

9.5.12 INSTRUMENTATION

9.5.12.1 GENERAL

(1) *General*

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

Equipment shall include at least the following:

- (a). Flow measuring devices
- (b). Level measuring devices
- (c). Pressure measuring devices
- (d). Temperature measuring devices
- (e). Water quality analyzer devices
- (f). Instrumentation panel
- (g). Panel mounted instrumentation equipment
- (h). Miscellaneous field instrumentation equipment.

Auxiliary and accessory devices necessary for system performance shall be included whether specified or not.

Related work specified elsewhere:

- (a). Electrical work shall be done under SUB-SECTION 9.5 and 9.6.
- (b). Piping work shall be supplied under SUB-SECTION 9.3 and 9.4
- (c). Valves with limit switches and position transmitters shall be furnished under SUB-SECTION 9.3 and 9.4.
- (d). Painting shall be in accordance with SUB-SECTION 9.1 and 9.2
- (e). Central monitoring system is specified in SUB-SECTION 9.5 and 9.6

(2) *References*

The following standards are referred to:

- JIS B 7546 Diaphragm Seal Pressure Gauges
- JIS B 7552 Proving Methods for Liquid Flow Meters
- JIS B 7554 Electro-magnetic Flow Meters.
- JIS C 0920 Test to prove protection against Ingress of Water for Electrical Equipment
- JIS C 1102 Electrical Indicating Instruments
- JIS C 1604 Resistance Bulbs
- JIS Z 8762 Measurement of Fluid by means of Orifice Plates and Nozzles
- IEC 439 Factory-built assemblies of low-voltage switchgear and control gear
- IEC 529 Classification of degrees of protection provided by enclosures
- IEC 144 Degrees of protection of enclosures for low-voltage switchgear and control gear.

(3) *Qualifications*

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

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

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

(4) *Shop Drawings*

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

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

(5) *General Requirements*

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

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

Standard output contact capacities shall be 0.5A one (1) normally open contact, one (1) normally close contact or more, for each voltages.

Electric equipment shall be designed for operation at 240V 50 Hz single phase and DC 110. Pneumatic equipment shall be designed for operation at 5-7 kg/cm² pressure.

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

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

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

All transmitters shall be provided with floor stand or wall mounted pipe as shown or as required.

All transmitters shall be provided with water proof type terminal boxes.

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

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

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

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

All instrument equipment design shall also consider corrosion proof against chlorine gas which will be vapourised from treated water.

Lighting protection shall be provided to protect the electronic instrumentation from induced surge propagating along the signal and power supply lines. Lightning protection shall be such that the protective level shall not interfere with normal operation, but shall be lower than the instrument surge withstand level, and be maintenance free and self-restoring. Solid state type with suitable lightning protection characteristics, such as ZNR (ZnO Non-linear Resister) shall be applied.

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

An Instrument List for each station giving tagging, application location and range information is in the particular SUB-SECTION 9.6 PARTICULAR SPECIFICATIONS-ELECTRICAL WORKS.

9.5.12.2 SCHEDULE

The instrumentation schedule will be specified in SCHEDULE OF SUB-SECTION 9.6 PARTICULAR SPECIFICATIONS-ELECTRICAL WORKS.

9.5.12.3 FLOW MEASURING DEVICES

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

- (a). Flow meter tubes (Fv)
- (b). Flow meter orifice (Fo)
- (c). Flow transmitter (Ft)
- (d). Manifold Assembly (Fm)
- (e). Electro-magnetic flowmeter (Fe)

(f). Ultrasonic flowmeter (Fu)

(1) *Flow Meter Tubes (Fv)*

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

The flow meter tubes shall be designed and manufactured in accordance with the following conditions.

- Type : Short venturi or Dall tube type
- Overall accuracy : $\pm 1.5\%$ of full scale (including flow transmitter accuracy)

There shall be no inwardly projecting parts nor shall piezometer vents be drilled on curved surfaces.

The flow metering tube shall be of the insert or insert flanged (fabricated) type. It shall be the responsibility of the supplier of this section to conform to the pipe being provided under another section.

Pressure loss shall be 0 – 20% of maximum differential pressure unless otherwise specified.

Body of flow meter tube shall be made of high tensile cast iron. Throat liner and inlet taps shall be of low zinc brass or bronze bushed. Taps shall be a minimum of 19 mm to reduce the time lag to flow transmitters.

Inner tube shall be painted with tar epoxy paint, Amercoat 79 of DIMET or approved equal conforming to the Paint System E1 as specified in the SUB-SECTION 9.1.6 PAINTING AND PROTECTIVE COATING, GENERAL SPECIFICATIONS – CIVIL WORKS.

Exterior tube shall be painted with the Paint System D2 as specified in the SUB-SECTION 9.1.6 PAINTING AND PROTECTIVE COATINGS GENERAL SPECIFICATIONS – CIVIL WORKS unless otherwise specified.

A certified head versus flow curve shall be provided for each flow meter tube.

(2) *Flow Meter orifice (Fo)*

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

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

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

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

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

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

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

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

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

(3) *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.

- Type : Diaphragm sensing type
- Accuracy : $\pm 0.5\%$ of full scale
- Working pressure : 100 kg/cm²

Range springs shall be utilized with integral square root extraction to provide an output signal linear to flow. Additional range shall be furnished for both lower and higher differentials.

The transmitter shall have an immersion proof type housing.

The material of the diaphragm shall be type 316L stainless steel, and other wetted parts and housing shall be type 316 stainless steel. The transmitter shall be mounted with manifold assembly on 50 mm standing pipe, stainless steel, Schedule 40.

(4) *Manifold Assembly (Fm)*

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 mounted with a transmitter on 50 mm standing pipe, stainless steel, Schedule 40.

(5) *Electromagnetic Flowmeter (Fe)*

The electromagnetic flowmeter applying "Faraday's Principle" shall be designed and manufactured in accordance with the following conditions:

- Accuracy (For < DN400) : less than $\pm 0.5\%$ at maximum design flow
- Accuracy (For > DN400) : less than $\pm 1.0\%$ at maximum design flow
- Installation : Flange joint
- Lining : Polyurethane rubber or chloroplane rubber
- Electrode : Stainless Steel (SUS 316L)
- Body : Carbon steel
- Terminal box : Aluminium alloy
- Nominal diameter : As shown on the drawing
- Power source : AC 240V + 10% 50Hz
- 15%
- Output signal : 4 \geq 20 m A DC (For actual flow rate)
pulse output (For accumulative flow)
status output (For alarm, high and high high)

- Protective degree : IP 66 or IP 67. 2 contacts)

The electromagnetic flowmeter shall be of integrated type which detector and converter/transmitter are combined.

A converter / transmitter shall be mounted on the detector terminal box.

The converter / transmitter including built-in microprocessor shall have the following functions:

- (a). Instantaneous flow rate digital display (LED 6 digits)
 - (b). Totalization digital display (Accumulative flow, LED)
 - (c). Self-diagnostics
 - (d). Converter failure, flow tube failure, setting error shall be diagnosed and displayed.
 - (e). Automatic zero adjustment
 - (f). Zero point shall be able to be adjusted automatically with front panel key when the flow velocity is zero.
 - (g). Totalization presetting
 - (h). Totalized value shall be able to be preset with a front panel key.
 - (i). Flow noise cut-off
 - (j). Flow noise (spike noise) shall be able to cut off by setting a rate limit
 - (k). Arrester
 - (l). Built-in for power source and output signal terminals.
- (6) *Ultrasonic Flowmeter (Fu)*

The ultrasonic flowmeter shall be designed and manufactured in accordance with the following conditions:

(i) Detector

- Accuracy : less than $\pm 1.5\%$ at maximum design flow
- Installation of the detector : Mounted on outer wall of pipe
- Measuring method : One (1) measuring line system (Z method) by using of two (2) detectors
- Materials of the detector : Stainless steel (SUS 304)
- Waterproof of the detector : Immersion proof (JIS C0920) or submerged type.

(ii) Transmitter

The transmitter shall be installed in the room.

- Measuring method : Time difference digital processing
- Basic measuring cycle : 0.2 sec
- Analogue signal output timing : 10 sec
- Low flow rate cut off point : 3% FS
- Self-diagnosis circuit : Display via self-diagnosis program
- Power supply source : AC 240 V + 10%, 50 Hz
- 15%
- Housing structure : Indoor dust proof

- Analogue output signal : 4 to 20 mA DC
- Display : LED display
- Arrester : Built-in for power source and output signal terminals

9.5.12.4 LEVEL MEASURING DEVICES

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

- (i) Float type level transmitter (LTft)
- (ii) Flange type level transmitter (LTfg)
- (iii) Displacement type level transmitter (LTd)
- (iv) Capacitance type level transmitter (LTc)
- (v) Immersion type level transmitter (LTi)
- (vi) Ultrasonic type level transmitter (Ltu)
- (vii) Air bubbler purge transmitter (Lap)
- (viii) Prove type level switch (Lsw)

(1) *Float Type Level Transmitter (LTft)*

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

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

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

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

The transmitter shall have a waterproof type housing.

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

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

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

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

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

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

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

(2) *Flange Type Level Transmitter (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:

- Type : Diaphragm sensing type
- Accuracy : $\pm 0.5\%$ of full scale.

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

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

(3) *Displacement Type Level Transmitter (LTd)*

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

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

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

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

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

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

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

(4) *Capacitance Type Level Transmitter (LTc)*

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

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

- Type : Capacitance sensing type
- Accuracy : $\pm 2.0\%$ of full scale.

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

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

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

(5) *Immersion Type Level Transmitter (LTi)*

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

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

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

- Output signal : DC 4 to 20mA
- Power supply : DC 24V
- Type : Diaphragm sensing type
- Accuracy : $\pm 0.5\%$ of full scale
- Allowable over pressure ; 150% of measuring range

The submerged detector and stand shall be Type 316L and 304 stainless steel respectively.

The detector shall be designed to be placed on the bottom of the structure and shall be of lifting type.

Special cable shall be hollow cable and be composing of electric wire and atmosphere pressure introduction pipe.

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

The transmitter shall have a water proof type housing, and a field indicator (class 1.5 and 0 to 100% linear scale).

The transmitter shall also include built-in arrester.

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

- One (1) set of diaphragm detector
- One (1) set of special cable

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

(6) *Ultrasonic Type Level Transmitter (LTu)*

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

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

- Type : Ultrasonic reflection sensing type
- Overall Accuracy : plus or minus 1.0% of full scale.(include converter accuracy)

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

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

The detector and converter shall have a waterproof type housing. The detector shall be stainless-plate locally mounted and converter shall be for remote panel mounting.

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

(7) *Air Bubbler Purge Assembly (Lap)*

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

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

Air supply for purge assembly shall be at least 0.35 kg/cm^2 greater than the maximum depth of immersion of the bubble pipe tip, expressed in kg/cm^2 . Components shall be arranged in a compact assembly suitable for subpanel or bracket mounting.

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

An air supply in excess of $40 \text{ cm}^3/\text{sec}$ free air shall be furnished for each bubbler system.

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

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

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

(8) *Probe Type Level Switch (Lsw)*

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

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

9.5.12.5 PRESSURE MEASURING DEVICES

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

- (i) Pressure transmitter (PT)
- (ii) Pressure switch (PS)

(1) *Pressure Transmitter (PT)*

The pressure transmitter shall be pressure actuated through a diaphragm element.

The accuracy shall be ± 0.5% of full scale.

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

The motion of the sensing element shall actuate the input linkage to the transmitter and have a locking type range adjustment. The drive linkage shall include a zero adjustment. The input shall be as stated on the Instrument List.

The transmitter shall have an immersion proof type.

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

(2) *Pressure Switch (PS)*

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

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

The pressure switch shall have a waterproof type.

9.5.12.6 TEMPERATURE MEASURING DEVICES

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

- (i) Resistance type temperature sensor (Tr)
- (ii) Temperature converter (Tc)

(1) *Resistance Type Temperature Sensor (Tr)*

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

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

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

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

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

(2) *Temperature Converter (Tc)*

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

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

9.5.12.7 WATER QUALITY ANALYZER DEVICES

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

- (a). Turbidity analyzer (Tubt)
- (b). PH analyzer (pHT)
- (c). Residual chlorine analyzer (RC1T)
- (d). Chlorine gas detection system (CGD)
- (e). Analyzer mounting racks (ANAL-R)

(1) *Turbidity Analyzer (TubT)*

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

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

- Type : Surface-scattered light type
- Range of measuring : Three (3)
- Representability : $\pm 2.0\%$ of full scale
- Response time : Approximately three (3) minutes
- Output signal : Proportional and isolated 4-20 mA DC

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

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

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

The turbidity analyzer shall be Type WLS 301 as manufactured by YOKOGAWA ELECTRIC CORPORATION, TOKYO, JAPAN or Type 141E1 as manufactured by TOSHIBA CO. LTD., TOKYO, JAPAN or an approved equal.

(2) *PH Analyzer (pHT)*

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

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

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

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

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

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

The pH analyzer shall be Type ZWA,T as manufactured by FUJI DENKI CO. LTD., or Type 111E, 101 E as manufactured by TOSHIBA CO. LTD., or an approved equal.

(3) *Residual Chlorine Analyzer (RCIT)*

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

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

- Type : Rotating platinum pole and platinum comparative pole with automatic temperature compensating resistance type.
- Range of measuring : 0 – 3 ppm (total and free residual chlorine)
- Representability : \pm 2.1% of full scale
- Response time : Approximately four (4) minutes
- Output signal : Proportional and isolated 4 – 20 mA DC.

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

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

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

The residual chlorine analyzer shall be Type ZWM as manufactured by FUJI DENKI CO. LTD., TOKYO, JAPAN or Type 151 as manufactured by TOSHIBA CO. LTD., TOKYO, JAPAN or an approved equal.

(4) *Chlorine Gas Detection System (CGD)*

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

- Type : Non-reagent, semiconductor sensing type.
- Rate of measuring : 0 – 3 ppm
- Accuracy : Within ! 30% indicated value
- Response time : Approximately 30 seconds.

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

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

Power supply of leakage system shall be AC 220V.

It shall be Type SHIN-CHLOMEGAR, CA-22 as made by Suido Kiko Kaisha Ltd., Tokyo, Japan or an approved equal.

(5) *Analyzer Mounting Racks (ANAL-R)*

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

The mounting racks shall be designed to mount suitable water quality analyzers which will be specified elsewhere in the PARTICULAR SPECIFICATIONS- ELECTRICAL WORKS.

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

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

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

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

Type and quantity of analyzers will be specified in the PARTICULAR SPECIFICATIONS-ELECTRICAL WORKS.

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

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

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

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

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

9.5.12.8 INSTRUMENTATION PANEL

- (1) *Type: Indoor, Metal enclosed, Self-supported, Dust and vermin proof.*
- (2) *Protection Degree: IP 40*
- (3) *Construction*

“SUB-SECTION 9.5.1 GENERAL shall be complied, where applicable, except the followings:

It shall be considered for the panel design that the instrumentation panel mount the equipment or the instruments having small voltage signal circuit such as DC4 to 20 mA or DC 0 to 5V.

Especially, counter-measure against items below shall be made:

- High ambient temperature affecting their life
- High humidity affecting their life
- Noise causing their maloperation or missoperation.

As a countermeasure for the noise, application of photo coupler, twist pair panel wiring and separate wiring ducts (one duct for dirty wiring such as for power circuits, another duct for clean wiring such as for signal circuits) is considerable.

9.5.12.9 PANEL MOUNTED INSTRUMENTATION EQUIPMENT

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

(i) Process indicators	(I)
(ii) Recorder	(R)
(iii) Totalizer	(Q)
(iv) Controller	(C)
(v) Alarm unit	(A)
(vi) Summator	(Y)
(vii) Signal converter	(SC)
(viii) Square root extractor	(SQ)
(ix) E/E Positioner	(EE)
(x) Arrester	(Ar)
(xi) Power supply unit	(PWS)
(xii) Distributor	(DBT)
(xiii) Signal limiter	(SL)
(xiv) Signal isolator	(SI)
(xv) Data collection equipment	(DCE)
(xvi) AC circuit transducer	(TD)

(1) *Process Indicators (I)*

Process variable indicators shall be of two (2) types: (1) Automatic balance type electronic meter (2) Wide angle type or pointer vertical/horizontal sliding type moving coil meter. Automatic balance type shall have the accuracy of $\pm 0.5\%$ of full scale and scale shall be at least 100 mm vertical length. Moving coil type shall have the accuracy of $\pm 1.5\%$ of full scale and scale shall be at least 100 mm vertical/horizontal length or 240 degrees from zero having 110 mm square. Each indicator shall be panel mounted. Zero and span adjustment shall be provided.

Automatic balance type indicator shall have the following functions:

- (i) Two (2) points indicator
 - Vertical bar graph indication
 - LED indication method
 - Indicates two (2) different values at the same time.
- (ii) Five (5) digital output signals
 - Fault output
 - High alarm output
 - Low alarm output
 - High High alarm output
 - Low Low alarm output
- (iii) Power failure detection
- (iv) Setting made by pressing of relevant keys mounted on front side.
- (v) Self diagnosis function
- (vi) Power supply
 - DC 24V supplied by DC distribution panel, or AC 240V 50Hz.

For the indicator of electrical system, such as Ammeter, Voltmeter, Wattmeter, Frequency meter, Watthourmeter and Varhommeter, etc., Clause 8.1.19 shall be applied.

(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 on the drawing. Charts shall be 100 mm or 180 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 125 mm/hour minimum to 50 mm/hour speed by manually changing. The accuracy shall be $\pm 0.5\%$ of full scale. Recorder shall be panel mounted. Charts shall record 31 days at 12.5 mm/hour. Applicable number of pen is two (2) or three (3).

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

Power source for the recorder shall be of AC 240V.

The following spare parts shall be furnished for each recorder:

Fifty (50) Rolls of recording papers
Each colour fifty (50) pieces of ink cartridges
Each colour three (3) pieces of recording pen
500% pieces of fuses
Five (5) pieces of index cards
Ten (10) pieces of blotting papers
One (1) set of string
One(1) piece of syringe
One (1) set of check pins.

(3) *Totalizer (Q)*

Totalizer shall be provided panel mounted. Totalizer shall consist of integrator and counter. The integrator shall accept a 4 to 20 mA DC signal or pulse signal input. Counter shall be of 6 digits LED display. The accuracy shall be less than $\pm 0.5\%$ of input signal.

The following function shall be specified:

- (i) Reset method
Zero resetting possible with reset pushbutton switch
- (ii) Power supply
DC 240V or AC 240V 50 Hz.

(4) *Controller (C)*

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

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

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

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

(5) *Alarm Unit (A)*

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

The dial set point accuracy shall be $\pm 3.0\%$ of full scale and repeatability shall be $\pm 0.5\%$ of full scale.

(6) *Summator (Y)*

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

(7) *Signal Converter (SC)*

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

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

(8) *Square Root Extractor (SQ)*

The square root extractor shall be provided where indicated, mounted back-of-panel and shall accept 4 to 20 mA inputs and output a 4 to 20 mA signal which is proportional to the square root of the input. Zero and span adjustment shall be provided. The accuracy shall be $\pm 0.5\%$ of full scale.

(9) *E/E Positioner (EE)*

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

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

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

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

(10) *Arrester (Ar)*

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

	<u>Two line system V</u> <u>24 V</u>	<u>Power Supply</u> <u>220V AC</u>
Line-to-line voltage pulse height	: Within 60V	Within 1000V
Line-to-earth voltage pulse height	: Within 200V	Within 1000V
Surge discharge capacity	: 2 kA or more	2 kA or more
The arrester shall be the plug-in type.		

(11) *Power Supply Unit (PWS)*

The power supply unit shall be designed to stabilize DC power for instruments and to be installed in the auxiliary relay panels or monitor and control panels. The output voltage setting accuracy shall be $\pm 1.0\%$.

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

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

(12) *Distributor (DBT)*

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

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

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

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

(13) *Signal Limiter (SL)*

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

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

(14) *Signal Isolator (SI)*

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

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

(15) *Data Collection Equipment (DCE)*

Data collection equipment by using of the floppy disk drive unit shall be provided for collection for data such as water level, flow rate and pressure, etc.

The followings shall be suitably considered to the data collection system:

- (1) Data collected in floppy disk can be analyzed by the popular personal computer without protocol problem.
- (2) To avoid failure of collection due to overflow against floppy disk capacity, suitable hard disk having big memory capacity shall be installed independently.
By this means, missing of the data before replacement of new floppy disk is to be avoided.
- (3) Interval of data collection: maximum 10 minutes.
- (4) Without replacement to new floppy disk, data during one (1) month shall be stored in a floppy disk.

(16) *AC Circuit Transducer (Td)*

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

a. Type	Voltage	Ampere	Active and reactive power	Power factor	Frequency
	VTd	ATd	kWTd	PFTd	HTd
b. Mounting method	Back-of-panel center mount				
c. Input	0-150V or 0.220V	0-5A or 0.1A	3 Ø 3W or 3 Ø 4W	Lead or Lag	0.5 or 0.5 45-55 Hz
d. Output	4 – 20 mA	DC	or 1 – 5V	DC	
e. Accuracy of full scale	± 0.5%	± 0.5%	± 0.5%	± 3.0%	± 0.5% Hz
f. Resistance to over input	:				
- Voltage circuit	continuous	120% 2 hour, momentarily	200%	1 minute	
- Current circuit	continuous	200% 2 hour, momentarily	400%	1 second	

9.5.12.10 MISCELLANEOUS FIELD INSTRUMENTATION EQUIPMENT

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

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

(1) *Position Transmitter (ZT)*

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

The transmitter shall have a waterproof type housing.

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

(2) *Direct Flow Indicator (Id)*

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

(3) *Pressure Gauges (PG)*

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

9.5.12.11 TESTS

Following installation and final adjustment of all instruments, meters, and flow control devices, a performance check shall be made on each metering and flow control system. Meters shall be tested at 10% or 12-1/2%, 20%, 50%, and 100% of scale, as required.

The total error based on the manufacturer's certification for differential producer, when added to the field determined instrument errors, shall not exceed $\pm 2\%$ of the actual flow within the specified range as computed from the differential manometer readings taken during tests.

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

(1) *Factory Tests*

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

- (i) Verification of construction
- (ii) Mechanical operation tests
- (iii) Characteristics tests
- (iv) Accuracy tests
- (v) Insulation resistance tests
- (vi) Withstand voltage tests
- (vii) Strength test
- (viii) Accessories and spare parts tests.

(2) *Field Tests*

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

- (i) Verification of construction

- (ii) Mechanical operation tests
- (iii) Electrical operation tests
- (iv) Insulation resistance tests
- (v) Withstand voltage tests
- (vi) Accuracy tests
- (vii) Accessories and spare parts tests.

9.5.12.12 INSTALLATION

The instrumentation and accessory equipment shall be installed in accordance with the manufacturer's instructions and located as shown on the drawings or as approved by the Engineer. Local electrical 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 disconnects unions as shown. Electrical work shall be in accordance with SUB-SECTION 9.5.

It shall be the responsibility of the Contractor to check SUB-SECTION 9.5 GENERAL SPECIFICATIONS-ELECTRICAL WORKS and the Electrical Drawings to ensure that the wiring and power availability, is sufficient, and if not, to provide all additional facilities necessary at the Contractors expense.

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

9.5.13 LOW VOLTAGE PANEL

9.5.13.1 GENERAL

(1) *General*

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

(2) *References*

The following standards are referred to:

IEC 144	Degrees of protection of enclosures for low-voltage switchgear and control gear.
IEC 439	Factory-built assemblies of low-voltage switchgear and control gear
IEC 529	Classification of degree of protection provided by enclosures

9.5.13.2 SCHEDULE

The panel boards schedule will be specified in SCHEDULE of the SUB-SECTION 9.6 PARTICULAR SPECIFICATIONS-ELECTRICAL WORKS.

9.5.13.3 TYPE, RATING AND CHARACTERISTICS

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

(ii) Type	: Indoor, metal-enclosed dead-front, self-supported or wall mounted type
(iii) Number of phases	: Three (3) Phase, four (4) wire and DC circuit
(iv) Rated Frequency	: 50Hz
(v) Rated insulation voltage	
- Main circuit	: 600V AC r.m.s.
- Control circuit	: 250V AC r.m.s.
(v) Rated operation voltage	
- Main circuit	: 415/240V AC
- Control circuit	: 240V AC and 110V DC
(vi) Power frequency withstand voltage	:
- Main circuit	: 2000V AC r.m.s.
- Control circuit	: 1500V AC r.m.s.
(vii) Rated operating and control voltage	
- DC	: 110V + 10% (IEC 255) - 20%
- AC (r.m.s)	: 240V + 10% (IEC 694 Clause 4.8) - 15%

9.5.13.4 CONSTRUCTION

All interiors shall be completely factory assembled with circuit breakers, busbars and wire connectors. All wire connectors, except screw terminals, shall be of the anti-turn solderless type and shall be suitable for copper wire of the sizes indicated.

Interiors shall be so designed that circuit breakers can be replaced without disturbing adjacent units and without removing the main bus connectors and shall be so designed that circuits may be changed without machining, drilling, or tapping.

Branch circuits shall be arranged using double row construction except when narrow column panels are indicated. Branch circuits shall be numbered by the manufacturer.

The trim shall be fabricated from steel. All exterior and interior steel surfaces of the panel boards shall be properly cleaned and finished with Muncell paint over a rust inhibiting phosphatized coating.

Trim for flush panels shall overlap the box by at least 20 mm all around. Surface trim shall have the same width and height as the box. Trim shall be fastened with quarter turn clamps.

9.5.13.5 BUSBARS

Busbars for the mains shall be copper. Full size neutral bars shall be included. Busbar taps for panels with single pole branches shall be arranged for sequence phasing of the branch circuit devices.

Busing shall be braced throughout to conform to industrial standard practice governing short circuit stresses in panel boards.

Phase busing shall be full height without reduction. Cross connectors shall be copper.

Neutral busing shall have a suitable lug for each outgoing feeder requiring a neutral connection.

Spaces for future circuit breakers shall be bussed for the maximum device that can be fitted into them.

9.5.13.6 TESTS

(1) *Factory Tests*

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

- (a). Verification of construction
- (b). Mechanical operation tests
- (c). Electrical operation tests
- (d). Withstanding voltage tests
- (e). Measurement of insulation resistance.

(2) *Field Tests*

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

- (a). Verification of construction
- (b). Electrical operation tests
- (c). Withstanding voltage tests
- (d). Measurement of insulation resistance.

9.5.13.7 EQUIPMENT INCLUDED

The panel boards shall include the following equipment:

(1) *Circuit Breakers*

Circuit breakers shall be the molded case type with auxiliary switch built in. Circuit breakers shall have suitable interrupting current value.

(2) *Electro-magnetic Switches*

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

Each motor starter shall have 240V AC or 110V DC operating coil and three (3) or one (1) element overload relays. Auxiliary contacts shall be provided as shown on the drawings or as required.

In case of star-delta motor starting, contacts having high reliable and ample current capacity which will be especially required in change-over to delta from star connection shall be provided.

Overload relays shall be adjustable and manually reset.

(3) *Auto Transformer*

If Condorfer motor starting will be applied for low voltage motor, an auto transformer shall be provided.

Its details are specified below.

- Type : Dry molded type, indoor use, built-in type
- Rated primary voltage : 415V AC, 3 Phase
- Tap : 50% - 65% - 80%
- Capacity : Ample short time duration capacity to be able to start the relevant motor sufficiently.

(4) *Reactor*

If reactor motor starting will be applied for low voltage motor, a reactor shall be provided.

Its details are specified below.

- Type : Dry type, indoor use, built-in
- Rated voltage : 415V AC, 3 Phase
- Tap : 50% - 65% - 80%
- Capacity : Ample short time duration capacity to be able to start the relevant motor sufficiently.

- Insulation class : Class B

(5) *Instrument and Relays*

Section 9.5.2.8 (1) shall be complied, where applicable.

(i) 2E Relay

Motor protective relay, 2E, having two (2) elements (overload protection and out of phase protection), three (3) phase, plug-in insert, solid state type.

(6) *Phase and Sequence Selector Switches*

Section 9.5.2.8 (2) shall be complied, where applicable.

(7) *Control Switches*

Section 9.5.2.8 (3) shall be complied, where applicable.

(8) *Signal Lights*

Section 9.5.2.8 (4) shall be complied, where applicable.

9.5.14 MOTORS

9.5.14.1 GENERAL

(1) *Scope of Work*

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

(2) *References*

The following standards are referred to:

IEC 34	Rotating electrical machines
IEC 72	Dimension and output rating for rotating electrical machines
IEC 136	Dimension of brushes and brush-holder for electrical machinery
IEC 276	Definition and nomenclature for carbon brushes, brush-holders, commutators and sliprings
IEC 467	Test procedure for determining physical properties of carbon brushes for electrical machines
IEC 560	Definition and terminology of brush-holder for electrical machines.

9.5.14.2 SQUIRREL CAGE INDUCTION MOTORS

(1) *Type and Rating*

(i) Type	:	Horizontal or vertical, drip-proof or totally enclosed type
(ii) Cooling method	:	Self-ventilation
(iii) Number of phases	:	Three (3) phase,
(iv) Rated frequency	:	50 Hz
(e). Rated voltage	:	
- High voltage	:	6,600V AC or 3,300V AC.
- Low voltage	:	415V AC
(vi) Class of rating	:	Continuous
(vii) Class of insulation	:	
- High voltage	:	B Class or F Class.
- Low voltage	:	E Class
(viii) Limited temperature rise	:	
- E Class	:	75 deg. C (resistance method).
- B Class	:	80 deg. C (resistance method)
- F Class	:	100 deg. C (resistance method).
(ix) Ambient temperature	:	45 deg. C
(x) Standard direction of rotation	:	Clockwise when viewed from the opposite side to the coupling
(xi) Voltage variation	:	10% over and under the rated value, at the rated frequency
(xii) Frequency variation	:	5% over and under the rated value, at the rated voltage.
(xiii) Momentary excess current	:	150% of rated current for not less than 15 seconds.
(xiv) Momentary excess torque	:	160% of rated torque
(xv) Overspeed	:	120% of the maximum rated speed

- (xvi) Power frequency
withstand voltage (r.m.s)
- less than 1 KW : 500V + 2E (1,000V min.)
- less than 10,000 kW : 1000V + 2E (1,500V min.)

(2) *Construction*

Squirrel cage induction motors for exterior service shall be of weather proof design suitable for continuous service in a tropical environment.

Minimum output shall be as shown on the mechanical specification schedule and the mechanical drawings.

The motors for the driven equipment except pumps shall be capable of developing the motor power required by the units under all specified operating conditions without overload, and shall develop adequate starting torque for the driven equipment.

The motors for the driven pump shall have a rating that will not be exceeded with the pump operating at any point on its characteristic curve and in addition shall have a service factor of at least 1.15.

The motors shall be designed for full voltage starting. Locked-rotor current shall not exceed 600%.

All motors shall be run without injury in normal service, when under a load equal to the rated output, irrespective of a terminal voltage variation of 10% over and under the rated voltage, at the rated frequency.

Motor torque characteristics shall be equal to the requirements of the pumps being furnished. The motor shall have sufficient torque to start and synchronize with the discharge valve closed. Motor thermal capacity shall be sufficient to allow time for the discharge valve to open.

Stator and rotor cores shall be made of low loss, non-aging, electrical sheet steel with insulated laminations.

Stator coils shall be form wound, pre-insulated and fitted into open slots and adequately secured and braced to prevent movement during full voltage starting. Stator coils shall be form wound, of identical size, shape, insulation and number of turns.

In case motor output exceeds 100 kW, six resistance, Pt. 100 ohm, 0 deg. C type temperature detectors shall be furnished in the stator winding between coil sides of different phases. The detectors shall be wired to an enclosed terminal block. The detector coil indicating the highest temperature at test shall be marked at the factory for connection to a stator temperature relay.

Bearings shall be sleeve type. Each bearing shall be furnished with bearing temperature relays, in case of motor output of 150 kW..

Stator terminal boxes of motor output exceeding 100 kW shall be oversized for stress cone connections and differential protection transformers. A ground lug attached to the motor frame shall be mounted in the stator terminal box. The ground lug shall be suitable for the size wire shown on the drawings.

The motor having a rated output of not less than 5.5 kW shall be of such construction that the star-delta starter can be used, as required.

If required, space heaters shall be installed and arranged to be automatically energizing when the motor is at rest and to automatically maintain a pre-determined motor temperature.

Motors shall be free of objectional noise and vibration. Maximum vibration at any speed or load shall not exceed two mils peak-to-peak.

(3) *Tests*

(i) Factory Tests

The squirrel cage induction motors shall be completely assembled at the factory. The squirrel induction motors shall be subject, unless otherwise noted, to the following tests by the Contractor:

- (i) Construction check
- (ii) Measurement of stator winding resistance
- (iii) No-load tests
- (iv) Calculation of full load characteristics and breakway torque
- (v) Calculation of minimum starting torque
- (vi) Tests for starting input characteristic
- (vii) Temperature tests (Certificate of type test with test report may be acceptable)
- (viii) Withstand voltage tests
- (ix) Noise tests
- (x) Vibration tests
- (xi) Measurement of insulation resistance
- (xii) Lock test (Certificate of type test with test report may be acceptable)

(ii) Field Tests

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

- (i) Construction check
- (ii) Measurement of insulation resistance
- (iii) High voltage test
- (iv) Rotating check

9.5.14.3 SYNCHRONOUS MOTORS

(1) *Type and rating*

- | | | |
|------------------------|---|---|
| a. Type | : | Horizontal, drip-proof, bracket, or pedestal mounted on a common steel base type. |
| b. Cooling method | : | Self-ventilation |
| c. Number of phases | : | Three (3) phase |
| d. Rated frequency | : | 50 Hz |
| e. Rated voltage | : | 6,600V AC or 3,300V AC |
| f. Class of rating | : | Continuous |
| g. Class of insulation | : | B Class or F Class |

h. Limits of temperature rise		
B Class	:	80 deg. C (resistance method)
F Class	:	100 deg. C (resistance method)
i. Ambient temperature	:	45 deg. C
j. Standard direction of rotation	:	Clockwise when viewed from the opposite side to the coupling.
k. Voltage variation	:	10% over and under the rated value, at the rated frequency
l. Frequency variation	:	5% over and under the rated value, at the rated voltage.
m. Momentary pull-out torque	:	150% of rated torque for not less than 15 seconds.
n. Overspeed	:	120% of the maximum rated speed
o. Power frequency withstand voltage (r.m.s)		
- less than 1 kW	:	500V + 2E (1,000V min.)
- less than 10,000 kW	:	1,000V + 2E (1,500V min.)

(2) *Construction*

Synchronous motors for exterior service shall be of weatherproof design suitable for continuous service in a tropical environment.

Synchronous motors shall be construction with unity power factor, with speed to match the pump to be driven. Motor frame structure of synchronous motor shall be either bracket type or pedestal type mounted on a common steel base.

Minimum output shall be as shown on the mechanical specification pump schedule.

The motors shall have a rating that will not be exceeded with the pump operating at any point on its characteristic curve and in addition shall have a service factor of at least 1.15.

Locked-rotor current shall not exceed 600%.

Optimum synchronizing speed is to be selectable over a limited range in the vicinity of 95% synchronous speed.

A system using timed random application of motor field excitation is not acceptable.

Motor torque characteristics shall be equal to the requirements of the pumps being furnished. The motor shall have sufficient torque to start and synchronize with the discharge valve closed. Motor thermal capacity shall be sufficient to allow time for the discharge valve to open.

All motors shall be run without injury in normal service, when under a load equal to the rated output, irrespective of a terminal voltage variation of 10% over and under the rated voltage, at the rated frequency.

Stator and rotor cores shall be made of low loss, non-aging, electrical sheet steel with insulated laminations. Stator coils shall be form wound, of identical size, shape, insulation and number of turns.

Stator coils shall be form wound, pre-insulated and fitted into open slots and adequately secured and braced to prevent movement during full voltage starting.

Six resistance, Pt. 100 ohm, 0 deg.C type temperature detectors shall be furnished in the stator winding between coil sides of different phases. The detectors coil indicating the highest temperature at test shall be marked at the factory for connection to a stator temperature relay.

Field pole windings shall be either of wire or strip copper, depending on electrical requirements. Pole bodies shall be well insulated with care taken to seal corners between pole-body insulation and flange.

Field windings shall be cemented with insulating compound to hold wires firmly against distortion from centrifugal force and to seal against the entrance of moisture.

Starting cage winding joints shall be phos-copper brazed-welded to maintain starting torques throughout the life of the motors.

The rotating brushless excitation system shall include a direct connected three phase, AC generator feeding a full wave three phase diode bridge rectifier with the output applied to the field of the synchronous motor through a silicon controlled rectifier which is gated at the proper motor speed and phase angle by semi-conductor operated logic circuitry to achieve maximum positive pull-in torque.

The rotating logic circuitry must further provide a means for energizing the motor field in the event the motor pulls into step under lightly loaded conditions through its reluctance torque (zero slip feature). It also must be capable of removing motor field at pull-out.

Bearings shall be sleeve and ring oiling type. Each bearing shall be furnished with bearing temperature relays.

Stator terminal boxes shall be oversized for stress cone connections and differential protection transformers. A ground lug attached to the motor frame shall be mounted in the stator terminal box. The ground lug shall be suitable for the size wire shown on the drawings.

Space heaters shall be installed and arranged to be automatically energized when the motor is at rest and to automatically maintain predetermined motor temperature.

Motors shall be free of objectional noise and vibration. Noise level shall be equal to or less than 85 decibels. Maximum vibration at any speed or load shall not exceed two mils peak-to-peak.

(3) *Tests*

(i) Factory Tests

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

- (i) Construction check
- (ii) Measurement of stator winding resistance
- (iii) No-load saturation characteristic tests
- (iv) Short-circuit characteristic tests
- (v) Field current tests
- (vi) Starting characteristic tests
- (vii) Temperature tests (Certificate of type test with test report may be acceptable)
- (viii) Excitation equipment tests

- (ix) Withstand voltage tests
- (x) Noise tests
- (xi) Vibration tests
- (xii) Measurement of insulation resistance
- (xiii) Lock test (Certificate of type test with test report may be acceptable)

(ii) Field Test

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

- (i) Construction check
- (ii) Measurement of insulation resistance
- (iii) High voltage test
- (iv) Rotating check

9.5.15 WIRES AND CABLES

9.5.15.1 GENERAL

(1) *General*

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

(2) *References*

The following standards are referred to:

IEC	228	600V PVC	Insulated Wire (IV)
JIS C	3307	600V PVC	Insulated Wire (IV)
JIS C	3342	600V Vinyl	Insulated Vinyl Sheath Cable (VV, CVV)
JIS C	3605	600V Polyethylene	Insulated Cables and 600V Cross Linked Polyethylene Insulated Cables
JIS C	3401	Control Cables	
JIS C	2811	Terminal Blocks for Industrial and Similar Use	
IEC	60947	Terminal Blocks for Industrial and Similar Use	
JIS C	2804	Compression Terminals	
JIS C	2805	Crimp-type Terminal Lugs for Copper Conductors	

9.5.15.2 WIRES AND CABLES

The wires and cables used shall be as hereinafter specified.

- (i) 600V PVC insulated wire (IV)
- (ii) 600V heat resistance PVC insulated wire (HIV)
- (iii) 600V Vinyl insulated vinyl sheath cable (CVV)
- (iv) 600V vinyl insulated vinyl sheath cable with shield (CVVS)
- (v) 600V cross-linked polyethylene insulated vinyl sheath cable (XLPE)
- (vi) 3300V cross-linked polyethylene insulated vinyl sheath cable (XLPE)

All conductors shall be copper unless otherwise specified.

9.5.15.3 DRUM

The cables and wires shall tightly and firmly be rolled on the drums and applied with damp-preventing measure. Each cable shall completely be sealed.

The drum shall be made of wood or steel or robust construction and be provided with anti-termite and anti-rodent protection.

9.5.15.4 TESTS

(1) *Factory Tests*

The following tests shall be carried out:

- (i) Construction test
- (ii) Resistance measuring
- (iii) Withstand voltage test
- (iv) Insulation resistance test
- (v) High temperature insulation resistance test
- (vi) Tensile strength test
- (vii) Coiling test
- (viii) Thermal shrinkage test
- (ix) Oil proof test
- (x) Non-inflammability test
- (xi) Shield conductivity test
- (xii) Impulse breakdown voltage test
- (xiii) AC breakdown voltage test
- (xiv) Chlorine gas measurement

9.5.16 GROUNDING SYSTEM

9.5.16.1 GENERAL

(1) General

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

(2) References

The following standards are referred to:

IEC 228	600V Vinyl Insulated Wire (IV)
JIS C 3307	600V Vinyl Insulated Wire (IV)
JIS C 2806	Non-insulated Crimp-type Sleeves for Copper Conductors
JIS H 3100	Copper and Copper alloy-Sheets, Plates, Strip and Coiled Sheets.

9.5.16.2 WIRE

The wire used for the wiring shall be as hereinafter specified.

- (i) 600V Vinyl Insulated Wire (IV)
- (ii) Soft annealed Copper Stranded Bare Conductor

9.5.16.3 MATERIALS

Wire shall be of soft drawn annealed, 98% conductivity, stranded copper and bare conductor.

9.5.16.4 GROUND PLATES

Ground plates shall be copper plate of 1.5 mm or more thickness and 1000 mm x 1000 mm square or equal.

The connections between the ground plates and grounding wires shall comply connected by brass-welding with electrolytic corrosion-proof treatment.

9.5.16.5 GROUNDING RODS

Grounding rods shall be copper clad steel rods, 10 mm or more in diameter, 1.5 meter long and with pointed and chamfered tops. Grounding rods shall be equipped with couplings and driven bolts, and shall be driven to the depths and number of rods needed to obtain the desired resistance.

Grounding rod clamps shall be cast copper alloy, and shall tightly grip the rod and cable.

9.5.16.6 GROUNDING CONNECTORS

Grounding connectors shall be made by compression type. Grounding connectors shall be corrosion resistant and provided for cable to flat surface connections on equipment and structural steel.

9.5.16.7 GROUND ELECTRODE MARKERS

The marker for buried ground plates and rods shall be installed to construction wall near each electrode.

Each marker shall be made of brass or stainless steel, and shall have written down the bury position, depth, resistance and date, etc.

9.5.16.8 INSTALLATION

Various ground works shall be grounded independently of and separately from the common ground. Grounds of the following equipment shall be done separately from the common ground, in addition to the electrical equipment grounding.

- Lightning arrester
- Lightning rod
- Instruments for instrumentation and communication equipment.

If acceptable and specified ground resistance value cannot be actually measured, suitable countermeasures such as addition of grounding rods including grounding plates, extension of grounding system and considerable others shall be made so as to satisfy its target value specified in the SUB-SECTION 9.6 PARTICULAR SPECIFICATIONS-ELECTRICAL WORKS.

The ground electrode shall be separated 2.0 m or more from other steel frames and pipes as far as possible.

For the above measurement, a grounding terminal board shall be installed.

All electrical equipment shall be connected to the nearest available grounding rods. The protecting conduits shall be bonded to the grounding conductor at both ends.

The Contractor shall not allow the grounding connections to be painted. If the connections are painted, they shall be disassembled and remade with new fittings.

All equipment enclosures, panel, motor, transformer and conduit systems, exposed structural steel and similar items shall be grounded.

A grounding wire and cable shall be run in all electric power conduits. The cable rack and control station shall be grounded by a separate green coloured, insulated, grounding conductor.

Although all metallic conduits shall be grounded, they shall not be used to provide grounding for motors or other electrical equipment.

The Contractor shall exercise care to ensure good ground continuity, in particular, between the conduit system and equipment frames and enclosures. Where necessary, jumper wires shall be installed.

9.5.16.9 TESTS AND OTHERS

The Contractor shall test the ground resistance of the system. All test equipment shall be provided by the Contractor and approved by the Engineer. Dry season resistance of the system shall not exceed six (6) ohms. If such resistance cannot be obtained with the system as shown, the

Contractor shall provide additional grounding as instructed by the Engineer, without additional payment.

In order to make effective project construction schedule in total, partial grounding system to be embedded under the ground especially may be included in other Civil Contract (other Contract package).

Even such case, to avoid undesirable additional grounding after completion of the civil work the Contractor shall make necessary co-operation, supervising, measuring and confirmation whether its grounding resistance is satisfied, with the Civil Contractor.

It shall be noted that in any case the Contractor shall be responsible for any defects and failures for the grounding system to establish complete it.

9.5.17 DIESEL ENGINE GENERATOR FACILITY

9.5.17.1 GENERAL

(1) General

The Contractor shall furnish and install the diesel engine generator facility for emergency power source for the duration of normal power interruption, as hereinafter specified and as shown on the drawings.

(2) References

The following standards are referred to:

IEC 34	Rotating electrical machines
IEC 801	Radio frequency interference

9.5.17.2 SCHEDULE

The diesel engine generator facility schedule will be specified in SCHEDULE of the SUB-SECTION 9.6 PARTICULAR SPECIFICATIONS-ELECTRICAL WORKS.

9.5.17.3 TYPE, RATING AND CHARACTERISTICS

(1) Diesel Engine

Type	:	4 cycle, radiator water cooled, direct fan drive vertical straight or vertical V-type multi-cylinder, direct injection, electrical governor.
Rotating Speed	:	1500 r.p.m
Starting	:	24V DC long life Lead-Acid batteries including small charger equipped with the engine.
Noise	:	Not more than 95 dB at 1 m from exhaust outlet.
Rated Output	:	As shown on this single line diagram and schedule of the Special Specifications.

(2) Generator

Type	:	Brushless exciter, 4 pole, indoor use.
Rated frequency	:	50 Hz
Insulation	:	Class H or Class F
Rated Voltage	:	AC 415V/240V, 3 phase 4 wire.
Power Factor	:	0.8 lagging
Rotating speed	:	1500 r.p.m..
Voltage regulation	:	Max. \pm 3.0% under load from no load to 100% rated load.
Class of rating	:	Continuous full load operation.

Cooling	:	Self-cooling
Ambient temperature	:	45 deg. C
Frequency regulation	:	Max. \pm 3 Hz under load from no load to 100% rated load
AC waveform total harmonic distortion	:	Less than 5% total no load to full linear load, and less than 3% for any single harmonic.
Overspeed strength	:	120% of rated speed for one (1) minute under no-load.
Power frequency Withstand voltage	:	1000 V + 2E (1500 V min.)

(3) *Control Panel*

Type	:	Self-stand on the common base (with generator and engine,) metal enclosed.
Equipment included	:	<ul style="list-style-type: none"> (i) Frequency meter (ii) AC Ammeter with selector SW (iii) AC Voltmeter with selector SW (iv) DC Voltmeter (v) Running time meter (hour meter: digital) (vi) Automatic Voltage Regulator (vii) Overcurrent relay (51) (viii) Voltage relay (84) (ix) Undervoltage relay (27) (x) Instrument transformers (xi) Control SW (Run / Stop) (xii) Changeover SW (Auto / Manual) (xiii) Tachometer (xiv) Lubrication oil pressure gauge (xv) Lubrication oil temperature gauge (xvi) Coolant temperature gauge (xvii) Emergency stop pushbutton SW (xviii) Battery and charger (xix) Molded case circuit breakers (xx) Indicator lamps <ul style="list-style-type: none"> - Control power failure - Under generating power supply (status) - Under commercial power supply (status) - Charging - Start fail - Oil pressure low - Cooling water high temperature - Over speed - Emergency stop - Overcurrent - Aux. Equipment failure - Cooling water level low - Oil level low - Others, if required.

9.5.17.4 AUXILIARY EQUIPMENT

The diesel generator facility shall be complete with fuel system, exhaust system and all essential and desirable auxiliaries for a complete installation whether specifically mentioned in this specification or not.

(1) *Fuel System*

The following equipment of the fuel system shall be specified hereinafter and such equipment shall be complete with all necessary apparatuses.

- (i) Fuel service tank
- (ii) Fuel pump

The fuel service tank shall be provided of rolled steel for a welded structure, not less than 3.0 mm thick, reinforced where necessary, and shall include an steel angle stand with gusset plates, fixing bolts and all necessary accessories.

The fuel service tank shall be included with all interconnecting piping, valves, oil level gauge.

The hand type pump shall be furnished, and shall be hand operated, semi-rotary type pump.

(2) *Exhaust System*

The exhaust system shall be suitably lagged to reduce noise, and shall be installed completely with a bellows type flexible joint attached to the engine, exhaust piping, expansion joints, an exhaust silencer hanging rigidly from the ceiling, and exhaust to the air.

The acoustic noise level shall not exceed 95 dB (A) at a distance of 1.0 m from the outside of the generator room.

The exhaust silencer shall be the standard model of a manufacture regularly engaged in the manufacture of engine exhaust silencers, and shall be the multiple chamber type.

The exhaust silencer shall be covered with insulation of a non-combustible type and jacketed with a stainless steel jacket. The insulation shall be a refractory asbestos, held in place with stainless steel banding and covered with a 0.4 mm thick stainless steel jacket, secured with screws and jacketing lapped a minimum of 75 mm thick. Fittings, flanges and valves shall be insulated with asbestos covering material cut to fit.

9.5.17.5 TESTS

(1) *Factory Tests*

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

Generator with Exciter and all Panels

- (i) Verification of construction tests
- (ii) Mechanical operation tests
- (iii) Electrical operation tests

- (iv) Fifteen (15) seconds of 150% over current test (type test report may be acceptable)
- (v) Two (2) minutes of 120% over speed test (type test report may be acceptable)
- (vi) Steady state voltage regulation test (type test report may be acceptable)
- (vii) Transient voltage dip test (type test report may be acceptable)
- (viii) Temperature rise tests (type test report may be acceptable)
- (ix) Noise tests (type test report may be acceptable)
- (x) Vibration tests
- (xi) Protection devices tests
- (xii) Deviation factor of wave form (type test report may be acceptable)
- (xiii) Excitation equipment tests
- (xiv) Measurement for calculations of characteristics
- (xv) Insulation resistance test
- (xvi) Power frequency withstand voltage tests
- (xvii) Accessories and spare parts tests.

Diesel Engine with all Accessories Equipment

- (i) Verification of construction tests
- (ii) Mechanical operation tests
- (iii) Electrical operation tests
- (iv) Starting characteristic tests
- (v) Two hours under full load and one hour under varying load
- (vi) Load operation tests (type test report may be acceptable)
 - Thirty (30) minutes of 25% load test
 - Thirty (30) minutes of 50% load test
 - Thirty (30) minutes of 75% load test
 - Two (2) hours of full load test
 - Thirty (30) minutes of 125% load test
- (vii) One (1) minute of 110% speed test
- (viii) Governor performance test (Type test report may be acceptable)
- (ix) Temperature rise tests (Type test report may be acceptable)
- (x) Noise tests (Type test report may be acceptable)
- (xi) Vibration tests
- (xii) Protection devices tests
- (xiii) Auxiliary equipment test
- (xiv) Accessories and spare parts tests.

(2) *Field Tests*

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

- (i) Verification of construction tests
- (ii) Mechanical operation tests
- (iii) Electrical operation tests
- (iv) Ten (10) minutes of no-load operation test
- (v) One (1) minute of 110% overspeed test

- (vi) Noise and vibration tests
- (vii) Insulation resistance measuring
- (viii) High voltage test

9.5.17.6 TOOLS AND SPARE PARTS

(1) Tools

For each equipment item, all essential and desirable accessories for the installation, operation and maintenance shall be furnished and installed. The followings shall be included to but not be limited to each item specified hereinafter.

- One (1) set of geared chain block, as the 0.5 ton portable lifting equipment
- One (1) complete set of deflection gauges with a dial gauge
- One (1) complete set of clearance gauges
- One (1) complete set of wing pump for drain water
- One (1) set of bar type thermometer (0 – 600° C) with case
- One (1) set of hand type rotameter
- One (1) set of disassembly and re-assembly tools for generator
- One (1) set of disassembly and re-assembly tools for engine
- One (1) set of painting materials
- One (1) set of steel lockers for storing the tools and spare parts about 1000Wx 2000Hx500W
- One (1) lot of other necessary tools recommended by the manufacturer.

(2) Spare Parts

The list of spare parts to be furnished by the Contractor as specified in Section 9.3.1.22 shall include but not be limited to the following:

Generator

- One (1) complete set of speed relays
- One (1) complete set of AVR
- One (1) complete set of tacho-generator
- One (1) phase complete set of semi-conductor rectifiers for the exciter
- Each type 500% pieces of light bulbs
- Each type 500% pieces of fuses for high voltage and low voltage
- Each type One (1) complete set of MCCB
- Each type Two (2) complete sets of electromagnetic switches with thermal relays
- Each type two (2) complete sets of signals and annunciator lights
- Each type One (1) complete set of changeover switches and control switches
- Each type five (5) complete sets of auxiliary relays
- Each type two (2) complete sets of timers
- Each type two (2) complete sets of space heaters with thermostats
- Each type ten (10) pieces of spare name plates and tag plates
- * One (1) lot of other spare parts recommended by the manufacturer.

Diesel Engine

- One (1) set of Governor
- Each six (6) sets of piston rings and oil rings

Each two (2) sets of intake valves and springs with cock
Each four (4) sets of exhaust valves and springs with cock
Each six (6) sets of starting valves and springs
Six (6) sets of fuel injection valves
Each three (3) sets of nozzles and springs for fuel valve
Each three (3) sets of plungers, liners, valve seats and springs for fuel injection pumps
Each type one (1) complete set of solenoid control valves
Each type one (1) set of stop valves
Each type one (1) complete set of valve-belts
Each size five (5) meters of piping material
One (1) complete set of ball tap
Each type five (5) pieces of all springs, packings, split pins and bolts/nuts
Two hundred (200) litres of lubricants with hand pump
One (1) lot of spare parts chests with chest
* One (1) lot of other spare parts recommended by the manufacturer

9.5.17.7 INSTALLATION

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

All piping arrangements shall be recommended by the engine manufacture.

All piping lines shall be connected to the engine by a suitable section of flexible joint as recommended by the engine manufacture. All flexible joints shall be stainless steel 304, below type with flange connections at both sides.

The 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.

An overhead geared mono-rail hoist shall be provided at generator room of sufficient capacity for maintenance of the facility. Portable lifting equipment shall be provided for removal of the generator rotor.

**9.6 PARTICULAR SPECIFICATIONS
– ELECTRICAL WORKS**

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9.6 PARTICULAR SPECIFICATIONS - ELECTRICAL WORKS

9.6.1 GENERAL

9.6.1.1 SCOPE OF WORK

(1) *Work to be Performed*

This "PARTICULAR SPECIFICATIONS-ELECTRICAL WORKS" shall cover the scope of work stipulated in SUB-SUB-SECTION 9.5.1.1, GENERAL SPECIFICATIONS – ELECTRICAL WORKS.

The work shall include but not be limited to the following:

(i) Gothatuwa – Kolonnawa Pump House

- Control facilities for three (3) sets of transmission pump (165 kW) including associated valves (Low voltage motor control panels).
- Low voltage (AC 415/240V, 3 phase 4 wire) switch gear (Low voltage incoming power panel, programmable logic controller)
- Low voltage (AC 415/240V, 3 phase 4 wire) distribution power facilities (Low voltage ancillary equipment panels)
- DC power facilities (DC 110V storage battery & charger panel, DC panel)
- Local control facilities (Local switch boxes)
- Instrumentation system (Flow meter, Pressure transmitter, Water level sensors, Instrument panel, Programmable logic controller)
- Facilities (lighting, lightning protection, convenience outlets) for pump building and others
- Outdoor lighting
- Grounding system
- Ancillary facilities
- All required cables and wiring

(ii) Gothatuwa Ground Reservoir and Pump House

- Control facilities for two (2) sets of pump (130 kW) including associated valves (Low voltage motor control panels)
- Low voltage switchgear for 415/240V incoming line (Low voltage incoming power panel)
- Low voltage (AC 415/240V, 3 phase 4 wire) distribution power facilities (Low voltage ancillary equipment panels)
- DC power facilities (DC 110V storage battery & charger panel, DC panel)
- Local control facilities (Local switch boxes)
- Instrumentation system (Flow meters, Pressure transmitters, Water level sensors, Instrument panel and Programmable logic controller)

- Facilities for pump building (lighting, lightning protection, convenience outlets)
- Outdoor lighting
- Grounding system
- Ancillary facilities
- All required cables and wiring
- Emergency diesel engine generator facility.

(iii) Gothatuwa New Water Tower

- Lighting
- Lightning Protection

(2) *General Requirement*

Except the followings, SUB-SECTION 9.5.1 of the GENERAL SPECIFICATION – ELECTRICAL WORKS shall be provided where applicable.

(i) The following system connection shall be applied on this project:

- 415/240V : 3 phase, 4 wire, wye-connected system with effectively grounded neutral.
- 110V DC : Mid-point will be grounded through earth fault detector.

(ii) The following manufacturer's service shall also be included:

The manufacturer of the equipment and accessories supplied under each Section shall complete the followings by qualified Engineer(s):

- Supervision shall include the check of all components before power is supplied.
- The equipment shall be placed in operation and all necessary adjustments shall be made.
- Field tests specified herein shall be done in full accordance with the manufacturer's recommendations under supervision of the manufacturer's Engineer(s).
- The manufacturer shall execute at least thirty (30) days of Training to instruct the Owner's personnel in the use, operation and maintenance of all the equipment.
- Call back service shall be done for two (2) years at 60 day intervals to check the operation of equipment, make necessary adjustments and check calibration.

(iii) The following power receiving works shall be included:

- Prior to executing the work, the Contractor shall consult with the power supply company, LECO, and obtain approval on the design and execution.
- All required documents to make application for power receiving will be submitted to LECO from the Employer.

Such documents including required number set of its copy shall be made and procured by the Contractor, and submitted to the Engineer and the Employer.

- All other necessary works to receive the power from LECO shall be performed by the Contractor.
- For Gothatuwa - Kolonnawa Pump House, co-operation with NWSDB operations shall be required to receive the power from the existing sub-station in the Ambatale Treatment Plant.

9.6.1.2 OPERATION AND MAINTENANCE MANUAL

A. General

(1) *Scope of Work*

The Contractor shall furnish at least twenty (20) sets of operation and maintenance manuals for the Gothatuwa – Kolonnawa Pump House and Gothatuwa Pump House which will be specified hereinafter, as requested under OPERATION AND MAINTENANCE MANUALS of the GENERAL CONDITIONS.

(2) *General Arrangements*

Operating and maintenance manuals for the pump houses, chlorination facility and others to be completed under this Contract shall include but not be limited to the following:

- a. Operation Manual
- b. Technical Instructions for Mechanical and Electrical Systems
- c. Electrical Wiring Diagrams
- d. Maintenance Manual and Record System
- e. Audio Visual Instruction System
- f. As-built Drawings
- g. Field Test Records.

(3) *Documentation Arrangements*

All operating and maintenance manuals furnished under this Section shall be arranged properly in accordance with the following.

- a. All information shall be in English Language. All dimensions and units shall be in the metric system.
- b. All manuals shall be in the International A4 size and all data called for below shall be photo reduced or enlarged to this size. Where drawings would be illegible when reduced to this size, fold out drawings may be provided such that the whole drawing folds out clear of the book.
- c. All manuals shall be bound in A4 size hard plastic files having four inclined D-rings with double lock.

Spine of the file shall be provided with the following coloured indexes:

- | | | |
|--------------|---|-------|
| - Mechanical | : | Blue |
| - Electrical | : | Red |
| - Others | : | White |

Coloured indexes shall be provided with lettering as directed by the Engineer.

- d. The format, arrangement, index, etc., shall be submitted to the Engineer for approval before final binding and printing.
- e. Twelve (12) sets of indexes including a comprehensive index for each volume and overall index volume shall be furnished and each set shall be bound in a hard plastic file specified above.
- f. The Contractor shall furnish self-standing steel cabinets for storing two (2) full sets of all operating and maintenance manuals furnished under this Section for each station. Steel cabinets shall be painted and furnished with full sized glass front, and a master key plus three (3) spare keys.

B. Operation Manual

The Operation Manual written for use by the plant operator shall contain but not be limited to the following:

- a. Process description for complete pump houses, electrical system, instrumentation and others.
- b. List of alarms, giving possible causes for alarm initiation, and sequence of remedial actions to be taken.
- c. Step by step account of pump house and power substation start-up and shut-down procedures.
- d. Instruction for normal operations with particular reference to:
 - Transmission and flow control
 - Inlet flow control and pump
 - Power substation
 - Electric power distribution.
- e. Instructions on monitoring of pump house and sample log sheets for each mechanical and electrical equipment item, to be filled by operators on a routine basis.
- f. Basic maintenance procedures for mechanical equipment such as major pumps, sump pumps, crane and others, and electrical equipment such as power transformer, circuit breakers, switch gears and others.
- g. 'Do's and 'Don'ts' in operation such as major pumps, circuit breakers, switch gears and other mechanical and electrical equipment. Operators' attention shall be drawn to all operations considered to be dangerous to operators or likely to cause damage to the plant.
- h. Trouble-shooting chart containing symptoms, probable causes, and remedies that should be taken.
- i. A3 size copies of all drawings, folded to A4 size referred to in the operation manual.

Operation manual shall be simple and written in either non-technical or semi-technical language. Wherever possible, the operation manual shall be presented in a tabulated and easy to understand form.

C. Technical Instructions for Mechanical and Electrical System

Technical instructions for the mechanical and electrical system shall include but not be limited to the following:

- a. A detailed process description for transmission and high lift pump system, power receiving system, power substation, power distribution system, motor starting system and other mechanical and electrical system.

Descriptions shall be supported by detailed process and instrumentation drawings.

- b. A detailed description of mechanical plant items which shall include:

- detailed description of each system;
- duty of individual equipment;
- function of equipment;
- full specification of equipment;
- manufacturer and type reference.

- c. A detailed description of all instrumentation which shall include:

- instrumentation system;
- instruments provided;
- Operating principles for all monitoring, indication and control equipment;
- Function of instruments;
- Location of instruments and indicators;
- Full specification of each instrument;
- Manufacturer and type reference.

Descriptions shall be supported by detailed process and instrumentation drawings.

- d. A detailed description of all control systems which shall include:

- methods of control for start-up and shut-down;
- list of alarms, method of initiation and remedial action to be taken;
- plant trips and interlocks.

- e. A detailed description of the electrical plant which shall include:

- (i) description of switch gear and panels:

- full specifications, manufacturer, type, voltage ratings;
- general list of circuits including currents and power ratings;

- (ii) circuits:

- circuit heading;
- list of components including manufacturer's type reference;
- sub-paragraphs for each circuit giving description of control including control mode and starting condition, and alarm features with cross reference to plant control description, especially methods of control for start-up and shut-down.

- f. A detailed description of plant start-up and shut-down procedures, which shall include:

- all pre-operational checks and tests on the mechanical and electrical plant;
- an account of pump house and power substation start-up and shut-down.

The description shall be supported by system operation and instrumentation drawings.

- g. A detailed description of day to day plant operation procedures shall include instructions for major pumps, power receiving and power distribution.
- h. A detailed description of plant operation under emergency conditions which shall include:
 - (i) sequence of events giving action required to make plant safe, and corrective action to safeguard plant from damage in event of:
 - failure of any major plant item;
 - failure of any control system;
 - power failure;
 - (ii) sequence of events to be followed on restoration of power which shall include a list of plant items which will re-start automatically and items which require manual re-setting before starting;
 - (iii) manual operation of plant under emergency conditions;
 - (iv) operation of plant under any other foreseeable emergency condition.

The descriptions shall be supported by drawings using logic diagrams showing the sequence of operations, checks and remedial operations to be taken under emergency conditions.

- i. Technical specification sheets for all major plant items; in the case of pumps, blowers, fans, etc., characteristics curves shall also be included.
- j. A3 size copies of all drawings, folded by in A4 size referred to in the technical instructions for mechanical and electrical system.

D. Maintenance Manual and record System

(1) General

Maintenance manual and record system shall include but not be limited to the following:

- a. Maintenance Manual
- b. Maintenance Record System
- c. Manufacturer's Instructions
- d. Other Requirements.

(2) Maintenance Manual

- a. Checking, testing and replacement procedures to be carried out on all mechanical and electrical plant items on a daily, weekly and monthly basis or at longer intervals to ensure trouble-free operations. This information shall be presented in a tabulated form with hard and thick paper and bound in hard plastic files.
- b. Fault location and remedy charts to facilitate tracing the cause of malfunctions or breakdown and correcting faults
- c. A complete list of recommended lubricants and lubrication charts for individual plant items. The charts shall include at least three trade names of the products, which are available in the city of Colombo.

- d. A spare schedule which shall consist of a complete list of itemised spare for all electrical and mechanical plant items with ordering reference and part numbers.
- e. A complete manufacturers and suppliers list which shall include address, telephone / fax numbers and E-mail addresses of manufacturers, suppliers and local agents. The list shall be tabulated in alphabetical order giving the name of manufacturer and supplier.
- f. A complete list of manufacturers instructions for operation and maintenance of all bought-out equipment. The list shall be tabulated in alphabetical order giving the name of the manufacturer, supplier identification of the plant item giving the model number and the literature provided including instruction leaflets and drawing numbers.

(3) *Maintenance Record System*

Maintenance record system, one (1), four (4) card maintenance record system shall be furnished. This four (4) card system shall include all electrical and mechanical equipment furnished under this Contract.

The system shall consist of a four (4) card set for each item of equipment to be maintained and a file for card storage and display.

Sufficient four-card sets shall be furnished to provide one set for each item to be maintained plus 20% extra stock.

The format of each card shall be to the approval of the Engineer. Each card shall be of hard and thick paper approved by the Engineer and this maintenance record system shall be found in hard plastic files specified.

The cards shall include the following information.

(i) Card 1 - Equipment Data

- a. The name of item of equipment
- b. The name and address of the manufacturer
- c. The name and address of the supplier
- d. The name and address of the local agent.
- e. An identification number designated by the Engineer.
- f. Record of spare parts held in stock with provision for additional spare parts.
- g. Provision for recording maintenance performed, together with the data and cost.
- h. Preventive maintenance schedule with coloured tabs for monitoring completion of each maintenance item.
- i. Any other pertinent data required by the Engineer.

(ii) Card 2 - Master Maintenance Data

- a. Record of all scheduled maintenance procedure outline including frequency and type of lubricant to be used for each item of equipment.
- b. A reference to the bound instruction manual where the full description of the maintenance operation may be found.
- c. List of special equipment that may be required that would not be carried at the plant, e.g., mobile crane.
- d. Any other details requested by the Engineer.

(iii) Card 3 - Preventive Assemblies Record Card

Provision for recording all past maintenance data.

(iv) Card 4 - Drive Assemblies Record Card

Record of all motor, gear reducers or drivers, and control data for each motor.

E. Video Visual Instruction System

(1) *General*

The Contractor shall furnish two (2) sets of video visual instruction systems for each pump house with two (2) sets of visual display units with video replay units.

The video visual instruction system shall be used to instruct proper operation and maintenance of the plant to the operators and to keep record of proper operation and maintenance for a long time.

The Contractor shall be required to take and arrange pictures of operation and maintenance instructions with a video camera during the start-up and test run period of the plant construction.

Final arrangements of the video tapes shall be approved by the Engineer. Each volume of video tape shall be provided with appropriate narration in English.

Each video tape shall be provided with an appropriate title showing items of content at the beginning of the tape. The spine of the cassette shall be provided with an index and lettering as directed by the Engineer.

The Contractor shall furnish two (2) sets of steel cabinets, appropriately sized for storing video cassette tapes, with one cabinet for each set of system.

The video system shall be VHS system and VHS type, video cassette tape shall be used.

The Contractor shall furnish two (2) sets of list of video cassette and the lists shall be bound in hard plastic files specified.

All video tapes furnished under this Section shall become the property of the owner.

This video visual instruction system shall include:

- a. Construction record
- b. Instruction for plant operation
- c. Maintenance instruction
- d. Safety instruction
- e. Others.

(2) *Construction Record*

Construction record shall include manufacturing, shop testing, shipping, transporting, erection, checking, start-up and testing of all equipment and systems furnished under this Contract.

(3) *Instruction for Plant Operation*

Instruction for plant operation shall include but not be limited to the following:

- a. Pumps in Gothatuwa-Kolonnawa Pump House
- b. Pumps in Gothatuwa Pump House
- c. Chlorination facility
- d. Others.

(4) *Maintenance Instruction*

Maintenance instruction shall include but not be limited to the following:

(i) Mechanical Plant

- a. Checking and testing procedure of all mechanical equipment.
- b. Lubricants checking and replacement.
- c. Packing and other spare parts checking and replacement.
- d. All other special maintenance procedures of mechanical equipment.

(ii) Electrical Plant

- a. Circuit breaker maintenance procedure including switchgear draw outting and inserting, replacement vacuum bulbs and others.
- b. Battery cells maintenance procedure including measurement of temperature and specific gravity of electrolyte, water supply and others.
- c. Motor maintenance procedure including replacement bearing and others.
- d. Withstand voltage test procedures for all panels and equipment.
- e. Megger test procedure for all panels, equipment and cables.
- f. Grounding resistance measurement procedure.
- g. Testing procedure for all protection relays.

(iii) Instrumentation

- a. Replacing procedure of paper, pen and ink for all types of recorders.
- b. Analyzer maintenance procedure including inspection, disassembly, zero point correction using reagent, dissolving reagent, cleaning of electrodes and others.
- c. Programme input and correction procedure for sequence controller.
- d. Transmitter zero-point correction procedure.

(iv) Visual Display Unit with Video Replay Unit

The Contractor shall furnish two (2) sets of visual display units with videoplayer unit.

Each unit shall be the latest model, and visual display unit and videoplayer unit shall be supplied from the same manufacturer.

Video system shall be the VHS system and video cassette tape shall be VHS cassette. The visual display unit shall be a standard colour TV set and size shall be at least 20 inches.

Video player unit shall be the standard, solid state, compact type, having but not limited to the following functions:

- a. HQ and EX 4 tape heads
- b. High quality replay system with ANR Circuit and twin filter
- c. High quality and easy recording system
- d. 5 steps slow motion
- e. Double speed replay
- f. Taper counter
- g. Others.

9.6.1.3 AS-BUILT DRAWINGS

The Contractor shall prepare and submit "as-built drawings" and they shall be approved by the Engineer before printing.

As-built drawings shall include drawings which are originally prepared by the Consultant and are modified by the Contractor to meet all systems furnished by the Contractor and shop drawings which are finally modified and corrected by the Contractor and other related drawings referred to all work furnished under this Contract.

As-built drawings shall be so photo reduced that all scales shall be just half scale to the original scale and shall be printed with international A2 size hard plastic films having a reinforced holder attached on the left side of each film, as the original one.

Two (2) sets of original drawings photo reduced shall be submitted and each set of original drawings shall be bound in appropriately sized hard binders.

A total of 18 sets of drawings, printed on A2 size paper shall be submitted. Each set of drawings shall be bound with a hard cover which shall be provided with lettering as directed by the Engineer.

9.6.1.4 FIELD TEST RECORD

The Contractor shall prepare and submit field test records which shall be approved by the Engineer.

Field test records shall include field performance test records and other test records for mechanical and electrical equipment, executed by the Contractor during start-up and test-run of the plant.

9.6.2 INSTRUMENT TRANSFORMERS

9.6.2.1 SCHEDULE OF INSTRUMENT TRANSFORMERS

Schedules of all Instrument Transformers, which shall be furnished and installed under this Contract, are summarized in the following Table;

Table 1 LOW VOLTAGE CURRENT TRANSFORMERS

Identification	LCT - 1	LCT - 2	
Number of Current Transformers	3	6	
Type		Indoor, Dry-molded (epoxy resin)	
Location	Gothatuwa-Kolonnawa Pump House		
Mounted Panel	Incoming Panel	Pump No.1 to No.3 Panel	
Rated Voltage (V)	415	415	
Current Ratio (A)	1200 / 5	400 / 5	
Accuracy Class	1.0 Class	1.0 Class	

Identification	LCT - 3	LCT - 4	LCT - 5
Number of Current Transformers	6	4	6
Type	Indoor, Dry-molded (epoxy resin)		
Location	Gothatuwa Pump House		
Mounted Panel	Incoming Panel	Pump No.1 to No.2 Panels	D / G Panel
Rated Voltage (V)	415	415	415
Current Ratio (A)	600 / 5	300 / 5	600 / 5
Accuracy Class	1.0 Class	1.0 Class	1.0 Class

Table 2 : LOW VOLTAGE POTENTIAL TRANSFORMERS

Identification	LPT - 1	
Number of Potential Transformers	1	
Number of Phase	3	
Type	Indoor, Dry-mould, (epoxy resin), 3 Phase type	
Location	Gotharuwa-Kolonnawa Pump House	
Mounted Panel		
Rated Primary Voltage (V)	415	
Accuracy Class	1.0 Class	

Identification	LPT - 2	LPT - 3
Number of Potential Transformers	2	1
Number of Phase	3	3
Type	Indoor, Dry-molded, (epoxy resin)	3 Phase type
Location	Gothatuwa Pump House	
Mounted Panel	Incoming Panel	D / G Panel
Rated Primary Voltage (V)	415	415
Accuracy Class	1.0 Class	1.0 Class

Table 3 : LOW VOLTAGE ZERO-PHASE SEQUENCE CURRENT TRANSFORMERS

Identification	ZCT - 1	ZCT - 2	ZCT - 3
Number of zero-Phase Sequence Current Transformers	3	2	1
Type	Indoor, Dry-Type		
Location	Gothatuwa-Kolonnawa Pump House		
Mounted Panel	Pump No.1 and No.3 Panels	Ancillary Equipment Panel	Fan Switch Panel
Rated Primary Voltage (V)	415	415	415

Identification	ZCT - 4	ZCT - 5
Number of zero-Phase Sequence Current Transformers	2	1
Type	Indoor, Dry-Type	
Location	Gothatuwa Pump House	
Mounted Panel	Pump No.1 to No.2 Panels	Ancillary Equipment
Rated Primary Voltage (V)	415	415

Identification	ZCT - 6	ZCT - 7
Number of zero-Phase Sequence Current Transformers	1	1
Type	Indoor, Dry-Type	
Location	Gothatuwa Pump House	
Mounted Panel	D / G Panel	Fan Switch Panel
Rated Primary Voltage (V)	415	415

9.6.3 POWER CAPACITORS

9.6.3.1 SCHEDULE OF POWER CAPACITORS

Schedules of all Power Capacitors and reactors, which shall be furnished and installed under this Contract, are summarized in the following Table;

Table 1 : POWER CAPACITORS AND REACTORS

Identification	LCAP 1
Number of SC and SR	3 Sets (* 1 Set / Pump)
Location	Gotharuwa-Kolonnawa Pump House
Mounted Panel	Pump No.1 to No.3 Panels
Nominal Voltage (V)	415
Rated SC Capacity (kVA)	48
Rated SR Capacity (kVA)	6% of SC Capacity

Identification	LCAP 2
Number of SC and SR	(* 1 Set / Pump)
Location	Gothatuwa Pump House
Mounted Panel	Pump No.1 to No.2 Panels
Nominal Voltage (V)	415
Rated SC Capacity (kVA)	38
Rated SR Capacity (kVA)	6% of SC Capacity

9.6.4 BATTERY SYSTEM

9.6.4.1 SCHEDULE OF BATTERY SYSTEM

Schedules of all Battery System, which shall be furnished and installed under this Contract, are summarized in the following Table;

Table 1 : BATTERY AND CHARGER PANEL

Identification	BC - 1	BC - 2
Number of Panels	1 Set (2 panels)	1 set (2 panels)
Number of Cells	55	55
Type	Self-cooling	Self-cooling
Location	Gothatuwa-Kolonnawa Pump House	Gothatuwa Pump House
Battery Capacity (AH)	30	30
Type of Battery	Sealed Lead Acid	Sealed Lead Acid
Other Equipment Included	As shown on the Drawings and relevant Specifications	

Note: Number of panels includes DC panel

9.6.5 LOCAL CONTROL PANEL

9.6.5.1 SCHEDULE OF LOCAL CONTROL PANELS

Schedules of all Local Control Panels, which shall be furnished and installed under this Contract, are summarized in the following Table;

Table 1 : SUMP PUMP SWITCH BOARD

Identification	SPB - 1	SPB - 2
Quantity	1	1
Type	Indoor, wall mounted, Metal enclosure	
Location	Gothatuwa-Kolonnawa Pump House	Gothatuwa Pump House
Application	Power supply and control for sump pumps	
Other Equipment Included	As shown on the Drawings and relevant Specifications	

Table 2 : SWITCH BOARD (CHLORINATION SYSTEM)

Identification	SBC - 1
Quantity	1
Type	Indoor, wall mounted, Metal enclosure
Location	Maligakanda Reservoir Chlorination House
Application	Power supply for lighting, ventilation fans and feed pumps
Other Equipment Included	As shown on the Drawings and relevant Specifications

Identification	SBC - 2
Quantity	1
Type	Indoor, wall mounted, Metal enclosure
Location	Ellie House Reservoir Chlorination House
Application	Power supply for ventilation fans and feed pumps
Other Equipment Included	As shown on the Drawings and relevant Specifications

9.6.5.2 SPARE PARTS & TOOLS

List of spare parts for 5 years of operation on manufacturer's recommendation shall be furnished as described in SUB-SECTION 9.5, GENERAL SPECIFICATIONS – ELECTRICAL WORKS. The list shall include but not limited to the following spare parts & tools for local control panels:

- (i) Each type one (1) complete set of control switch
- (ii) Each type two (2) complete sets of push button switches
- (iii) Each type 300% pieces of fuses
- (iv) Each type 300% pieces of light bulbs

- (v) Each type two (2) complete sets of signals and annunciator's lights
- (vi) Each type one (1) complete set of space heater with thermostat
- (vii) Each type two (2) complete sets of auxiliary relays, if any.

9.6.6 INSTRUMENTATION

9.6.6.1 SCHEDULE OF INSTRUMENTATION

Schedule of all instrumentation, which shall be furnished and installed under this Contract, are summarized in the following Table;

Table 1 : INSTRUMENTATION PANELS

Identification	IP - 1	IP - 2
Number of Panels	1	1
Type	Indoor, wall mounted, Metal enclosure	
Location	Gothatuwa-Kolonnawa Pump House	Gothatuwa Pump House
Major Equipment Included		
- Process Indicator (Automatic balance type two points)	3	2
- Totalizer	1	2
- Data Collection Equipment	1	1
- Pen Recorder (180 mm chart)	1 (3pen)	2 (3pen or 2pen)
- 24 Hour Schedule Indicator Programmed	1	-
Other Equipment Included	As shown on the Drawings and relevant Specifications	

Table 2: ELECTRO MAGNETIC FLOW MEASURING DEVICES

TAG No.	QTY.	PIPE SIZE	LOCATION	APPLICATION	MEASURING RANGE	REMARKS
FE-TR-1	1	600mm	Gothatuwa Kolonnawa Pump House	Outflow	0 – 3000m ³ /H	
FE-GT-1	1	350mm	Gotatuwa Ground Reservoir	Inflow	0 – 1500m ³ /H	
FE-GT-2	1	300mm	Gothatuwa New Water Tower	Outflow	0 – 1500m ³ /H	

Table 3: LEVEL MEASURING DEVICES

TAG No.	QTY.	TYPE	APPLICATION	LOCATION	MEASURING RANGE	REMARKS
LT-TR-1	1	Immersion	Pump suction Well water level	Gothatuwa Kolonnawa Pump House	0 – 15m	(for main)
LS-TR-1	1	Electrode x 3	Pump suction Well water level	Gothatuwa Kolonnawa Pump House	As required	(for backup)
LT-GT-1	1	Immersion	Reservoir water level	Gothatuwa Pump House	0 – 10m	(for main)
LS-GT-1	1	Electrode x 3	Reservoir water level	Gothatuwa Pump House	As required	(For backup)
LT-WT-1	1	Pressure	New Tower water level	Gothatuwa Pump House	0 - 10m	(For main)
LT-WT-2	1	Pressure	Existing Tower water level	Gothatuwa Pump House	0 - 10m	(For main)
LS-WT-1	1	Electrode x 3	New Tower water level	Gothatuwa Pump House	As required	(For backup)
LS-WT-2	1	Electrode x 3	Existing Tower water level	Gothatuwa Pump House	As required	(For backup)

Table 4: VALVE POSITION AND PRESSURE MEASURING DEVICES

TAG No.	QTY.	TYPE	APPLICATION	LOCATION	MEASURING RANGE	REMARKS
GT-1	1		Flow control Valve position	Gothatuwa Ground Reservoir	0 – 100%	MOCV-GT-S
PT-TR-S	3	Pressure Transmitter	Suction pressure	Gothatuwa-Kolonnawa Pump House	0 – 0.1 MPa	
PT-TR-1	1	Pressure Transmitter	Transmission pressure	Gothatuwa-Kolonnawa Pump House	0 – 1.0 MPa	
PT-GT-S	2	Pressure Transmitter	Suction pressure	Gothatuwa Pump House	0 – 0.1 MPa	

For Gothatuwa-Kolonnawa Pump House, the pumps operate automatically according to a 24 hour schedule that is programmed into PLC by the operator.

The devices to comply with above requirement shall be provided, and mounted on the pump control panel.

Setting device to be connected to PLC shall be mounted on a pump control panel in common for every pump.

Such device shall have LCD (Liquid Crystal Display) indicator which is confirmable latest setting contents about unit number to be run hourly.

Setting push buttons shall be included the setting device.

9.6.6.2 ACCESSORIES AND SPARE PARTS

(I) Accessories

For each equipment item, all essential and desirable accessories for an installation and operation shall be furnished, which shall include but not be limited to the following:

- (i) One (1) set of portable type instrument testers for adjustment and maintenance.

The testers shall have following functions:

Measuring range

- Voltage	(mV)	:	DC.0-15/30/50/100/300/500/1000
- Current	(mA)	:	DC.0-15/30/50
- Resistance		:	0-10, 0-100

Signal generating range with output adjustment volume

- Voltage	(mV)	:	DC.0-15/30/50/100/300/500/1000
- Current	(mV)	:	DC.0-15/30/50
- Resistance		:	Equivalent resistance of pt. 100 resistance bulb
- Accuracy		:	± 0.5% of full scale
- Accessories		:	Each lead wire

- (ii) One (1) air-connection set for calibration of pressure transmitters and other pressure instruments.

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

Tool Name	Quantity	Remarks
Packing	1	
Seal Tape	1	0.1 mm x 13 mm x 5 mm, teflon
Bulkhead union	3	For PVC tubing (6 mm OD x 4 mm ID)
Connector	3	JIS PT ¼ taper pipe thread
Connector	3	1 / 4 NPT taper pipe thread
Connector	3	1/8 NPT taper pipe thread
Rubber tube connector	3	For rubber tubing (8 mm OD x 5 mm ID)

Tool Name	Quantity	Remarks
PVC tube	1	6mm OD x 4 mm ID, 5 mm
Adjusting valve set	2	For PVC tubing (6 mm OD x 4 mm ID)
Bulkhead union	2	For copper tubing (6 mm OD x 4 mm ID)
Type T union	2	For PVC tubing (6 mm OD x 4 mm ID)
Connectors for DP transmitters	2	
Others	1 lot	
Case	1	

(iii) 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 No.2	1	
Phillips type screwdriver No.1	1	
Screwdriver	1	6 mm x 100 mm
Screwdriver	1	4 mm x 100 mm
Vewller's screwdriver	1	No.3 standard
Screwdriver	1	2.5 mm x 35 mm
Tweezers	1	

Offset socket wrenches	1	For drain plug
Tape measure	1	Stainless steel, 2 m, take up
Allen wrenches (metric system)	7	1.5, 2, 2.5, 3, 4, 5 and 6 mm
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	

Tool Name	Quantity	Remarks
5 pcs. of plain file	1	Bastard cut
Tape measure	1	1 m, take up
T117 sparkle solder	1	1 mm dia. x 1 m
PVC tape	1	13 m wide, 10 m
Electric soldering iron stand	1	
Type 4S soldering iron	1	230V, 25W
Adjustable wrench	1	4-inch
Diagonal cutting nipper (with stripper)	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	

- (iv) One (1) tool set for electrical instruments.

This set shall include but not be limited to the following

Tool Name	Qty.	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 the case)	1	No.0 and No.1 (Phillips type) 1mm x 35mm (Standard)
Tweezers	1	
Exchange bit Vewller's screwdriver	1	3mm x 35mm (Standard)

Vewller's screwdriver	1	No.3 (Standard)
Phillips type screwdriver	1	No.1
Screwdriver	1	4mm x 100mm
Phillips type screwdriver	1	No.2
Exchange bit box-driver	1	M3 x 0.5, M3 x 0.6
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 (with stripper)	1	With insulated grip
Lead wires with clips	4	Each red, yellow, pink & black
Allen wrenches	2	M2.3 and M3 x 0.5
Others	1 lot	

- (v) 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" x 5/15"	1	For amplifier mounting and restricter mounting
Single ended spanner, 7/16"	1	For span adjustment
Screwdriver 1.5 mm x 12 mm	1	For adjustment pen pressure, movement and zero point
Screwdriver 3.3 mm	1	For driving element and movement hub screws
Single ended spanner 1 / 2"	1	For span adjustment

Screwdriver 2.5 mm x 35 mm	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

Tool Name	Quantity	Remarks
Socket wrench	1	For driving element, and movement hub screws
Alignment pin for link 40 mm	1	For centering the movement
Alignment pin for link 20 mm	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 mechanism 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" x 3/6"	1	For link adjustment
Others	1 lot	

(vi) Two (2) steel lockers with glazed doors and shelves.

(2) *Spare Parts & Tools*

List of spare parts for 5 years of operation on manufacturer's recommendation shall be furnished as described in SECTION 9.5 of the GENERAL SPECIFICATION – ELECTRICAL WORKS. The list shall include but not be limited to the following spare parts & tools for instrumentation:

- (i) One (1) complete set of the transmitter for each type of electro magnetic flow meter.
- (ii) One (1) complete set of pressure transmitter (PT)
- (iii) One (1) complete set of immersion type level transmitters
- (iv) One (1) complete set of process indicator (automatic balance type)
- (v) One (1) complete set of totalizer
- (vi) 50 sets of empty floppy disk for the data collection equipment
- (vii) Recorder ink for four (4) years operation
- (viii) Recorder chart paper for four (4) years operation
- (ix) Five (5) complete sets of arresters

- (x) Each type 500% pieces of fuses
- (xi) Each type 500% pieces of light bulbs
- (xii) Each size five (5)-m pieces of piping material
- (xiii) Ten (10)-m length of electrodes with connectors and spacers
- (xiv) One (1) complete set of the PLC equipment for each type
- (xv) Two (2) complete sets of the print card in the PLC for each type
- (xvi) Other necessary spare parts recommended by the manufacturer.

9.6.7 LOW VOLTAGE PANEL

9.6.7.1 SCHEDULE OF LOW VOLTAGE PANELS

Schedules of all Low voltage panels, which shall be furnished and installed under this Contract, are summarized in the following Table;

Table 1: LOW VOLTAGE INCOMING POWER PANEL

Identification	LIP - 1	LIP - 2
Number of Panels	1	1
Type	Indoor, Rear door, Metal enclosed, Vermin and dust proof, Self-supported	
Location	Gothatuwa-Kolonnawa Pump House	Gothatuwa Pump House
Nominal Voltage (V)	415	415
Rated Bus Current (A)	1200	600
Rated short time Withstand Current (kA)	50	25
Major Equipment Included		
- Circuit Breaker	1 ACB (Air Circuit Breaker)	2 MCCB (Moulded Case Circuit Breaker)
- PT as per Schedule XV sheet 3 of 18	2 as per Schedule XV sheet 4 of 18	2 as per Schedule XV sheet 5 of 18
- CT as per Schedule XV sheet 9 of 18	2 as per Schedule XV sheet 10 of 18	6 as per Schedule XV sheet 11 of 18
- Change over Switch (Magnetic Contractor)	Nil	1
- UV relay (3 phase)	1	1
- OV relay (3 phase)	Nil	1
Other Equipment Included	As shown on the Drawings and relevant Specifications	

Table 2: LOW VOLTAGE MOTOR CONTROL POWER PANELS

Identification	LMP – 1
Number of Panels	3
Type	Indoor, Rear door, Metal enclosed, Vermin and dust proof, Self supported
Location	Gothatuwa-Kolonnawa Pump House
Nominal Voltage (V)	415
Motor Type	Squirrel Cage Induction Motor
Motor Output (kW)	165
Motor Rated Voltage (V)	415
Rated Bus Current (A)	1200
Rated short-time Withstand Current (kA)	50
Starting Method	Condorfer starting (Auto Transformer)
Major Equipment Included (each panel)	
- Auto Transformer (3 phase)	1/ panel
- MCCB	1/ panel
- MC	2/ panels
- CT as per Schedule XV sheet 10 of 18	2/ panels
- ZCT as per Schedule XV sheet 15 of 18	1/ panel
- 2 E Relay	1/ panel
- * Controller (sequencer)	1/ panel
Other Equipment Included	As shown on the Drawings and relevant Specifications

Identification	LMP – 2
Number of Panels	2
Type	Indoor, Rear door, Metal enclosed, Vermin and dust proof, Self-supported
Location	Gothatuwa Pump House
Nominal Voltage (V)	415
Motor Type	Squirrel Cage Induction Motor
Motor Output (kW)	130
Motor Rated Voltage (V)	415
Rated Bus Current (A)	600
Rated short-time Withstand Current (kA)	25
Starting Method	Condorfer starting (Auto Transformer)
Major Equipment Included (each panel)	
- Auto Transformer (3 phase)	1/ panel
- MCCB	1/ panel
- MC	2/ panels
- CT as per Schedule XV sheet 12 of 18	2/ panels
- ZCT as per Schedule XV sheet 17 of 18	1/ panel
- 2 E Relay	1/ panel
- * Controller (sequencer)	1/ panel
Other Equipment Included	As shown on the Drawings and relevant Specifications

Note: * The controller shall have suitable function of automatic operation (including 24 hours pump running schedule programming) for the pumps, the discharge valves and control valve, as shown on the logic diagrams.

The controller shall be of solid state type equipment using advanced technology.

The following shall be considered for design to avoid undesirable failures because of its mounting inside the panel.

- High ambient temperature (inside the panel) affecting its life
- High humidity (inside the panel) affecting its life
- Noise causing its maloperation or misoperation

Table 3: LOW VOLTAGE ANCILLARY EQUIPMENT PANEL

Identification	LAP - 1	LAP - 2
Number of Panels	1	1
Type	Indoor, Rear door, Metal enclosed, Vermin and dust proof, Self-supported	
Location	Gothatuwa-Kolonnawa Pump House	Gothatuwa Pump House
Nominal Voltage (V)	415	415
Rated Bus Current (A)	1200	600
Rated short time Withstand Current (kA)	50	25
Other Equipment Included	As shown on the Drawings and relevant Specifications	

Table 4: LOW VOLTAGE FAN SWITCH PANEL

Identification	LFP - 1	LFP - 2
Number of Panels	1	1
Type	Indoor, Rear door, Metal enclosed, Vermin and dust proof, Self supported	
Location	Gothatuwa-Kolonnawa Pump Station	Gothatuwa Pump House
Nominal Voltage (V)	415	415
Rated Bus Current (A)	400	400
Rated short time Withstand Current (kA)	50	25
Other Equipment Included	As shown on the Drawings and relevant Specifications	

Air circuit breaker shall be provided and installed in the incoming power panel at Gothatuwa-Kolonnawa Pump House.

The air circuit breaker shall have ample breaking capacity against the expected maximum short circuit faulted current.

Overcurrent relay protection static type equipment with suitable current transformer shall be included and provided in the air circuit breaker.

The air circuit breaker is of motor driven spring charged operation, and is of draw-out type.

Manual spring charge shall also be possible by using of a suitable handle.

The circuit breakers for other feeders except above incoming line shall be applied with the molded case type.

9.6.7.2 SPARE PARTS

The spare parts for 5 years operation shall be furnished but not be limited to the followings;

- (i) 300 percent of indicating lamps of each type
- (ii) 300 percent of fuse of each type and rating used
- (iii) 1 piece of complete assembly of each type of MCCB or ACB
- (iv) 1 set of complete assembly of each of type of meter
- (v) 1 piece of complete assembly of each type of control switch
- (vi) 1 piece of complete assembly of each type and rating for instrument transformer
- (vii) 1 piece of complete assembly of each type and rating for the contactor or power change – over switch.
- (viii) 1 piece of complete assembly of each type and rating for the motor starter (Auto TR with Switch Contactor).
- (ix) 1 piece of complete assembly of each type and rating for power capacitor with series reactor
- (x) 1 piece of complete assembly of each type and rating for protective relay
- (xi) 300 % of complete assembly of each type and rating for auxiliary relay
- (xii) Other spare parts recommended by the manufacturer

9.6.7.3 ACCESSORIES

- (i) One (1) set of maintenance tools for ACB
- (ii) One (1) set manual charging handle
- (iii) One (1) moving cart with lifter

9.6.8 WIRES AND CABLES

9.6.8.1 GENERAL

(1) *Work to be Performed*

This contract shall include all necessary cables and wires with appropriate terminal connections, installation, necessary auxiliary devices, supervision for installation, field testing and start-up work, in accordance with the drawings and relevant Specifications where applicable.

9.6.8.2 INSTALLATION

For cabling work at the site, sufficient cable length shall be assumed and determined prior to actual cabling work between equipment.

Any intermediate connection of the cabling shall not be accepted, because of determination failure for the cable length.

Cable end termination work to the equipment shall be made with sufficient and suitable care especially.

Unsuitable cable end termination treatment will be brought its partial heat or insulation breakdown.

Cable and termination with compression type shall be applied. Working by skilled electrical technician shall be made.

9.6.9 GROUNDING SYSTEM

9.6.9.1 GENERAL

(1) *Work to be Performed*

This contract shall include grounding terminals board, necessary auxiliary devices, supervision for installation and field testing, as below:

- (i) Ground plates and all wiring for Gothatuwa-Kolonnawa Pump House
- (ii) Ground plates and all wiring for Gothatuwa Pump House and Ground Reservoir

In order to make effective project construction schedule in total, partial grounding system to be embedded under the ground especially shall be included in Civil Construction Work, previously.

However, additional grounding system work(if necessary after completion of the civil construction work) shall be made on the basis of co-operation with the Civil Engineer(s).

Contractor shall be responsible for any defects and failures for the grounding system to establish complete it.

9.6.9.2 INSTALLATION

Target value of the grounding system: Less than 10 ohm.

Every equipment such as Low voltage switchgear, motors, D/G set, local voltage panels, cable trays, conduits and others shall be grounded and connected to the grounding system embedded under the outside ground.

In such case, a concrete terminal box is constructed at near outside pump house.

The terminal box shall be applied to measure the actual grounding resistance in any time, for the maintenance purpose.

All necessary materials to make complete terminal box, such as copper plate, supporting base and foundation bolts, etc., shall be provided and completed by the Contractor, as shown on the drawings.

Conductors for the grounding system shall be as follows:

<u>Size</u>	<u>Equipment to be grounded</u>
(1) More than 38 sq.mm	415 V Motor (110 kW to 300 kW)
(2) More than 22 sq. mm	415V Motor (10 to 100 kW)
(3) More than 5.5 sq. mm	415V Motor (less than 7.5 kW)
(4) More than 14 sq. mm	Instrument panel
(5) More than 60 sq. mm	Low voltage panel
(6) More than 5.5 sq. mm	Local switch box

Conductor size for the neutral point shall, especially, be determined on the basis of expected earth fault current value.

Connector shall be of compression type, free from cutting each conductor for connection works and shall be of approved type.

9.6.10 DIESEL ENGINE GENERATOR FACILITY

9.6.10.1 SCHEDULE OF DIESEL ENGINE GENERATOR FACILITY

Schedule of all diesel engine generator facility, which shall be furnished and installed under this Contract, are summarized in the following Table;

Table 1: DIESEL ENGINE GENERATOR

Identification	GE - 1	OB-1
Number of Diesel engine Generator Set	1	
Type	Indoor, 4 cycle engine, Electrical governor, Brushless exciter	
Location	Gothatuwa Pump House, Diesel Generator Room	Maligakanda Office Building
Number of Phase	3	3
Rated Capacity (kVA)	375	60
Rated Voltage (V)	415	415
Rotating Speed (r.p.m)	1500	-
Rated Frequency (Hz)	50	50
Control Panel	As shown on the drawings and SUB-SECTION 9.5.17 GENERAL SPECIFICATIONS – ELECTRICAL WORKS	
Auxiliary Equipment	As shown on the drawings and SUB-SECTION 9.5.17 GENERAL SPECIFICATIONS – ELECTRICAL WORKS	
Other Equipment Included	As shown on the drawings and SUB-SECTION 9.5.17 GENERAL SPECIFICATIONS – ELECTRICAL WORKS	

An integral fuel tank shall be mounted on the skid base in common with the generator set.

The tank shall have storage capacity for at least 6 hours operation under rated output power.

An independent fuel and service tank mounted on the structure in the pit provided near the generator set is acceptable in lieu of the integral fuel tank having at least six hours storage capacity.

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