal Conduits
k)	JIS C 8330	:	Fittings for Rigid Metal Conduits
l)	JIS C 8336	:	Boxes for Rigid Metal Conduits
m)	JIS C 8359	:	General Rules for Fittings of Metal Conduits and Underfloor Ducts
n)	JIS H 8641	:	Zinc Hot Dip Galvanizing
o)	MS 17-1981	:	Polyvinyl chloride (PVC) insulated cable and flexible cords
p)	MS 18-1982	:	Hot-dip galvanised coatings on iron and steel articles-Guiding principles and requirements

40903 Materials

(1) Cable Wiring Works

a) 400V/230V Cables

All cable used for 400/230V power distribution circuits, three-phase motors and single phase motors shall be 600 V grade Polyvinyl Chloride insulated and sheathed power cable type NYY-600 Volt with four or three or two conductors. Conductors more than 4.0 square millimeters shall be used.

b) 230V Cables

Cable used for lighting, receptacles and other single phase loads shall be 500V grade Polyvinyl Chloride insulated and sheathed cable type NYM-500V Volt. Conductors more than 2.5 square millimeters shall be used.

c) Control Cables

All cables used for 230V AC and 24V DC control circuits shall be 600 V grade Polyvinyl Chloride insulated and sheathed cable type NYY-600 Volt. Conductors more than 1.5 square millimeters shall be used.

d) Instrument Signal Cables

All cables used for instrument signal circuits shall be 600 V grade Polyvinyl Chloride insulated and sheathed cable with copper-tape shielding type (CVV-S). Conductors more than 2.5 square millimeters shall be used.

e) 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 0.8 millimeters (diameter) shall be used.

f) Wires

Wire used for grounding and electrical construction shall be Polyvinyl Chloride insulated wire type MYA-1000 Volt or 600 volt IV. Conductor more than 2.5 square millimeters shall be used.

(2) Conduits, Boxes and Fittings

a) Rigid steel Conduit

Steel conduits shall be of hot-dipped galvanised steel, and equipped with couplings and thread protector caps. All surfaces and threads shall be coated with zinc bichromate. No conduit shall be smaller than 20 millimetres electrical trade size in diameter installed.

The sectional area of a steel conduit shall be at least 2.5 times of the total cross sectional area of cables to be put in.

Couplings and elbows shall be of the same type as the conduit to which they are to be connected.

b) Plastic Conduits

The plastic conduits and fittings shall be made of rigid PVC super high-impact heavy gauge approved. No conduit shall be smaller than 20 millimeters in diameter installed.

No conduit shall be smaller than 20 millimeters electrical trade size in diameter installed.

Couplings and elbows shall have heavy gauge, plain ends, tight press fits and form watertight joints.

c) Flexible Metal Conduits

Liquid tight flexible metal conduit shall have an interlocked flexible galvanised steel core with a permanently bonded exterior polyvinyl chloride jacket.

d) Boxes and Fittings

The pull boxes and fittings shall be fabricated from hot-dip galvanised steel of 2.0 mm or more thickness with hot-dip galvanised cover and stainless screws.

The pull boxes and fittings which will be installed outdoors and installed in basement floor of building shall be fabricated from stainless steel of 2.0 mm or more thickness with stainless steel cover and screws.

The pull boxes shall be of sufficient size to accommodate the connected conduits and enclosed conductors. Outlet boxes shall be of hot-dip galvanised steel square and octagonal, and of sufficient size to accommodate all the required conductors enclosed in the box.

All metal boxes shall be fitted with an earth terminal.

Deep boxes or extension rings or standard circular boxes shall be used where

necessary in order to bring the front of each box flush with the ceiling or wall.

All fixing on concrete or stone structures shall be made by means of pipe hangers or similar hangers of steel.

(3) Electrical flexible conduit

Electrical non-metallic flexible reinforced type conduit shall be of a wavelike super high-impact heavy Polyethylene type.

(4) Man-hole and Hand-hole

Man-holes or hand-holes shall be built of reinforced concrete and be watertight. At a corner of the bottom thereof, a sump shall be provided.

The inside measurement of the man-hole and hand-hole shall be the following:

a)	Man-hole	:	Minimum 1.2m x 1.2m x 1.6m depth.
b)	Hand-hole	:	Minimum 0.8m x 0.8m x 0.8m depth.

Covers of man-holes or hand-holes shall be made of cast iron with coating of anti-corrosive black colour paint. Covers shall be made to be watertight and have endurance for load of not less than 5 tones.

At the wall of man-holes or hand-holes, support fittings shall be fitted rigidly so as to support cables and joints securely. When manhole or hand holes depth exceeds 1.0 meters, a ladder shall be provided. Exposed surfaces of the walls of hand hole or manhole shall be finished with mortar. Covers shall be set firmly.

(5) Cable Racks

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 galvanised steel with 400g/m2 Zinc volume on one-side.

Concrete inserts for ceiling hangers and wall mountings shall be made of stainless steel. Beams of cable rack shall be spaced at intervals 0.3 meter or less.

(6) Cable Ducts

Cable duct material shall be hot-rolled mild steel sheets, not less than 2.0 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 galvanising.

(7) Cable Pits

This contract shall include all necessary steel products and installation for cable pits, checkered plates, angles, steel flats, separators, supports and others, all made of hot-dip galvanised steels and painting finish.

Such fittings shall be firmly fixed to the pit to hold securely the cables and other.

(8) Earthing

The wire and cable used for the wiring shall be 500 V Grade Polyvinyl Chloride Insulated Power Cable NYM-500 Volt or IV 600 volt.

Electrodes shall be copper clad steel rods, 14 millimeters or more in diameter, 3 meter long and with pointed and chamfered tops. Electrodes 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.

Earthing connectors 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 earth connections.

The marker for buried electrodes shall be installed to construction near each electrode. Each marker shall be made of concrete pole or others.

40904 Installation

(1) Cable Wiring Works

Cable dimensions shall comply with the rules and regulations and with the information given on the Drawings or mentioned herein.

Under all wire and cable installation work between terminals, any wire and cable connection work at any points except terminals will not be permitted. 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.

Finishing of terminals of all cables having a section over 10 square millimeters shall be made by using terminal finish materials and fittings.

Connections of each terminal of equipment shall be done with solder less terminals, and cables shall be marked by identification marks and colour index on bands or tags fitted every 20 meters to sheathes.

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.

Cable work to be undertaken in the pit shall include separators, supports and others, all made of hot-dip galvanised steel. Such fittings shall be firmly fixed to the pit to hold securely the cables and others.

(2) Steel Conduit Work

Rigid steel conduits shall be provided for all exposed and embedded installations.

Radius of curvature of conduits shall be over 6 times of inside diameter thereof and the bending angle shall not exceed 90 degrees. Bendings in one section shall not exceed 3 points, and the total of bending angle shall not exceed 270 degrees.

When one section of conduit exceeds 15 metres or when technically required, a pull/draw box shall be provided.

Conduit and boxes shall be fitted securely to structures. Fitting conduit to a place without access for inspection shall not be permitted.

For connection of conduit, couplings shall be used, and tightly screwed.

The sectional area of a steel conduit shall be at least 2.5 times of the total cross sectional area of cables to be put in.

All conduits and boxes shall be painted.

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.

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.

Conduits terminating in pressed steel boxes shall have double lock nuts and insulated bushings.

For a cable branching out from a cable duct, flexible conduit or rigid conduit shall be used for protection thereof.

Expansion and deflection fittings shall be used where conduits cross building expansion joints.

(3) *Plastic Conduit Work*

Plastic conduit shall be provided for installations in corrosive areas. Plastic conduit shall be installed as same the right conduit works.

Plastic conduit shall be fitted to the structures by using saddles or hangers, and their intervals shall be less than 1.5 metres for surface installation.

(4) Flexible Metal Conduit Work

The radius of curvature of conduit shall be over 6 times of inside diameter, and shall be laid in the manner it can be replaced easily. Flexible metal conduit shall be used for all motor terminations and other equipment with pull box.

For connecting a flexible metal conduit with another metal conduitor equipment, connectors shall be used to secure a tight mechanical and electrical connection. Provide earth continuity conductors in all flexible metal conduits.

Pressed steel boxes shall be used for concealed work. Exposed boxes and fittings shall be cast metal.

(5) Electrical Flexible Conduit Work

Electric flexible conduit shall be used, unless otherwise specified, for underground cable installation.

Proper location of underground cables and others shall be approved by the PMO/Engineer before execution of burying work.

Pilot wire shall be provided inside electrical flexible conduit in the course of its production and shall be connected with the cable pilot wire to pull the cable into the conduit.

Electrical flexible conduit shall be installed from ground level more than 0.75 m depth irrespective of the size of pipe. If conduit is under pressure, more than 1.2 m depth.

Electrical 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 less than 50 mm), 70 mm distance (diameter less than 150 mm). Filling shall be used with backfilled soil.

Joining conduit shall consist of straight joining, bell mouth, spare cap and waterproof wall sealing compound.

Cables shall be pulled into the conduit by utilizing the pilot wire previously accommodated in the conduit.

At the important locations of underground conduit, concrete sign poles shall be provided for indication of such locations.

The buried indication sheet for underground cable shall be continuously installed from 20 cm to 40 cm above the buried electrical flexible conduit.

(6) Man-holes and hand-holes

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. The Contractor shall use excavation machinery with caution in areas containings existing underground pipe systems and others.

(7) Cable Racks

Cable rack lengths shall be not less than 3 meters, and connections shall be with splice plates.

Cable rack and duct supports shall be spaced at intervals 1.5 meter or less, and against swing supports as required to obtain rigid construction.

Each cable racks and ducts end shall be connected by a grounding bond with the grounding terminals.

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.

(8) Earthing work

All electrical apparatus, panels, motors and conduits system, exposed structural steel, and similar items shall be earthed.

Earth electrodes shall be buried deeper than 3.0 meter in ground from the surface, and the soil of earthing shall have much as moisture as possible, and be free from corrosion due to gas or acid.

Provision shall also be made for connection with the neutral of the incoming supply.

Means shall be provided, e.g., a test clamp, to isolate the electrode from the system for periodic testing.

Internal earthing and bonding shall comply with the IEE Regulations except that insulated switches and lighting fittings need not be earthed from a safety aspect. Certain fittings, however, may require to be earthed to effect proper operation.

40905 Field Tests

After installation of all wiring works, the field tests shall be executed before energizing.

a) Insulation resistance of wires and cables
b) Power frequency withstand voltage tests
c) Earthing resistance tests

The bonding of other services or connections of neutral to earth shall be made after satisfactory completion of earth continuity and line earth loop impedance test.

The Contractor shall test the ground resistance of the system. All test equipment shall be provided by the Contractor and approved by the PMO/Engineer. Dry season resistance of the system shall not exceed 10–ohms.

If such resistance cannot be obtained with the system as shown, the Contractor shall provide additional grounding as instructed by the PMO/Engineer, without additional payment.

Tests shall also be carried out and the results recorded.

40906 Spare Materials

The following spare materials be furnished, which shall include but not be limited to the following.

(1) Cables

a) 200 m	Length of power cables NYY 4 mm2–3C.
b) Each type 100 m	Length of control cables NYM 1.5mm2–2C, 1.5 mm2–3C
c) 200 m	Length of signal cables CVVS2 mm2–2C.
d) 100 m	Length of communication cables CPEVS 0.8 mm (dia)–5P
e) Each type 100 m	Length of five kind of insulation wires with 2.5 mm2, 4 mm2
f) Each type 100	Pieces of solder less terminals 2.5 mm2, 4 mm2
g) Each type 4	Complete sets of terminal finish materials

h) Each type 20 — Pieces of color insulation tape Red, blue, black, yellow and white

i) Each type 200 — Pieces of identification tag plates with bands

(2) Conduits

a) Each size five(5) — Pieces of rigid steel and PVC conduits, size 22, 28, 36 and 42.
b) Each size five(5) — Pieces of rigid steel and PVC normal bends, size 36,42.
c) Each size ten(10) — Pieces of pipe support materials
d) Each size 5-m — Length of flexible conduits size 22, 28
e) Each size ten(10) — Pieces of connectors for flexible conduits, size 22, 28.
f) Each type five(5) — Pieces of outlet and outlet boxes
g) Three (3) — Pieces of pull boxes of stainless steel, size 300x300x200 mm

(3) Electrical flexible pipes

a) Each size 50 m — Length of electrical flexible conduits, size Ø50, Ø100 mm
b) Each five (5) — Pieces of connector, size Ø50,Ø100 mm
c) 100 m — Length of buried indicator sheet.

40907 Measurement and Payment

Measurement for payment for the supply and installation on the wiring works shall be made on the actual installed number or length as follows:

a) Installed cables : measured in meters
b) Right steel conduits : measured in meters
c) Electrical flexible pips : measured in meters
d) Cable racks : measured in meters
e) Man-holes and hand-holes : measured in pieces
f) Electrodes : measured in pieces

Payment shall be made of the numbers or length as provided above at the unit prices stated in the Bill of Quantities, in which unit prices shall constitute full compensation for the cost

of all labors, tools, apparatuses, equipment and materials including those for the test, excavation, backfill and other items necessary to complete the work.