

ELECTRICAL WORKS
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2. ELECTRICAL WORK

2.1 Electrical Plant

General

The Electrical Works under this contract shall comprise of the complete electrical equipment, installation and the related services for the new water supply system including all systems for the supply of electrical power, the control systems, the automation and instrumentation systems, communication and all other installations.

The Contractor shall read the other tender documents pertaining to this project and observe all specifications therein together.

The water treatment and distribution works have to meet all requirements for drinking water stipulated by the National Water Supply & Drainage Board of Sri Lanka. The Electrical Works have to be executed so, that these requirements for the whole works are fulfilled, especially where the reliability, performance, safety and security of the systems are concerned.

The Contractor has to offer the whole works, so that the aim of the project is completely fulfilled, as specified.

The specifications of the Electrical Works given here are not meant to give complete information or descriptions for all items required under the contract. The intention of the specifications for electrical equipment is to define the fundamental design and to specify the quality, ratings, functions and purpose of the main required electrical systems and components. It is the responsibility of the Contractor to include in his offer all electrical deliveries and services required for the complete Works, and to state the exact quantity and dimensions as necessary to suit his design of the Works. The electrical components and systems shall be as specified in the Tender Documents. Additional components have to be selected by the Contractor and must be described in detail in his offer. Any such component has to fulfill the uniform high quality standard that is required for the whole Electrical Works.

Together with his offer, the Contractor has to submit his preliminary design with all information, diagrams, lists and drawings necessary to verify all components, quantities and sizes. The contractor has to submit any additional or alternative information or conditions, which he considers desirable, in a covering letter together with his offer. Any such details shall not be binding unless approved by the Employer and subsequently incorporated into the contract.

Scope of work

The Contractor's scope of work shall include the designing, manufacturing, supplying, factory testing, finishing, painting, export packing, insuring, shipping, delivering to the site storage yard designated by the Employer, shifting to installation site, installation and erection, field testing and commissioning (the trial running) of all equipment. The training of Employer's local staff on the operation of the equipment at the Site shall be included.

In this regard the Contractor shall extend Full Corporation to the Engineer, whenever the Engineer indicates such requirements.

The Contractor shall provide all labour, materials, equipment and incidentals to furnish and to install the complete electrical system.

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

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

Units of Measurement

In all correspondence, technical schedules and drawings, Metric Units of measurement shall be employed. On drawings where other units have been used, the metric equivalent shall be marked in addition

Workmanship

All Plant and components shall be new and shall be designed and manufactured in the most sound manner, using materials most suited to the particular applications and services. All materials shall comply with the latest relevant authorized standards for testing materials unless otherwise specified or permitted by the Engineer. The design of equipment shall be such as to enable easy maintenance of equipment.

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

All joints, datum surfaces, and mating components shall be machined and all castings shall be spot faced for nuts. All screws, bolts, studs & nuts and threads for pipe shall conform to the latest standards of the International Organization for standardization covering these components and shall either all conform to the standards for metric sizes.

The method of replacement of manufacturing errors, material defects and performance shortcomings shall be subject to the approval of the Engineer.

Suitable structural steel bases or frames shall be provided where necessary to transmit to the concrete foundations all loads imposed by the various parts of the equipment.

Such bases or frames shall be supplied complete with suitable anchor bolts and shall be so proportioned that the bearing loads imposed on the concrete foundations will not exceed 45 kg per square centimeter, unless otherwise necessary. All materials and equipment supplied and installed under this contract shall be suitable in all respects to operate under climatic and weather conditions prevailing at the respective site location.

Rules and Regulations

The work shall be carried out according to the local rules and regulations

The contractor shall comply with rules and regulations and shall carry out work in accordance with the requirements of: local jurisdiction such as:

Ceylon Electricity Board (CEB); The local electricity board
Local labour regulations
Local Government regulations of the area
The standards in the Specification
Any other authority affected by the work of the Contractor

The Contractor shall file the required notice with any authorized organization having jurisdiction over such permits and obtain and pay for all permits required

Photographs

The Contractor shall keep colour photographic records of the equipment manufacturing, the factory testing and the progress of the Site work. Digital versions of the photographs are acceptable on CD-ROMs, however one postcard size colour print shall also be provided each month of progress of the Works.

Upon completion of the Works, the Contractor shall submit three (3) sets of recorded photographs, one set on rewritable CD-ROM, another set on read only CD-ROM, and a third set of postcard size colour prints adequately edited in a book with explanations to the Engineer's satisfaction. The Contractor shall provide himself necessary access to the Work and temporary facilities to photograph any parts of the Work at any stage of installation or manufacture

Interpretation of Drawings

All three-phase circuits shall be run in the conduits unless otherwise specified.

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

Any work installed contrary to or without approval by the Engineer shall be subjected to change as directed by the Engineer, and no extra compensation will be allowed the contractor for making these changes.

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

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

The Contractor shall furnish all labour and materials necessary to install and place in satisfactory operation all power, lighting, and other electrical systems shown. Additional circuits shall be installed by the Contractor wherever needed to conform to the specific requirements of the equipment.

The ratings of motors and other electrically operated devices, together with the size shown for their branch circuit conductors and conduits, are approximate only and are indicative of the probable power requirements insofar as they can be determined in advance of the purchase of equipment. The ratings shown for motor branch circuit protective devices are the maximum ratings permitted. Lower ratings may be used where approved as being proper for the dynamic characteristics of the motor and its connected load. Unless otherwise specified, all conduits, wires, cables and the support systems for the conduits and cables that are required to make the electrical connections to equipment shall be furnished and installed by the Contractor. All connections to equipment shall be made as shown, specified, and directed and in accordance with the approved shop drawings

Mains Electricity

The mains electricity supply will be provided by the Ceylon Electricity Board the local electricity authority. The exact characteristics of the supply shall be obtained from the Ceylon Electricity Board (CEB) by the Contractor and suitably rate the equipment to be provided by the Contractor. For tendering purposes the supply characteristics may be taken as:

- i) Low voltage
230/400 V, 3 phase, 4 wire, 50Hz
Star point solidly grounded
Fault current 35 KA
Voltage fluctuation +10 to - 10%
Frequency 2 %

Type of Enclosures

Unless otherwise specified in the Schedule of the Special Specification, all equipment enclosures are to be designed and manufactured in accordance with the protection degrees classified in IEC 529.

Outdoor Control Cubicle	..	IP65
Outdoor / (Indoor) Instruments	..	IP65 / (IP54)
Outdoor / (Indoor) Motor	..	IP65 / (IP54)
Indoor Control Cubicles / Panels	..	IP54

Climatic conditions

The conditions under which the plants are required to operate are known to vary throughout the year. The conditions can be arduous with excesses of heat, dust, rainfall and humidity. Reference ambient temperature of design of all electrical equipment is 40°C.

Replace and Remedy

The contractor shall, if found defective during test, remedy or replace any defective work, and adjust such systems as and within such time as the Employer shall require. He shall also instruct in the use of the systems or apparatus to such persons designated by the Engineer.

Accessories, Spare Parts and Tools

(1) Accessories

For all equipment and panels, all essential and desirable accessories for an installation, operation and maintenance shall be furnished and installed, which shall include but not be limited to the each item specified in the GENERAL and /or PARTICULAR SPECIFICATIONS.

(2) Spare Parts

Purpose: For replacement of wear and tear parts.

The Contractor shall supply all spare parts recommended by the manufacturer (Contractor) for all items for a period of five years. The Contractor shall submit a itemized price list together with the offer.

(3) Tools

For maintenance work of the LV-Distribution system four complete sets of tools for the electrician are to be supplied. All tools that are necessary to carry out any maintenance work at the delivered plant are to be delivered in suitable lockable toolboxes, including also all specialized tools that may be required for this specific plant. The set consists at least of;

- 1 Pair of pliers, flat-nose, 160 mm
- 1 Pair of pliers, round-nose, 160 mm
- 1 Auto-Grip plier 8"
- 1 Insulation stripper - Auto-mechanical, multi wire section type
- 1 Forceps, 150 mm
- 1 Screwdriver, 0.5x3.0x75 mm, isolated up to 1000 V
- 1 Screwdriver, 0.8x5.5x125 mm, isolated up to 1000 V
- 1 Screwdriver, 1.0x7.0x150 mm, isolated up to 1000 V
- 1 Screwdriver for cross-port, size 1, isolated up to 1000 V
- 1 Screwdriver for cross-port, size 2, isolated up to 1000 V
- 1 Screwdriver for cross-port, size 3, isolated up to 1000 V
- 1 Hammer, 200 grams
- 1 Knife, stainless (for electricians)
- 1 Set of files (6 pcs. flat, circular, semi-circular, two sizes each)
- 1 Pair of insulating gloves
- 10 Sets of insulating tape
- 1 Analog-multimeter for direct and alternating voltage and current, ranges as follows:

DC	:	0-120 mV ... 1000 V
AC	:	0-3 ... 1000 V
Direct current	:	0-60 mA ... 30 A
Alternating current	:	0-60 mA ... 30 A

Impedance : 0-0.05 Ω ...1 M Ω
Accuracy class : 1.5 = / 2.5 ~

Including complete measuring equipment and leather case

- 1 Digital-multimeter, measuring ranges and accessories same as above
 - 2 Tachometer (one mechanical, one electrical)
 - 1 Soldering -iron, 16 W, with 1 kg solder (60 % Sn) and desk holder
 - 1 Soldering -iron, 50 W, with 1 kg solder (60 % Sn) and desk holder
 - 1 Electrical handhold-drilling machine 230 VAC, 800 W, electronic speed control, reversible, complete with accessories and plastic carrying case.
 - 1 Set of drills 1 mm up to 15 mm, HSS quality, complete in metal box
 - 1 Electronic digital clip-on multimeter for AVO AC measuring with sensor and adapter to measure temperature, complete with connection wires and leather case.
- Provide battery operated analog type earth resistance tester and insulation resistance tester.

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

2.2 Standards

General

Contractor shall ensure all materials incorporated in the Works shall be suitable for the intended duty and shall be new and of first class commercial quality free from imperfections and selected for long life and minimum maintenance.

All materials and material finishes shall be selected for long life under the site conditions specified.

Relevant Standards

All electrical equipment, design, materials, manufacture, testing, inspection and performance shall, unless otherwise specifically mentioned in this Specification, conform to the authorized latest Standards by International Electro-technical Commission (IEC).

Other internationally acceptable national standards equivalent to IEC may be considered.

If the bidder offers, materials or equipment which conforms to standards other than the IEC and those stipulated in this Specification, full details including copies in the English language of such standards, grade and class, shall be submitted for approval. Such standards, if approved, shall be incorporated in the Contract, in all other cases IEC standards and the standards specified in these documents shall be strictly adhered to.

Relevant IEC Standards:

- 34 Rotating electrical machines
- 44 Instrument transformers
- 51 Direct acting indicating analogue electrical-measuring instruments and their accessories.
- 99 Surge arresters
- 146 Semiconductor converters
- 185 Current transformers
- 186 Voltage transformers
- 227 Polyvinyl chloride insulated cables of rated voltages up to and including 600/1000 V
- 255 Electrical relays
- 269 Low voltage fuses
- 287 Calculation of the continuous current rating of cables (100% load factor)
- 420 High voltage alternating current switch-fuse combinations
- 439 Low-voltage switchgear and controlgear assemblies
- 529 Degrees of protection provided by enclosures (IP Code)
- 614 Conduits for electrical installations - Specification
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- 755 General requirements for residual current operated protective devices
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- 909 Short circuit current calculations in three-phase a.c. systems
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- 1042 A method for calculating reduction factors for groups of cables in free air, protected from solar radiation.
- 1131 Programmable controllers
- 1136 Semiconductor power converters - Adjustable speed electric drive systems - General requirements

2.3 Design Criteria

The following design criteria shall apply to all electrical work forming part of this Contract.

Electrical Requirements

Electrical System Parameters

The following nominal voltages for various systems are required to be used:

Lighting and miscellaneous power	230 V - AC
Switchgear protection	110 V - DC
Control circuits	24 V - DC
Analogue signals	4-20 mA – DC

System Connection

Unless otherwise specified, the following will be applied:

400V/230V, 3 Phase, 4 wire system with effective grounded neutral

System Frequency

Rated frequency shall be 50 Hz.

Counter-measures against Ground-fault on the High Voltage System

In consideration of possible voltage rise resulting from ground fault in the high voltage system, provisions shall be made to prevent damage to the equipment and personnel.

In order to avoid electrical problems due to ground faults in the system, the control circuits, lighting facilities, overhead wires, piping, etc., shall be protected by serving adequate electrical insulation, by providing high dielectric strength or by any other suitable counter-measures.

Auxiliary Electricity Supplies

The electrical control equipment shall be designed to operate and function on the following auxiliary electric power supply system, unless otherwise specified.

- (i) Alternating Current
 - 1-phase, 2-wire, 50 Hz
 - Voltage : 230 Volts
 - Voltage Variation : $\pm 10\%$
 - (Bypass output circuit of UPS)
 - Frequency Variation : $\pm 1\%$

The AC auxiliary power supply shall be used for the instrumentation system and the CPU system, etc. The power shall be supplied through UPS having the function, which can supply continuously stable power even if the main normal power supply system will occur in any failure.

Direct Current

24 Volts, 2-wire for the instrumentation system, essential controls, indication, alarm, emergency lighting, circuit breaker tripping and closing supplies. The direct current power shall be supplied from the DC distribution panel. All equipment and apparatus shall be capable of operating satisfactorily at $+10 / -15\%$ of DC 24 V. DC power supply shall be made by the battery system composing of the storage battery, the silicon dropper and the battery charger, etc.

Interlock

For maintaining safe operation of the power circuit, necessary electrical or mechanical interlocks shall be provided for switching of circuit breakers and disconnecting switches and other operation.

The interlock shall be fail-safe type for preventing any accident or damage for persons and equipment.

Fault level calculation

The Contractor shall carry out short circuit fault level calculations in accordance with IEC909 to determine the necessary fault rating of all protective devices

Equipment protection

Equipment shall be protected against under voltage, over voltage, phase failure, earth fault, over load, short circuit as appropriate.

Protective Relay Settings

For protection system the Contractor shall take good co-ordination for selection of the protection system and setting of the protective relays.

Recommendable settings with its calculation sheet for the protective relays and calculation sheets to determine expected fault currents and voltages on the whole electrical system shall be submitted to the Engineer for approval.

Consideration of High Temperature and Chlorine Gas

In the designing and manufacturing all the equipment and facilities under the Contract, due consideration shall be given to factors that affect their life under high average temperature, high humidity conditions and presence of chlorine gas in the Sites.

Adiabatic Effect and Moisture Prevention

Provision shall be made for protecting outdoor equipment from harmful effects of heat resulting from direct sunshine. Panels, control boxes shall be provided with adequate space heaters for the prevention of moisture condensation

Insulation and Short Circuit Coordination

Insulation Co-ordination

For insulation of all electrical equipment in the system, the Contractor shall ensure good co-ordination of insulation level against external and internal voltage surges resulting from switching operations and lightning phenomena.

Short circuit coordination

All electrical protective devices shall be coordinated such that faults are detected and cleared in the shortest possible time and that discrimination is achieved over the full range of possible short circuit values so that the minimum amount of plant is disconnected due to a fault

Contactors, thermal overload relays and their short circuit protective devices shall be selected so as to guarantee coordination in accordance with IEC 947-4-1.

Motor Starting and speed control

The voltage drop caused by the starting of any electric motor shall not exceed 5% at the busbars of the MCC supplying that motor and shall also not exceed 15% at the terminals of the motor. The contractor shall select the motor starters according to the duty and power (kW) of the motor application. The following starting and speed controlling shall be used as applicable:

Direct on Line (DOL)

Star-Delta

Autotransformer

Variable speed drive (VSD)

Harmonics

The design of the electrical system shall be such that harmonics from non-linear electrical consumers shall not cause any damage to any part of the electrical system or result in overheating or faulty operation of any equipment.

Cable Rating Selection

Electric power cables shall be selected to have a continuous current rating which is at least 10% higher than the maximum demand of the connected equipment when operating at the design conditions. For cables supplying electric motors the continuous current rating of the cable shall be at least 10% higher than the nominal full load current of the connected motor.

Cable ratings shall take into account the ambient conditions, proximity of other cables and the method of installation. Calculations shall be in accordance with IEC287 and IEC 1042.

Conductor size shall be such as to ensure that the voltage drop along the cable does not exceed 3% for final circuits supplying motors and the like and 2% for main circuits supplying MCCs and switchboards.

Polarity

The standard phase arrangement when viewed from the front of the panel shall be R-Y-B-N from left to right, from top to bottom, and front to back for A.C three-phase and for single-phase circuits, and P-N from left to right, from top to bottom and front to back for D.C polarity. All relays, instruments, other devices, buses and equipment involving three-phase circuit shall be arranged and connected in accordance with the standard phase arrangement where possible.

All cables shall be so connected between main switchboards, distribution boards, plant and accessories that the correct sequence of phase colours is preserved throughout the system.

All cable cores shall be identified with phase colours. Where more than one phase is incorporated on a common system in one room then the live cores shall be red, yellow and blue as appropriate and fittings and switch accessories shall be permanently labelled and segregated.

2.4 LV Switchboards and Motor Control Centres

(1) General

The Contractor shall furnish and install and put to work all switchboards and motor control centres required. The panel shall be so designed to facilitate easy access and maintenance. The contractor shall submit single line diagrams and drawings giving physical dimensions with location of major components, IP class (given elsewhere in this spec) etc pertaining to all the panels. Proposed location of the panel with clearance to surrounding walls equipment etc shall also be submitted.

(2) References

The following standards are to be adhered 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
- IEC 947 Moulded Case Circuit Breakers (MCCB)
- IEC 898 Miniature Circuit Breakers (MCB)

(3) Ventilation, Heating, Air Condition, Fire Extinguisher

Contractor shall ensure an inner air-temperature between + 5°C and + 40°C, the switchgear cabinets and the rooms of the switching stations by means of ventilation, heating, and air-conditioning devices as appropriate.

The penetration of dust and insects through ventilation openings into the switchgear cabinets must be prevented.

The components of air conditioners (e.g. cryogenic fluid, insulation) must not contain any CFHC (Chloro-Fluorinated Hydro-Carbons).

In all rooms with electrical switchboards a sufficient number of Co₂-fire extinguishers has to be provided by the Contractor.

Type, Rating and Characteristics

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

- (i) Type: Indoor, metal-enclosed dead-front, floor-standing self-supported or wall mounted Type
- (ii) Number of phases : Three (3) Phase, four (4) wire
- (iii) Rated Frequency : 50Hz
- (iv) Rated insulation voltage
 - Main circuit : 600V AC r.m.s.
 - Control circuit : 250V AC r.m.s

- (v) Rated operation voltage
 - Main circuit : 400/230 VAC
 - Control circuit : 230 VAC
- (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:
 - AC (r.m.s) : 230V + 10% (IEC 694 Clause 4.8)
 - 15%

The low-voltage (L.V.) system has to be designed as 400/230 V three-phase alternating current. The energy is to be distributed from the L.V.-Distributions preferably through a 5-wire-system to the Sub-Distributions and consumers.

Type of Enclosures

Refer Section 2.1.

Construction

Unless specified otherwise cubicles and enclosures shall be floor -standing. The panels shall be constructed in sheet steel not less than 2 mm thick and suitably braced to form a rigid structure.

The main control panel shall be of floor-mounted type and all out door panel shall be of floor or wall mounted panel type.

Adequate removable eyebolts for lifting purposes shall be provided.

Access to the cubicles or cubicle compartments for all normal routine maintenance shall be from the front by hinged and lockable doors, gasketed with an approved material to form a dust proof seal. The doors shall be secured with cam type fasteners and cylinder locks with removable key and fitted with handles. Hinges shall be of substantial size and from a stainless steel and stops shall be provided to prevent doors touching adjacent cubicles. Rear access shall be by means of bolted panels. Suitable warning labels and instructions for earthing and isolating shall be fitted where necessary.

Where mild steel is used for the constructions of the cubicle it shall be thoroughly cleaned to the bare metal by pickling or other process approved by the Engineer. All cubicles shall be rust proofed by hot dipped galvanizing or metal spraying prior to receiving a paint system comprising 3 or more undercoats and two or more finishing coats. The paint system shall be of the epoxy resin or polyurethane type and shall have an overall thickness of not less than 100 microns.

The inside surface of the enclosures shall have two prime coats and one finishing coat of light cream colour. (5Y 7/1) unless otherwise specified

All cut-outs and holes to be drilled in the panel shall be carried out before rust proofing.

Cubicles shall be well ventilated top and bottom vermin-proof louvers with a brass gauze screen attached to a frame and secured to the inside of the louver openings. Cable and piping entries shall be made through glands in a plate covering the base of the cubicle.

All cubicles shall be adequately earthed independent of the earth connection via the cable glands, and cubicle sections shall be electrically bonded to each other.

Components shall be so mounted as to prevent mechanical shock being transmitted from large components to small components and thereby adversely affecting their proper function. The components shall be so arranged to give adequate accessibility for maintenance and for removal of any component with the minimum disturbance to the installation.

Heaters shall be provided for each cubicle to prevent condensation and they shall be fitted with an adjustable thermostat to maintain an internal temperature of 5 deg. C. above the ambient.

They shall be flush fronted with projections kept to a minimum and where two or more cubicles are joined together they shall be of uniform height.

Exterior edges and corners shall be rounded and the use of externally visible assembly bolts and fixings shall be avoided.

The design shall provide protection against dust, damp and entry of vermin without reducing adequate ventilation and air circulation. Gaskets shall be fitted to doors and removable panels. Cable entries shall be made vermin-proof after installation by the fitting of shaped metal or plastic fillets around the cables.

Cubicles and enclosures for outdoor locations shall be double layered and fitted with lockable outside doors, and housing so designed that all controls and instruments are fully enclosed and the whole assembly weatherproof and vandal-proof. The doors shall be fitted with stays to prevent overstraining of the hinge fixing. The internal cubicles shall also be weatherproof to allow operation of the controls when the outside doors are open during inclement weather.

The enclosures shall conform to BS 5420 (:1977) and have IP ratings specified in general conditions for electrical plants.

Painting of enclosures and cubicles

All outside panel surfaces shall be primed, filed where necessary, and given not less than two coats of synthetic undercoat. The finishing coat for the outdoor installations shall be gloss paint and for the indoor installations shall be a semi-gloss paint or powder coated epoxy paint subjected to the Engineer's approval.

The inside surface of the enclosures shall have two prime coats and one finishing coat of light cream colour. (5Y 7/1) unless otherwise specified.

The colour scheme for the finishing coats of all equipment, frames for meters and relays, and switch handle shall be proposed by the Contractor with presentation of colour samples or colour chips and shall be subject to the Engineer's approval.

The humid and tropical conditions shall be taken into account on selection of the paints and painting procedure.

Bus bars and primary connections

Bus-bars for the mains & neutral shall be of insulated copper running through the entire length of panel. Full size neutral bars shall be provided. Bus-bar taps for panels with single pole branches shall be arranged for sequence phasing of the branch circuit devices. Bus bars and connections shall be identified by phase colour marking. Current density in busbars shall not exceed $2A/mm^2$.

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

Bus bars shall be full height without reduction. Cross connectors shall also be of copper.

Neutral bus-bar shall have a suitable lug for each outgoing feeder requiring a neutral connection.

Labels

All internal and external labels shall comply with the requirements of the relevant clause specified elsewhere in Section 2.1.

Fuses

All fuses shall be High Rupturing Capacity (HRC) type and one spare fuse for each Rise fitted in the panel shall be supplied, clipped adjacent to the position in which it would be in service. A complete schedule of all fuses in the panel shall be affixed in a convenient position in the panel.

Neutral links shall not be arranged in fuse holders but shall be separately bolted copper links with one link for each fuse.

Type of LV Switchboards

LV switchboards shall be of the multi-cubicle type in accordance with BS 5486 :Part 1: 1986 (IEC 4339) and shall have the following electrical characteristics:

Rated operational voltage	400 V
Rated insulation voltage	660 V
Rated current to suit maximum load at each switch gear unit	
Rated frequency	50Hz
Rated short times and rated	
Peak withstands current	42 kA symmetrical rms.
Withstand current	
Rated fused short-circuit to suit short-circuit level at each switchgear Unit	
Current	

Test certification shall be provided for all type tests listed in Clause 8.1.1 of BS 5486: Part 1: 1986.

All routine tests as listed in Clause 8.1.2 of BS 5486: Part 1: 1986 shall be performed in the workshop of the manufacturer and test certificate shall be provided.

Switchboard Safety Arrangements

All terminals, connections relays and other components, which may remain or become energised when front access doors are open, shall be adequately screened. It shall not be possible to obtain access to adjacent cubicles when any door is opened.

Components within the cubicles shall be adequately labelled to facilitate testing.

Isolators, clearly labelled, shall be provided in such positions and so connected that maintenance can be carried out with maximum safety. This particularly applies to control circuits fed from a remote position. Where it is necessary to maintain certain components in a cubicle in an energised condition when the isolator is in the "Off:" position, such apparatus shall be screened and labelled to eliminate the possibility of accidents. Additionally a system of removable insulated links or isolating type terminal blocks shall be provided to enable particular components to be isolated for maintenance purposes whilst retaining other essential circuits in an energised condition.

When more than one outgoing circuit occupies a common distribution section all cable terminators, cable lugs and such like shall be fully insulated or screened to allow work to be carried out on any one circuit with other circuits remaining live.

Switchboard Small Wiring

Switchboard wiring shall be carried out in 600/1000 V PVC cable to BS 6231: 1981 and the conductors shall not be less than 1.5 sq. mm.

Wiring within the switchboard shall be distinctly coloured throughout and marked with ferrules at each end for identification. The letters and numbers used shall correspond with the switchboard-wiring diagram.

The wiring colour code shall conform to BS.6231.

The wiring shall be neatly laced and cleated to the switchboard structure and arranged so that access to equipment is not impeded. Where wiring passes through metalwork the access hole shall be fitted with a suitable grommet.

Wiring between cubicles or panel sections shall be terminated in terminal blocks at each end.

Terminations for screw or stud type terminals shall be crimped on ring type or claw and washer type.

Terminals

All terminals for outgoing connections shall be located within the cable 'one adjacent to the respective functional unit.

Space shall be provided to accommodate cable glands of appropriate size for incoming and outgoing circuits and non-ferrous gland plates shall be supplied where single core cables are terminated. All glands plates and trays shall be adequately earthed.

Terminals shall be clip-on, DIN rail mounted, tunnel type terminals with flat pressure plates. For all current transformer and voltage transformer secondary wiring disconnect/test terminals shall be provided to permit short-circuiting and disconnecting of wiring for testing purposes.

The Contractor shall terminate alt field wiring and interpanel wiring at terminal strips. No more than one wire shall be connected to each side of a terminal. 13 ridging bars shall be used for paralleling wires.

Terminals shall be grouped according to the working voltage of the circuits. Segregation shall be provided between low voltage and extra low voltage circuits by means of insulating barriers or by physical separation. Transparent insulating covers with warning labels shall be provided on 230 V terminals. All terminal strips shall be safely accessible with the switchgear in the service position and in normal operation.

All terminals and terminal groups shall be identified with numbers in accordance with schematic and termination diagrams

Switchboard Control Components

The switchboard control components shall be as described in this clause. All indicator lamps, push buttons switches or instruments shall be mounted on the access door and connected by flexible looms arranged vertically on the hinge side, so as to minimize strain on the cables.

Internally mounted components shall be housed in standard draw-out racks or on fixed or hinged sub-panels as appropriate. Access shall be readily available to all components and terminations through hinged lockable doors.

Indicating Instruments and Meters

All indicating instruments shall be of flush-mounted back-connected, dust-proof and heavy-duty switchboard type (if any). Each indicating meter and instrument shall have a removable cover, either transparent or with a transparent window. Each meter and instrument shall be suitable for operation with the instrument transformers under both normal and short-circuit conditions.

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

All indicating instruments shall be approximately 110 mm square enclosures and shall be provided with clearly readable long scale, approximately 240 degrees. The maximum error shall be not more than one and a half (1.5) percent of full scale range.

All meters shall be marked with red line at the rated value of the scale.

Wattmeter and watt hour meter for 3 phase 3 wire system shall be of two (2) elements.

For 3 phase 4 wire system, three (3) elements shall be applied.

Accuracy of watt hour meter shall be of 1.0.

Watt hour meter shall be of solid-state type.

All instruments shall be fitted with an externally accessible zero adjuster and shall be positioned not more than 1800mm and not less than 1200mm above finished floor level. They shall have not parallax error and their normal maximum reading shall be approximately 60% full-scale deflection.

Ammeters in motor starter circuits shall be capable of withstanding the starting current and shall have a compressed overload scale. The scale shall be clearly marked with a red line indicating normal full load current.

Indicating instruments shall comply with BS 89; 1977 (IEC 51) and shall be of industrial grade accuracy.

Kilowatt-hour meters shall comply with BS 5685: Part 1: 1979 (IEC 521) and shall have accuracy Class 2 except where otherwise specified.

Indicator Lights

Indicator lights shall be not less than 20mm diameter and shall be the projecting type so that they can be seen from the front and the side of the switchboard. They shall be visible under bright sunlight conditions.

The lights shall be under-run to give long life either by use of resistor to limit voltage to 90% of nominal value or by using higher voltage lamps.

Alternatively the lights shall be transformer operated or battery operated where a battery is available.

Colours of indicator lights shall generally comply with BS 4099 Part 1: 1986 (IEC 73).

Labels

All designating labels shall be finished white with engraved letters and numbers filled with black and fixed by non-rusting screws. Refer to Section 2.1. Terminal blocks at different voltages shall be grouped and labeled accordingly.

Push buttons shall be coloured as follows:-

Start -	green
Stop -	red
Others -	black

LV Circuit Breakers

Main Circuit Breaker

The Moulded Case Circuit Breakers (MCCB) or Air Circuit Breakers (ACB) shall be provided for protection and disconnection of the main circuit of AC power supply system.

The circuit breakers shall be of four poles, high speed fault limiting, thermal/ magnetic type to IEC 408 with quick make and quick break trip free mechanisms which prevent the breaker being held in against overloads and faults.

Tripping arrangements shall be such as to ensure simultaneous opening of all phases. Arc extinction shall be by de-ionizing arc chutes.

The dolly shall have three positions “on”, “off” and “tripped”. To reset from the “tripped” position the dolly shall first pass into the off position.

CB on the Main Switch Board shall have facilities to for locking in the “off” position.

The rupturing capacity of the ACB shall not be less than that of the switchboard itself, or if this is not the case back up fuses must be included.

Where required alarm switch, auxiliary switch shunt trip, under voltage trip and similar units which are to be moulder additions to the circuit breakers must be included.

All MCCBs and ACBs shall be selected from the one manufacturer

Moulded Case Circuit Breakers (MCCB)

Moulded case circuit breakers shall be manufactured to IEC 157-1 and 947-2.

MCCBs below 100A rating shall be rated for a fault current of 25 kA and above 100A rating, 35 kA, unless otherwise specified.

MCCBs shall have inbuilt adjustable thermal overload and magnetic short circuit tripping devices with a trip-free mechanism to ensure that the contacts cannot be held closed against a fault. MCCBs with rated frame sizes in excess of 200 A shall have inbuilt adjustable thermal and magnetic trip units with separately adjustable thermal and instantaneous settings. Contacts shall be silver tungsten tipped with a wiping quick make and break action. The case shall be non-hygroscopic, are resisting material and incorporate are chutes based on the deionising breaker.

MCCBs shall have a factory calibrated and sealed trip unit, interchangeable with similar units for varying the rating of the circuit breaker. Circuit breakers shall be calibrated to take account of the ambient temperature and the method of mounting.

Where dust and damp proof enclosures are to be used, then the circuit breakers shall be fully enclosed in a case with gasketed door. Circuit breakers mounted in a composite control panel shall be segregated form other equipment and have a matching purpose-made cover plate. The switch dolly and protruding face shall be engraved with the circuit rating and the ‘On’, ‘Off’ positions.

Circuit breakers shall have a positively driven mechanical position indicator visible with the door closed.

All MCCBs shall be selected from the one manufacturer.

The type and tripping characteristic of MCCBS shall be selected to ensure full discrimination between series combinations of MCCBs and MCBs at all fault current levels up to the maximum prospective fault level.

When used as part of a motor starter or feeder module in Form 3 motor control centres the MCCB shall be fitted with a rotating operating handle mounted on the hinged compartment door with positive engaging clutch for operating the circuit breaker When used as part of a power distribution board the toggles shall be arranged to project through the panel. Facilities shall be provided for padlocking the handle in the open position and for attaching danger tags.

When used as part of a motor starter module in Form 3 motor control centre the Contractor shall provide interlocking to prevent opening the compartment door with the circuit breaker in the on position. It shall be possible to defeat the interlock mechanism to allow the MCCB to be turn on after the door is opened for maintenance reasons.

Auxiliary contacts and be rated at minimum of 4 A, 230V ac. The Contractor shall provide the required number of contacts and additional spare normally open and one normally closed auxiliary contact

Earth leakage Circuit breakers

Earth leakage circuit breakers shall be of the residual current operated type complete with core balance transformer, test push button, trip coil and thermal over loads. They shall be double pole for single phase and four pole for three phase and neutral circuits and shall comply with the requirements of IEC 755.

The tripping current shall not exceed 30 mA for circuit breakers up to 60 amp rating and upto 500 mA for above this rating as appropriate.

Miniature Circuit Breakers

Miniature circuit breakers shall be manufactured and tested to IEC 947-2 or BS. They shall have a short circuit rating of at least 9KA. and shall be type 2 unless otherwise specified.

Miniature Circuit Breakers (MCBS) must be of the thermal magnetic non-adjustable type, in accordance with the relevant local, IEC 947-2 or BS standards.

The minimum short-circuit breaking capacities are to be as following:

6 – 40 A MCB: 10 or 16 kA at 230/400 VAC.

MCBs are to be tropicalised for operation at ambient temperatures up to 70 °C within panel board enclosures and humidity up to 95%, and are to be constructed from high quality, high temperature, moulded insulating materials. Guaranteed duties and characteristics are to be submitted for

temperatures above 40°C MCBs and combinational devices are to be modular, of unified profile and mounted to a standard rail.

Under overload conditions, thermal tripping is to provide close protection on insulated conductors. Under short-circuit conditions; magnetic trip is to operate at 7-10 times normal rated current. Magnetic operation is to be in the current limiting region and opening time is not to exceed 5 milliseconds.

Preferred rated currents are to be 6, 10, 16, 20, 25, 30, 40, 50 & 63 available as 1, 2, 3, and 4 pole circuit breakers. Derating above 40 °C may not exceed 1% per °C, and loading is not to exceed 70% of circuit breaker rating.

Protective Relays

Protective relays shall be mounted on the front of the switchgear or relay panel in such a position that operation and maintenance can be conveniently carried out. Auxiliary relays may be mounted inside a cubicle provide that they are readily accessible.

Each relay shall be contained in a dust proof case and be vibration proof. All metal bases and frames shall be earthed except where there are special technical reasons where this is impracticable. Each relay shall have a glass observation window and means of resetting the relay in the case of relays, which need resetting. All relay contacts shall be capable of making the maximum current, which can occur in the circuit without causing damage to the contacts

Flush, jack-in type relays are preferred. Each relay shall have an indicator device to show when relay has operated and if necessary, which phase element. Resetting devices shall not require the removal or opening of the relay.

Where solid-state relays are used, these shall be of the module type comprising a number of plug in elements allowing interchange of functions. Each of the protection elements shall have adjustable controls for current and time settings as required.

A built in test facility shall be provided for individual testing of the settings of each of the protector elements. The tests shall be carried out by means of test sockets so that element does not have to be removed from the panel.

All solid state relays of a particular type shall have interchangeable protective elements with other similar relays supplied under this Contract.

Protection relays shall comply with BS 142 where appropriate.

Current Transformers

Current transformers shall comply with IEC185 /BS 3938: 1973 (1982) and shall be of the wound-primary or bar-primary type according to ratio required. All current transformers shall have a short-time current rating of not less than that of the switch panel in which they are incorporated. For bar-primary current transformers this rating shall be for a period of 3 seconds. For wound-primary

patterns the rating shall preferably be for a period of 3 seconds but may be reduced to not less than 0.5 second subject to the Engineer's approval.

Where multi-ratio current transformers are specified, a label shall be provided, clearly indicating reconnections required for the alternative ratios. All ratio terminals shall be connected to the multi-core terminal box and be clearly marked. These connections shall also be shown on panel wiring diagrams.

Identification labels shall be fitted giving type, ratio, rating, output and serial numbers and duplicate rating labels are to be fitted on the exterior of the mounting chambers suitably located to enable reading without the removal of any cover or metal sheeting forming part of the structure of the switchboards.

Current transformers for balance earth fault protection shall be designed for a stability of not less than six times the rated primary current.

Current transformers for unit protection schemes shall be designed for a stability of not less than the maximum through fault of the units.

Where attracted armature relays are employed the spill current with maximum stability conditions shall not exceed one quarter of the operating current of the relay.

Magnetization characteristics, calculated performance and protection settings shall be provided.

Current transformers shall be of Class 1 accuracy for use with measuring instruments and Class 10P for use with protective relays.

Class 5P shall be used for combined over current and earth fault protection of the inverse time over current type.

One secondary terminal of each current transformer shall be earthed through removable link at the switchgear.

Switchboard Ancillary articles

The following ancillary articles shall be supplied with each switchboard.

- (i) 1 No. black fluted rubber safety mat running the length of the switchboard.
- (ii) 2 pairs rubber gloves to BS 697:1986 – class according to rated voltage or switchboard.
- (iii) 1 No. “treatment for electric shock” metal enamel instruction plate suitable for Screen attachment.

Control Voltages

Within motor starter enclosures the control voltage shall be one of the following:

- (i) The line voltage of the mains supply;
- (ii) The line neutral voltage of the mains supply;

When the starter control voltage is derived externally from the motor starter enclosure the isolator shall operate simultaneously to isolate the power and control.

Where remote control devices are connected into the motor starter the control voltage applied to the device shall be (ii).

If the control voltage is as detailed in (i) then all connections to the control device shall be via starter enclosure mounted relays or volt free contacts utilizing an external source of control voltage complying with (ii). A label shall be clearly installed within the enclosure warning of the presence of an external voltage source if it is not disconnected by the normal operation of the starter enclosure isolator.

Fuses

All fuses shall be high rupturing capacity (HRC) type and one spare fuse for each fuse fitted in the panel shall be supplied, clipped adjacent to the position in which it would be in service. A complete schedule of all fuses in the panel shall be affixed in a convenient position in the panel.

Neutral links shall not be arranged in fuse holders but shall be separately bolted copper links with one link for each fuse.

Unless otherwise specified all fuses shall be of the High Rupturing Capacity HRC type and comply with BS 88: 1975 (1982).

Terminals

All terminals for outgoing connections shall be located within the cubicle adjacent to the respective functional unit.

Space shall be provided to accommodate cable glands of appropriate size for incoming and outgoing circuits and non-ferrous gland plates shall be supplied where single core cables are terminated. All glands plates and trays shall be adequately earthed.

Terminals shall be clip-on, DIN rail mounted, tunnel type terminals with flat pressure plates. For all current transformer and voltage transformer secondary wiring disconnect/test terminals shall be provided to permit short-circuiting and disconnecting of wiring for testing purposes.

The Contractor shall terminate all field wiring and inter-panel wiring at terminal strips. No more than one wire shall be connected to each side of a terminal. 13 ridging bars shall be used for paralleling wires.

Terminals shall be grouped according to the working voltage of the circuits. Segregation shall be provided between low voltage and extra low voltage circuits by means of insulating barriers or by physical separation. Transparent insulating covets with warning labels shall be provided on 230 V terminals. All terminal strips shall be safely accessible with the switchgear in the service position and in normal operation.

All terminals and terminal groups shall be identified with numbers in accordance with schematic and termination diagrams.

Control Wiring

All internal control wiring shall be single conductor, 1.5 mm multistrand flexible PVC' insulated copper wire. For current transformer secondary wiring, voltage transformer secondary wiring and tripping/closing supply bus wiring use a minimum size of 4 mm² multistrand flexible PVC insulated copper wire.

Both ends of every cable core shall be fitted with approved marking ferrules of the interlocking type and identification shall be strictly in accordance with the wiring diagrams. Ferrules shall have black numbers on white background and shall fit firmly over the cable insulation. Ferrules shall be fitted so that on disconnection of cables from equipment the ferrules are retained on the cable. Critchley type Z or Graffoplast ferrules are preferred.

All main runs of wiring shall be enclosed in slotted PVC ducts. Duct sizing shall allow at least 30% spare space after all wires are installed. When not enclosed in ducts, wires shall be neatly and securely bunched and cleated. Keep loops in wiring runs which cross the hinge side of panels to prevent any strain being placed on the wires or terminations. Do not make joints in runs of wiring.

The Contractor shall terminate all control wiring with pre-insulated crimp terminations of the correct size for the conductor and installed with the manufacturer's termination tool. The tool shall be of the ratchet type which requires the correct pressure to be attained before the terminal can be released. Use pin type terminations for tunnel terminals and 1 circle lugs for stud or bolted terminals. The wiring colour code shall conform to BS.6231

Panel Earthing

A continuous and adequately sized copper earth bar shall run the length of switchboard with terminals for connection to the main earthing system. The cross-sectional area shall not be less than the recommendations of IEC439.

Indicating Lamps

Indicating lights shall be of 'oil tight' design. The indicator light shall utilise single hole mounting with a 22.5 mm hole.

Lamp replacement shall be from the front only, without disturbance to wiring or lamp holder.

Each indicator light shall have an engraved label plate mounted directly above the lens.

Where connected directly to a control circuit voltage in excess of 24 V, indicator lights shall be of the incandescent type with integral transformer, 6 V lamp and press-to-test mechanism. The lens shall be coloured glass or heat resistant plastic.

Where connected to a 24 V dc supply, indicator lights may be of the LED type. In this case the lens shall be clear and the colour shall be attained by the use of special coloured LEDs.

The lens colour of indicator lights shall be in accordance with the following:

Red - dangerous condition e.g. motor running; valve open; power on; isolator closed.

Green - safe condition e.g. motor stopped; valve closed; power off; isolator open.

Yellow/Amber - abnormal condition or fault e.g. motor overload or breaker tripped.

Blue or White - any oilier condition as approved.

Lamp test facilities shall be provided for all lamps which are not of the press-to-test type.

Isolating Switches

The compartment-isolating switch shall interrupt all supplies into the compartment to enable safe maintenance to be undertaken. Isolators shall have “ball and stick’ type handles and a fixed post shall be provided to enable the isolator to be padlocked in the off position only. One padlock with 4 keys shall be supplied for each isolator on the board.

Current Transformers see else where section

Voltage Transformers

Voltage transformers shall be of the isolatable epoxy resin insulated type with a secondary three phase voltage of 110 volts, and shall comply with IEC 186.

The primary shall be protected by HRC fuses which together with the connections between the fuses and the primary conductors shall be adequately rated to withstand the short circuit rating of the switchgear.

Fuses shall be included to protect the secondary windings, and they shall have safe access for renewal.

Protective Devices

The Contractor shall provide all necessary protective devices such as over current, short circuit, over/under voltage, earth fault relays etc, and be shall be responsible for so designing the protection that it is entirely suitable for the equipment being protected and relates correctly to the whole supply system.

Protective systems and devices shall comply with IEC255.

Safety Notice and Equipment

For each switchboard the Contractor shall supply the following equipment:

1 No. Notice in Sinhalese and Tamil as applicable language advising treatment for a person suffering from electric shock.

Interlocking

Mechanical interlocking shall be provided where possible. All electrical interlocking shall be of the double interlocked type having separate permission and prohibitive interlocks. Thus to allow a device to operate there must be an absence of prohibitive signals and a presence of permissive signals from the remaining devices in the interlocked system.

Suitable equipment shall be provided mechanically to prevent a device being manually operated when a prohibitive signal from another part of the interlocked system is present.

Control Relays / Auxiliary Relays/Interposing Relays

Relays shall be suitable for operation on a nominal 230V AC or 24V DC supply as required by the circuit design. Relays shall be suitable for operation at +10% and -15% of their nominal rated voltage.

They shall be of the plug-in type only complete with plastic cover and shall be fitted with normally open/normally closed or changeover contact combinations as necessary.

The contact materials shall be suitable for their specific application.

Mixed voltages must not be used on the different contacts of a particular relay. Additional relays shall be used, if necessary.

Coils shall be vacuum impregnated or guaranteed suitable for the climatic conditions specified.

Terminations to the relay bases shall be of the front connected screw clamp type. Relay bases shall be of DIN rail mounting type.

Relays shall be secured to their bases by retaining bar or clip to prevent malfunction due to the relay being loosened in its base.

Care shall be taken to ensure that relay contacts and associated wiring is suitably fuse protected.

DC operated relays shall have a miniature light emitting diode mounted within their clear covers which shall be connected directly across the relay coil to indicate when supply is connected. These indicators shall be easily seen when the relay compartment door is opened. A.C operated relays shall in a similar manner each be fitted with a neon indicator.

Relays having different contact configurations or different coil voltages shall under no circumstances be interchangeable.

A permanent means of identification shall be affixed to both relay and base and shall correspond with the circuit diagram reference.

Where remote supply voltages are used then care shall be taken to ensure that all relays and any other equipment involved such as terminals, fuses and the like are completely shrouded and segregated. A warning label shall be fitted onto or adjacent to any such equipment. Similarly where

voltages exceeding 55V to earth are employed in relay compartments or non-door interlocked sections then shrouding segregation and warning labels shall be applied.

Protection Relays

Protection relays and associated devices shall be provided as applicable. All switchboard relays shall be of the withdrawable pattern in dust-proof cases. Protective relays shall comply with IEC255.

Secondary injection shall be easily possible by means of purpose-made voltage and/or current plug-in type test terminal blocks which automatically open circuit or short circuit the integral voltage transformers or current transformers respectively and provide terminations for the test supply. Disconnection of any permanent wiring will not be acceptable.

2.5 Fuse Switches

General

Fuse switches shall comprise flush mounted heavy duty composite air break switches and fuse units complying with and fitted with fuses to IEC269 and shall be rated and equipped as detailed. Composite units shall be contained within an enclosure of metal and shall be fitted with an earthing terminal or equivalent to enable the enclosures to be earthed irrespective of any means of connection such as is provided for attaching armouring or other metallic covering of the cable supplying composite unit.

Enclosure – safety requirement

The enclosure shall be so constructed that the cover cannot be opened until the switch is fully opened and the construction shall be such that when the cover is opened a competent examiner can override the interlock and operate the switch. After such operation the cover shall be prevented from closing with the switch position indicator in a false position.

Switches shall be provided with mechanical ON/OFF indicators and operating handles.

Means shall be provided for locking the switch in the OFF position only.

Fuses

The fuse shall either include a suitable fuse carrier or it shall be capable of isolation. If the fuse carrier is included it shall be such that when it is being withdrawn normally or when it is completely withdrawn the operator is completely protected from accidental contact with any live metal of its fuse link fuse contacts and fixed contacts.

If the fuse is capable of isolation it shall be so interlocked with the switch that isolation is complete before the fuse enclosure can be opened further. The switch shall be prevented from closing while the fuse-cover is open.

2.6 Feed Pillars

Feed pillars shall be outdoor type free standing with lifting eyes, constructed of galvanized steel sheet 3 mm thick and painted grey in colour.

Each feed pillar shall have one incoming line and necessary number of outgoing ways with HRC fuses for protection of incoming and outgoing lines, shall be weather and vermin proof with minimum IP55 protection class and adequate ventilation. The door shall be provided with an integral lockable key and handle. Cable entry and exit shall be from the bottom, through suitable ducting in the supporting plinth and foundation. The support plinth shall be constructed from grade 25 concrete.

2.7 Motor Starters

General

The starter cubicles as required are to form part of a motor control centre and as such shall include all circuit connections, protection and control devices. The cubicles shall be easily accessible for maintenance purposes and shall be damp-proof and dust-proof. The motor starter shall be of rating to carry the full load current of its rated duty at its most severe load conditions. All starters shall be capable of at least 10 starts per hour at 100% full load torque.

Each starter shall be housed in a separate compartment which shall contain the following: -

- 1 No. Triple pole (TP) externally operated moulded case circuit breaker interlocked with the compartment door with provision for using a padlock to lock it in the OFF position and provided with suitable number of auxiliary contacts.
- 1 No. TP contactor fitted with the necessary number of auxiliary contacts.

Where an autotransformer starter is required there shall be provided magnetically operated starting accelerating and running contactors operating under electronic timing devices. The auto-transformer, with insulation class H up to 220°C, shall limit the starting current to that specified for the size of drive and full load current (FLC) with 60%, 70% and 80% tapings .

Ample short time duration capacity to be able to start the relevant motor efficiently. PTC sensors attached to the winding shall be provided with

- 1 No. Three pole thermal overload relay with double trip bar or similar offering single phase protection. The relay shall be fully adjustable but set at the optimum current setting required to give protection against a normal running overload condition.

Contactors shall be three pole, air break, block type complying with IEC947-4-1. The design shall be such that the coil and all contacts can be changed without disconnecting the line or load side three phase circuit wiring.

The main contacts shall be silver alloy double break type.

All coils shall be fitted with a surge suppression device.

The utilisation category shall be AC-3 minimum.

The duty shall satisfy both uninterrupted and intermittent operation.

The mechanical endurance shall exceed one million no load operating cycles.

Thermal overload protection shall comply with IEC947-4-1. The thermal overload protection shall operate under any or all of the following conditions:

Overloading in continuous or intermittent operation.

Extended acceleration time.

Failure of one phase of the supply.

Jamming of the motor.

For motors rated 15 kW or less the motor starter shall include a thermal overload relay consisting of an ambient temperature compensated, bimetal type thermal overload sensing element with differential sensing to operate at 25% out of balance under single phasing conditions. The relay shall be the same make as the contactor and shall be fitted directly to the load terminals of the contactor. The following standard features shall be provided:

Manual test button.

Mechanically or electrically operated manual reset button.

Adjustable overload setting.

Auxiliary contact rating 4 A, 230 V AC .

For motors from 15 kW to 185 kW rating the motor starter shall include an electronic motor protection relay consisting of an ambient temperature compensated, thermal overload sensing element with differential sensing to operate at 25% out of balance under single phasing conditions plus thermistor over temperature protection. The relay shall be the same make as the contactor and shall be fitted directly to the load terminals of the contactor. The thermistor relay may be built in to the overload relay or implemented as a separate device. The following standard features shall be provided:

Manual test button.

Mechanically operated manual reset button.

Adjustable overload setting by means of DIP switches on the front of the relay.

Selection of time/current tripping curve.

Inbuilt current transformers.

Separate visual indication of overload and over temperature trip conditions.

Auxiliary contact rating 4 A, 230 V AC to utilization category AC-I I.

Documentary evidence must be produced showing the current/time characteristic of each overload at its setting (hot/cold for the thermal overload) overload on the motor manufacturers thermal stability time/current characteristic for comparison. Consideration must be given as to the requested method of starting (DOL, auto transformer, star/delta or VSD).

1No. set of auxiliary relays and timers required to provide the necessary indication and control sequence.

- 1No. set of main motor terminals and auxiliary terminals for remote controls and indications complying with
- 1No set terminals for remote lock-off-stop push button.
- 1No 230/110V 50 Hz double wound single phase transformer with earth screen and of suitable capacity to supply all control circuit and pilot lamp requirements.

The transformer secondary shall be center tapped and earthed via a removable bolted earth link. The transformer primary shall incorporate a suitably rated fuse and neutral link with the control and lamp circuits having separate fuse protection on each side.

- 1No anti-condensation heater (off when starter contactor is closed). The heater shall be separately fused.

The following equipment shall be mounted on the front of the control panel:-

- 1 No ammeter fitted with suppressed scale to read motor running and starting current.
- 2 No pilot lamps to indicate 'MOTOR RUNNING' (Red.) and 'MOTOR FAIL' (Amber)
- 1 No "HAND/OFF/AUTO" selector switch.
- 1 set "START/STOP" push button.
- 1 No. externally operated overload reset push button.
- 1 No. hour counter reading to 9999 hours.
- 1 No Duty Label.

Remote indication

In view of the fact that remote indication of all drives may be required in the future each starter should be designed for this purpose.

The signal for the remote indication will be taken via auxiliary contacts fitted to the isolators and contactors or relays of the individual starters.

Automatic Control

The motors in some groups will be required to operate in a predetermined sequence and starters for these shall include suitable auxiliary relays and contacts.

Field control units (FCU)

The contractor shall provide FCUs to operate valves, pumps, aerators another consumers at the location of installation during maintenance or control system failures.

Services and Deliveries

For each valve, pump, aerator, etc. a local control switch box has to be mounted at a location where the function of the equipment can be observed. For this encapsulated switchgear assemblies with the degree of protection IP 65 are required. They must be suitable for use in water treatment plants and

outdoor mounting. The casings for surface mounting are installed vertically, with cables fitted from below to a screwed watertight gland according to the cables. Labels, white with black inscription, have to be fixed with screws.

The switchgear assembly consists of:

Suitable number of pushbuttons with flat button and a cover plate resistant to abrasion, with inscription (e.g. "Open", "Close", "Stop", "On", "Off", "Slow", "Fast", etc.)

1 key lock switch according to plant's locking system, for electrical blocking of the pushbuttons, with abrasion-proof label "Local control - Off - Central control", key removable in all switch positions

1 mushroom-head emergency pushbutton (red), latching, including key lock according to plant's locking system and surrounding circular yellow label with black inscription "Emergency Stop"

Sign in red colour, fixed with screws, in English language: "Before working at this machine the main power supply must be switched off and locked"

The emergency-stop-button has to be equipped with two NC contacts.

Due to heat, dust and rain all field-mounted key locks underlie heavy abrasions and may be blocked by dirt if no special precautions are taken. Therefore the Contractor shall propose various adequate locking systems like safety-lock, square-key, triangular-key, etc. to the Engineer for consideration.

The whole switchgear assembly is surface-mounted into a weather-proof casing made of high-grade steel (material 1.4541 / V2A) installed on a suitable pole with protective sun and weather roof, made of high-grade steel (material 1.4541 / V2A), each key lock provides a protective cap to protect the cylinder from being affected by dirt. The installation ready for operation and all mounting and installation material have to be included.

Tower water level transmission

All towers shall be equipped with level sensing equipment and communication equipment to transmit water levels to the treatment plant control room. Ultra sonic, probe type sensors or submersible pressure sensors with communication link with antennas shall be used for this purpose.

Where there is no local authority power supply available, battery pack with solar charger shall be provided to power level sensing equipment and communication equipment. The battery pack shall have the capacity to supply the load during the night with out interruption.

In other locations UPS together with power supply from the local authority should be provided. UPS shall be rated to supply the required load for 08 hrs in case of a power outage. Data collected shall be applied to control the HL pumps at the treatment plant.

2.8 Electric Motors

General

Motors shall be selected from the following to satisfy the contractors performance requirement.

All motor enclosures shall satisfy and be selected from:

- (a) IP 54 for general-purpose drivers.
- (b) IP 65 for outdoor use or machines subject to splashing or washing down.
- (e) IP 65 for submersible machines.

The motors shall run in ball and/or roller bearings and the weight of the motor shall be carried by thrust bearings incorporated in the motor body.

The efficiency and power factor of the motors shall be high over a wide range of load conditions and the motors shall be designed manufactured and tested in accordance with

IEC34 for continuously rated industrial electric motors with ('Class 'F' insulation but limited to Class B 'temperature rise). The maximum continuous rating (MCR) of capacity of the motor shall be as set out in the following table and shall be rated and designed to suit the climatic data specified elsewhere.

Type and Rating

- (i) Type : Horizontal or vertical, totally enclosed type
- (ii) Cooling method : Self-ventilation
- (iii) Number of phases : Three (3) phase,
- (iv) Rated frequency : 50 Hz
- (v) Rated voltage : 400V AC
 - Low voltage
- (vi) Class of rating : Continuous
- (vii) Class of insulation
 - 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 : 35 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 : 1% 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) Over speed : 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.)

A motor shall be capable of starting 10 times per hour. The stalled motor current shall not exceed 6 times full load current.

The noise level of any motor shall not exceed 85 dBA. All motors shall be statically and dynamically balanced and shall run free from vibration.

Motors rated in excess of 11 kW shall be fitted with anti-condensation heaters of a size to maintain the temperature of the windings above ambient when the motor is not running. Each heater shall be provided with an auxiliary contact in the motor starter to automatically disconnect it when its motor is in operation.

The motors shall be suitable for bidirectional rotation and the direction of rotation corresponding to standard phase rotation R-Y-B on terminals A-B-C shall be clearly indicated on the stator frame. For self ventilated machines, the bidder shall state whether machines are fitted with unidirectional or bidirectional fans and if any impediment to reversal of direction exists.

Motors shall be totally enclosed fan cooled (TEFC) type

All motors and terminal boxes shall be protected to at least IP55

All motors shall be tropic-proofed. The additional treatment carried out to cater for this requirement shall be fully detailed in the bid.

All mechanical parts of motors shall be either cast iron or mild steel. Aluminium frames and plastic fans are not acceptable.

Bearings shall be end shield mounted ball or roller type for all sizes of machines.

Bearings shall be rated in accordance with DTN 622 for a L10 life of 50,000 hours with a factor of safety of 2.

All motors shall be fitted with a grease relief bearing arrangement. The arrangement shall be such that when new grease is forced into the bearing, it enters from one side, passes through the bearing and purges old grease out the other side out of the motor enclosure. It shall be possible to carry out greasing while the motor is in operation without causing excessive bearing temperature rise.

A hydraulic type of grease nipple is preferred incorporating a check ball. A plastic cap to prevent the accumulation of foreign matter is also required.

The type of grease recommended for each motor shall be stated on the motor data sheet.

Unless stated otherwise on the motor data sheet, all machines shall have. Standard single shaft extensions keywayed and with keys.

Terminal boxes shall be provided with glands suitable for PVC sheathed cable. The motor steel base where appropriate shall be drilled at works vertically below the terminal box gland for the passage of the cables and the edges of the hole slightly countersunk or the hole bushed.

Arrangements shall be made with the manufacturers so that the Employer may witness motor tests if so desired.

2.9 Power Factor Correction Capacitors

General

The Contractor shall furnish and install power factor compensation equipment for all motors above 5HP all discharge lamps. To maintain the power factor at 0.95 lagging, under varying conditions of load.

Particular attention should be given to the fact that harmonic distortion would be created by frequency converters, starters etc. Suitable arrangements should be made to provide filters or draining circuits to overcome this problem. In these arrangements harmonics up to the 13th Harmonic should be taken into consideration

The size of capacitor shall be selected to correct the power factor of the motor at its duty point but should not exceed the magnetizing KVAR of the motor even if a lower corrected power factor results.

The capacitors shall be of the oil or synthetic oil immersed type with paper or paper and plastic film dielectric in an oil tight steel tank complete with discharge resistances. A metal enclosed terminal box shall be provided with cable entry sealing facilities. Polychlorinated biphenyls or askarels are not acceptable impregnates.

The capacitor shall be connected after the line contactor but before the motor protection overloads and ammeter such that the motor current only is indicated.

All capacitors shall have a 3-phase set of protection fuses.

(2) The following standards are referred to: BS 650, IEC 70 Power Capacitors, IEC 801 Radio frequency interference, IEC 529 Degree of Protection

2.10 Variable Speed Drive (VSD)

Contractor may use Variable Speed Drive (VSD) for pump speed control.

The VSD shall be a product designed for water pumping applications from an Original Equipment Manufacturer operating and doing business at least for 10 years worldwide in the similar field under the present company name. Further the supplier of VSD should show reference of doing similar systems and works in Sri Lanka and should have a local branch or office and guarantee after sales services.

VSD shall be capable of:

Controlling speed of standard squirrel cage induction motors

Controlling the speed through out the required range with out imposing vibrations in the associated pipe work

Controlling parallel motors of mixed ratings

and disconnect any machine whilst running without causing tripping, running with no motor connected for service functions accepting power factor of the motor for energy saving

Efficiency:

Minimum efficiency at 100% load – 96% for up to 90 kW

Minimum efficiency at 100% load – 96% for over 90 kW

And at 20% load - 92%

If necessary cascade controller can be include as an integral part of the VSD, configured via keypad of VSD without requiring external programming and monitoring devices.

VSD shall have standard protections such as Heat Sink over temperature, Under Voltage and over voltage as minimum.

The contractor shall ensure trouble free operation of the equipment under the climatic conditions of the location of installation.

Equipment shall conform to recognized international standards and be manufactured to ISO 9001, IEC 1000, BS 5750 part 1 and 2 and shall be carry mark on EMC compliance from an internationally recognized laboratory such as CE, UL.

The Contractor shall:

arrange to provide training for the NWS&DB staff in operation and maintenance of VSD locally, and at the manufactures factory.

supply equipment, tools and spare parts necessary for 05 years of operation according to manufacturer's recommendation.

2.11 Cables

General

The wires and cables used shall be:

600V PVC insulated wire (IV)

600V heat resistance PVC insulated wire (HIV)

600V Vinyl insulated vinyl sheath cable (CVV)

600V vinyl insulated vinyl sheath cable with shield (CVVS)

600V cross-linked polyethylene insulated vinyl sheath cable (XLPE)

600V Steel armoured cross-linked polyethylene insulated vinyl sheath cable (SA-XLPE)

The Contractor shall ensure that each cable is of sufficient rating for its normal and fault conditions. To assess the rating and cross section required for each cable the following factors shall be considered:

- (a) Fault level.
- (b) Conditions of ambient temperature relevant to method of installation.
- (c) Voltage drop.
- (d) Voltage drops in motor circuits due to starting.

- (e) Over current setting of circuit breakers.
- (f) Proximity of adjacent cables.

The Contractor shall submit details of the cable sizes for the Employer's approval before ordering.

The selection of cables shall be based on the following conditions:

- (i) Ground temperature 25 oC
- (ii) Air temperature 40oC

The Contractor shall prepare technical schedules showing all principal power and control cables/wires to be supplied. All such cables and wires shall be numbered in the Schedule; the same reference numbers being used in the specifications. The following data shall be included for all cables in the schedule.

- (a) Cable identification number.
- (b) route from/to
- (c) type of cable.
- (d) derating factor used
- (e) cross sectional area (sq.mni)
- (f) length (metres)
- (g) number of cores (excluding earth conductors)
- (h) number of spare cores
- (i) type of cable construction

The format and details to be included in record schedules shall be agreed with the Employer.

No cable of less than 1.5 sq.mni. section shall be used throughout the installation.

All cables used shall bear the manufacturers original guarantee and all cables shall be delivered to Site in their original wrappings. The Contractor shall obtain the permission of the Employer before any cables are installed or wrappings removed. All cables shall have manufacturer's name, voltage grade marking on its outer surface at equal intervals not more than 5 meters.

PVC insulated Cables

PVC Insulated cables shall comply with IEC227 and shall be 600/I000V grade. The cable used shall not be less than 2.5sq.mm. cross-sectional area. Cables shall consist of stranded copper conductors, PVC insulation and an overall PVC sheath.

For multicore power cables the PVC insulation shall be coloured to indicate the phase. For multicore control cables the insulation shall be coloured white and shall have numbers embossed at regular intervals on the core.

Tests

The following tests shall be carried out by the contractor, in addition to the tests specified in the respective standards:

Routine Tests in factory

- Construction test
- Resistance measuring
- Withstand voltage test
- Insulation resistance test
- High temperature insulation resistance test
- Tensile strength test
- Coiling test
- Thermal shrinkage test
- Oil proof test
- Non-inflammability test
- Shield conductivity test
- Impulse breakdown voltage test
- AC breakdown voltage test
- Chlorine gas measurement

Method of cable connection to plant and equipment

A minimum length of 250 mm tails shall be left on all cables at outlet positions for connection of the lighting fittings or other apparatus fed by the outlet.

The installation of multi-core and single core cables or bunching of cables in conduit is to be carried out on the assumption that such cables will carry alternating current.

The Contractor shall include for terminating each cable in excess of 30 amp current carrying capacity in a pressure operated mechanically crimped lug terminal or terminal socket. The contractor shall use heat shrinkable terminating kits for terminating power cables at the MCC and LV switchboards.

The earthing conductor shall be of adequate cross sectional area and shall either be one core of a multicore cable or a separately run single core cable. The use of conduit, water or other service pipes in any part of the earth continuity conductor is strictly prohibited.

The Contractor shall supply and install all necessary cable glands and sealing boxes, terminating kits required to complete the installation. All materials used in the manufacture of the glands shall have no deleterious effect on the cable core or armouring and shall be non-corrodible.

The cores of each cable shall be taken direct to the terminals of the equipment to be connected. Cable ends shall be sealed in suitable chambers bolted to terminal boxes.

The general routing of cables may be indicated on the Drawings but the final routes shall be agreed with the Employer before any work in connection with the cable is carried out. All cables shall be installed in strict accordance with the requirements of this Specification.

2.12 Underground Cabling Methods

General

All cables shall be either clipped to walls ceilings and buildings structures, installed on cable ladder or tray or run in conduits, ducts and trenches or direct buried. All cable hangers, cleats, saddles, brackets and similar supporting devices shall be of an approved type and of adequate strength for the cable they are supporting, non-ferrous and so treated as to withstand site conditions without corroding.

Every cable whether in or out of sight shall be neatly run vertically horizontally or parallel to adjacent walls beams or other structural members.

Spacing of clips saddles and cleats shall be such to prevent sagging of the cables at all times during their installed life.

Cables run in indoor trenches shall be segregated and run on trays or brackets secured to the trench wall. No cables shall be run on the bottom of these trenches.

Where a Number of cables are terminated to any particular item of equip then special care shall be taken to ensure that the cables finally approach the equipment from a common direction and are individually terminated in an orderly and symmetrical fashion.

The Contractor shall prepare drawings showing his precise requirements for cable trench work detailing the width and depth of trenches and indicating the mad crossing cable ducts required. These drawings shall be prepared in consultation with the Employer and be approved or reviewed before issue.

The sanding and laying of buried cables shall satisfy the following requirements:

- (a) Cables shall be laid at a depth of 600 mm for LV and 1000 mm for HV cables. The depth shall be assessed from finished ground level unless otherwise directed by the Employer. In case depth as above is not possible due to obstructions, the Employer's direction and approval shall be obtained. LV and HV cables shall not be run in the same trench. Cable shall be run in steel conduits when crossing roads and such conduits shall be laid 600mm below the surface of the road
- (b) Before laying cables the Contractor shall inspect the trench work to ensure that the bottom of each trench is firm and of smooth contour and free from broken stones or rock.
- (c) 100 mm of sand shall be placed in the trench to form bedding for the cables.
- (d) Cables shall be laid with adequate separation and shall be gently "snaked" to avoid tension during backfilling and subsequent settlement.
- (e) Before sanding and backfilling all laid cables shall be inspected by the Employer.
- (f) After cables have been laid they shall be covered with a further 100mm of sand which shall be well tamped around the cables. Mechanical compaction devices shall not be used for this work.
- (g) After sanding cable covers shall be placed in position to overlap the cables by a minimum of 50mm either side of the cables,

- (h) The Contractor shall carry out backfilling and be responsible for ensuring that cable covers are not disturbed and that no large rocks or stones are included in the backfill material.
- (i) After backfilling the Contractor shall reinstate to finished ground level.
- (j) The Contractor shall supply and lay in position the necessary cable route marker posts at a maximum of 10 metres apart and at any change in direction of cable route.
- (k) The Contractor shall supply cable cover tiles. These shall be of precast concrete type complying with BS2484 and engrave "Electricity" or other suitable legend.

Where cables enter or leave buildings the ducts shall be sealed at the points of entry into the building. The Contractor shall include for caulking with an approved sealant compound and followed by not less than 40mm of bitumen compound or a weak sand/cement mixture as directed by the Employer. Care must be taken to ensure that the PVC sheathing of cables is not damaged during caulking.

Wherever it is necessary to remove the PVC sheath of a cable (e.g at a joint) the minimum length necessary shall be removed.

All cable shall be delivered on robust cable drums with cable ends treated to form an effective seal. When a cable is cut from a drum the cable end tell on the drum shall be immediately sealed in an approved manner to prevent the ingress of moisture.

Each and every cable shall be permanently identified at each end by its cable number. Cable markers shall comprise oval markers with semi-rigid black PVC carrier strip and shall be fixed axially by means of two PVC covered aluminium strips with buckles. Cable markers shall also be installed at entry and exist points of buried ducts, exits from buildings and in such other positions as are necessary to identify and trace the route of any cable.

All power cables shall be connected to main switchboards and other items of plant so that the correct phase sequence and phase colour coding are preserved throughout the system. All such cables shall be identified with phase colours for 3 and 4 wire systems and Red and Black for single phase.

In addition control cables shall have individual cores identified by means, of suitable permanent ferrules bearing the same numbers at both ends. Core identification shall occur at every point of termination using an approved system of ferrule markers. Numbering shall read from the terminal outwards on all cores. At those points of interconnection between wiring where a change of number cannot be avoided double ferrules shall be provided on each wire. The change of numbering shall be shown on the wiring diagrams of the equipment at which the change is made. The ferruling method followed to identify all control cable shall be starting from outwards of each case and starting from

- (1) Cable No. as per the cable schedule

- (2) Core No. for that particular cable
- (3) Terminal No. as shown in wiring diagram.

Junction Boxes

Should the Contractor propose to use junction boxes in auxiliary control cable circuits for the purpose of marshalling a number of cables feeding to a common item of equipment details shall be

given to the Employer and the Contractor shall only proceed after receipt of the Employer's written approval. Any such junction box shall be of the wall mounting pattern with double terminals with cores labeled and identified in accordance with the system schematic and cable diagrams.

2.13 Conduit System and Associated Cables

General

Approved conduit systems shall comply with IEC6 14. All conduit and fittings shall be hot dip galvanised.

Non-metallic conduit systems shall not be used without written permission of the Employer, Conduit shall be run on the surface or embedded in concrete as specified and be neatly arranged and ways shall be provided for additional conduits at all distribution boards. The sizes of conduits used shall be determined by the number of cables to be drawn in but in no case shall conduit less than 20 mm diameter is used. Embedded and concealed conduit systems shall support fittings independently of any false ceiling.

All conduits shall be installed in an approved manner and arranged with adequate ventilation and drainage where necessary. Where practicable all bends or sets shall be formed in the conduit itself. The Contractor shall ensure that conduit draw-in boxes and junction boxes are of sufficient capacity to allow all cables to be drawn in or withdrawn.

The whole of the conduit system shall be completely swabbed through to remove any loose matter or dirt before cables are drawn in, Where conduits connect to switch boxes draw-in boxes and the like the conduits must have a machined faced socket screwed on to the end which when tightened is flush with the outside of the box. The conduit is then to be secured to the apparatus by means of a hexagon smooth bore brass bush screwed from the inside of the apparatus into the conduit socket in order to make a sound and tight mechanical joint.

Surface run conduits shall be supported at intervals in accordance with the following schedule:

Size	Interval
20mm	1.2m
25mm	2.0
32mm	2.5m

Where bends and sets occur in the conduit run the conduit shall be securely fastened at a distance 225mm either side of the diversions.

Standard junction or adaptable boxes shall be provided at all junctions and at sharp changes of direction in addition to any special positions where they are called for by the Employer on Site. Steel or malleable cast iron inspection couplers may be used in long runs to facilitate drawing in cables

Particular care must be taken to ensure that no water is allowed to enter conduit at any time and all conduits shall be arranged with adequate ventilation and drainage where necessary as directed by the Employer. Inaccessible junction boxes will not be allowed. Only continuous lengths of buried

conduit shall be installed between boxes. No joint boxes being allowed in the floor screeds. Conduits crossing expansion joints shall be fitted with couplings of approved manufacture with an earthing clip at each side of the coupling connected by the correct size of tinned copper stranded wire.

The ends of conduits laid or set in form work prior to concreting shall be temporarily sealed off in an approved manner to prevent the ingress of concrete or other foreign matter.

Fixing to surfaces of walls shall be by means of spacer bar saddles securely fixed by screws. Where conduits are concealed or laid in structural floors they shall be held in position with substantial fixings of make and pattern to be approved by the Employer.

Conduit shall be of the screwed pattern galvanized by the hot dip process. All conduit fittings not carrying accessories shall be supplied with flat covers (fixed in position with round head brass screws rubber gaskets being utilized).

Adaptable boxes shall be cut 01 minimum 3 mm sheet steel or best quality cast iron finished as previously detailed for conduit boxes and sized to prevent the undue packing of cables in them.

Weather proof boxes and accessories shall be used outdoors where agreed on Site by the Employer or where indicated in this Specification.

Conduit shall be installed such as to permit complete rewiring without the need to remove false ceilings or carryout builders work.

No single conduit serving single phase socket outlets lighting points and switches shall contain more than one phase.

Wiring shall be carried out on the looping-in system and no joints other than at looping- in points will be allowed.

Flexible conduit

Where the conduit system terminates at any equipment requiring a non-rigid connection a flexible conduit shall be installed of the PVC or PVC sheathed metallic type fully watertight with purpose made connection adaptors.

Each flexible connection shall include not less than 400 mm length of flexible conduit and a separate earth conductor shall be run within the conduit connected to the earth terminals in the equipment and the fixed conduit run. The flexible conduit shall not be used as an earth continuity conductor.

Cable Tray

Cable trays shall be manufactured from not less than 2 mm thick perforated hot dipped galvanised steel or aluminium alloy. The edges of the cable trays shall be bent at right angle and each edge shall not be less than 25 mm in height. The perforated holes shall be at such a distance and of such a size that easy clamping of cables using clamps and nut bolts is possible.

Cables which shall be attached to cable tray or structure by saddles or cleats respectively shall be spaced to ensure a 25 mm gap between cables. The spacing of supports shall be 1200mm in all cases where cables are supported by cable tray and 750mm where supported from tray or by cleats. All cables shall be saddled or cleated in position as they are installed along the route. All cable tray changes in direction or level shall be made via sets and adequately sized angles to provide a support to the cables. All cables runs on trays shall be fixed to the tray by purpose made approved fixing clamps. Cable tray brackets shall be of galvanized steel in accordance with this specification.

2.14 Distribution Boards

General

All distribution boards shall be of the totally enclosed metal clad type.

The enclosure shall be made from mild steel formed to a clean line and complete with a lockable-hinged cover with gasket. Removable plates with conduit knockouts shall be provided at top and bottom. Refer to sec. Painting of enclosures and cubicles

All distribution boards shall be complete with an isolator of the same rating and number of phases as the upstream protective device through which it is fed.

Doors shall be fitted with gaskets and shall be easily removable to preserve the finish and simplify installation. Each distribution board shall be arranged for top and bottom cable entry and shall be provided with an ample cable termination plate and chamber to enable cables to be neatly glanded with tails grouped and terminated onto appropriate internal terminations. Distribution boards shall be wall or floor mounted and shall when specified incorporate on-load isolators which shall be front of panel operated with ON/OFF indicator and capable of being padlocked in the OFF position. Distribution boards shall incorporate combinations of single pole and triple pole miniature circuit breakers (MCBs) as specified.

Each bank of MCB's shall be clearly identified with its appropriate phase colour code and the mounting framework for the banks of MCB's shall be easily removable to simplify installation. Adequate phase barriers and shields shall be fitted to ensure that after installation and wiring all bare terminals and wires are covered to prevent accidental contact with live conductors during the normal procedure of fuse changing and resetting of MCB's.

All neutral bars shall have a separate terminal for each circuit within the distribution boards.

The termination of the circuit cables at distribution boards shall be neat and slack left at each MCB or neutral bar to enable the complete assembly to be removed for inspection without disconnection. Neutral conductors shall be connected to the bar in the same order as the phase conductors to the MCBs.

Each distribution board shall be complete with a permanent circuit identification chart preferably mounted within the front door. This chart shall be permanently and legibly filled in as circuits are completed the circuit description including the fuse rating.

Painting of distribution boards shall be in approved colours.

Miniature Circuit Breakers (MCBs) and Moulded Case Circuit Breakers (MCCBs) as incorporated in distribution boards shall comply with IEC947-2. They shall be fitted with thermal overload and instantaneous magnetic short circuit protection.

Back up HRC fuses shall be fitted if necessary to provide the rupturing capacity but the ratings of the MCBs and MCCB's must be correctly coordinated with the fuse rating to achieve the necessary degree of discrimination.

All fuses shall be of HRC cartridge pattern to IEC269.

Fuse holders and fittings shall be made of moulded plastic insulating material of an approved make. Ceramic materials will not be accepted. Fuse fittings shall be fully shrouded and it shall be possible to change the fuses without danger of contact with live metal.

Protection against Earth leakage

When used for lighting and small power in buildings and houses an Earth leakage Circuit Breaker (ELCB) shall be incorporated.

Wiring in Buildings

Unless otherwise specified on particular installations or parts there of wiring shall be carried out with PVC cables enclosed in heavy gauge screwed galvanised conduits. Minimum copper conductor size used shall not be less than 1.5 sq.mm. The use of junction boxes between fittings shall be kept to a minimum and where practicable all connections shall be made at the fitting. Where used junction boxes shall be rectangular pattern, and accessible. Circuit wiring shall not be connected directly onto the terminals of lighting fittings but shall be made off in point boxes consisting of a standard box containing shrouded pinch screw connectors to which connections shall be made to the light fitting by flexible cables.

Switches

Surface switches shall be of high impact plastic with a degree of protection of IP56. Where appropriate they shall be of the "Multiple Phase" type and where possible shall be arranged in multigang boxes. Switches shall be rocker type.

Exterior lighting switches shall be watertight galvanised steel-clad (or other approved material) with rocker switch action.

Special care shall be taken to ensure that all switches are securely fixed truly vertical and that flush mounted switches are flush with the wall finish so that the overlapping cover plates seat onto the rims of the boxes.

Not more than 10 fluorescent light fittings (20 tubes) shall be connected to any 5 amp lighting switch. Lighting fittings shall be distributed evenly between phases and throughout buildings to reduce stroboscopic effect and also to ensure that the loss of any one phase or contactor does not leave any area in total darkness.

Operating switches and contactor energizing coils shall also be distributed among phases.

2.15 Earthing

The scope of supply of the earthing system includes supply of earthing conductors, earth electrodes; their installation and approval to the satisfaction of the Employer under the tender specification.

Earth Network

The Contractor shall establish an earthing system for the works to ensure that dangerous voltages cannot appear on any metallic equipment due to 'a failure of the insulation system. The earthing system shall be designed to suit the distribution system. The earthing system shall ensure equipment and personnel safety and ensure proper operation of protective devices during earth fault conditions.

Connected Items and equipment

Metallic frames of all electrical equipment, control and distribution panels, socket outlets, all metallic conduits and pipes shall be securely connected to the earthing system.

All metallic conduits and pipes shall be connected to the earthing system.

Wires and tapes

- (i) 600V Vinyl Insulated Wire
- (ii) Soft annealed Copper Stranded Bare Conductor
- (iii) Copper tape on LV equipment 38mm x 5mm copper tape.

The metalwork of ALL items of electrical equipment provided in the Contract shall be securely bonded to earth. Earthing shall be effected by means of the earthing conductor in multicore cables or by means of a separate earthing conductor.

Continuity through equipment

Particular care shall be taken to ensure continuity across items of equipment situated within a cable run and should the design of such equipment not give adequate and lasting continuity through its structural body then additional earthing clips and conductors shall be provided to independently bond the cable sheaths together. Similarly additional earthing clips shall be provided to bond the cable sheaths to any piece of apparatus fitted with a special earth terminal should the earth connection of the terminating gland be considered inadequate. Any additional earthing clips shall be contained within the apparatus wherever possible.

The earth tapes shall be protected against corrosion and be complete with test links. When run on walls tape shall be held in position by saddles fixed by suitable fasteners.

Connections

Connections shall be securely made by either exothermic welding crimping or by a bolted clamp specifically designed for the purpose and shall be electrically and mechanically continuous. Joints between the main conductor and the earth electrodes shall be readily accessible for periodic inspection and shall be protected against damage and corrosion.

Where rigid or flexible conduit and/or trunking is incorporated into the Works a separate internal earth conductor shall be run which shall be securely bonded to the terminating apparatus by means of a special earth terminal. All bimetallic connections shall be treated with suitable compound to prevent moisture ingress.

Disconnecting and inspection chambers

Disconnecting chambers shall be provided for testing the earth periodically. Concrete disconnecting chambers with removable cover and disconnecting link, for test purposes. The top of the chamber shall be at finished ground level.

Test links

The test link shall be of copper or brass and not less than the connecting cables cross sectional area and shall have a generous contact area. Joints at the head of the earth rods shall be easily accessible for periodic inspection.

Disconnecting bolts, nuts, locknuts and washers shall be made from phosphor bronze

Interconnections

The earth for interconnections shall be an electrically unbroken ring and interconnections shall be PVC insulated stranded copper conductor. The cable shall be of sufficient low resistance to carry the maximum fault current for a period equivalent to the clearing time of the protective equipment without undue temperature rise. The earthing system shall be protected against damage by corrosion.

Trenching and backfilling

Contractor shall align, excavate and backfill all trenches and disconnecting and inspection chambers

Earthing Bar

The contractor shall if specified provide an earthing bus in buildings at a suitable location and connect the same to the earthing system. Earthing tape or cable shall originate from the bus and run inside the building facilitating the earthing inside the building.

Earthing Rods

The connection to ground shall comprise a number of interconnected copper clad steel earth rods, of minimum 15 mm diameter, by 2 metres long driven vertically into the ground at intervals of not less than 4 metres apart with heads located at a depth to suit the disconnecting chamber position.

Earth rods shall be provided with special hardened tips and caps to avoid distortion when driven into the ground. Approved non-ferrous clamps for connecting the rod to the copper strip shall be provided.

Leads from each electrode shall be brought to concrete disconnection chambers to enable each electrode to be disconnected for testing purposes.

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.

Testing

On completion of the earth installation the Contractor shall demonstrate to the Employer that the dry season resistance of the system is less than 6 Ohms.

Lightning Protection System

The contractor shall provide lightning protection system to the buildings and water towers. A system earth dry season resistance value not exceeding 6 Ohms shall be achieved. The system shall consist of air terminals, earth tape, isolation facilities for testing, earth rods or earth plates.

Up to 4 M from the ground level earth tape shall be run in a conduit. Requirements noted under Earthing shall also apply to the lightning protection system installation insofar as they are applicable.

2.16 Battery Units

General

The batteries and charger units shall be of the self contained types comprising constant voltage charger and nickel cadmium batteries housed in a floor mounted cubicle.

The equipment shall be designed to provide satisfactory and reliable operation in which continuity of service is the major consideration. The arrangement shall facilitate inspection, cleaning and maintenance.

References

The following standards are referred to:

IEC 896	Pb battery
IEC 623	Ni – Cd Battery
SBA 6001	Determining the capacity of stationary batteries

Batteries

Battery shall be of the nickel-cadmium type or the lead-acid type having cells contained in heat resistant, transparent, high impact plastic containers. The life span of the batteries shall be 05 years minimum.

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

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

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

The battery shall have 5 hours discharge rate for the nickel-cadmium type and 10 hours discharge rate for the lead-acid type respectively.

On failure of the AC supply the battery shall be capable of supplying the load for 12 hour period and at the end of this period, the battery terminal voltage shall not be less than 80% of the nominal system DC voltage.

Inter cell connectors shall be of low resistance, shall be in a clean condition when bolted, and shall be protected by petroleum jelly. The terminal bolts of the end cells shall be used as the battery output terminals. Inter cell connectors shall be made of nickel-plated heavy-duty copper bars and shall be suitable for bolting.

The battery rated output shall be that available at the outgoing terminals after making due allowance for all internal connections.

Battery Chargers

The charger shall be of the automatic current and voltage regulated type and shall be AC line compensated for the relevant input variations and be capable of being connected to a flat battery without overloading.

The charger shall comprise of rectifiers, transformers, switchgear and control gear, voltmeters, ammeters, indications and alarms as may be required. All circuits shall be fully insulated from earth.

The charger shall be suitable for supplying the initial charge to the battery, the float charge of the battery and supplying the maximum continuous parallel load on the unit. It shall be capable of operation with the battery disconnected and maintaining the performance limits specified.

The charger shall have automatic boost facilities. The automatic boost shall operate when the battery voltage falls to an adjustable predetermined value and continue until the battery has returned to a satisfactory state of charge. Manual boost charge with automatic return to float charge shall also be incorporated.

If the emergency period extends beyond that specified and the volts/cell is reduced to 1 Volt or less then on restoration of the AC supply the charger shall restore the battery to 80% of its ampere hour capacity within 8 hours. The remaining 20% of capacity shall be restored within a further 20 hour period. Throughout the charging period the charger shall also supply the maximum continuous load in parallel with the battery.

Separate HRC fuses or circuit breakers shall be provided to protect the charger and the charger control circuits. With the charger on full load continuously the maximum temperature rise shall not exceed 35°C and the maximum temperature rise of rectifiers shall not exceed 25°C.

Rectifiers

They shall be preferably silicon semi-conductors, naturally cooled and capable of carrying without damage the highest surge current that can occur. Semi-conductors shall be protected by cartridge fuses of an approved type.

Transformers

Rectifier transformers shall be of the air-cooled type continuously rated for the duty specified. Transformers shall be double wound with an earthed screen between primary and secondary windings and the insulation between each winding and other windings when connected to the case and screen shall withstand 1500 volts AC 50Hz for 1 minute and immediately afterwards its insulation resistance measured at 500V DC shall not be less than 20 megohms;

Off circuit tapings shall be provided on the primary side of relevant transformers to compensate for variations of AC supply voltage of $\pm 10\%$, in steps of $2\frac{1}{2}\%$. Changes to tapings shall be by means of bolted links situated in an easily accessible position.

Earth Indication

All battery connections shall be free of earth and an earth leakage test switch with an earth leakage voltmeter shall be provided to indicate whether there is an “earth” on the positive or negative pole of the common distribution bus. The switch shall be a three position switch with a spring return to the “OFF” position and shall be labelled ‘Earth on Positive’, “OFF”, ‘Earth on Negative’.

Alternatively an automatic “Earth Fault” indication may be provided from an earth leakage relay which on the occurrence of an earth fault shall operate an indicating lamp which shall be maintained until manually reset. The relay shall remain stable with fault not involving earth.

Alarms

Facilities shall be provided to monitor the following alarm conditions:

- (a) AC supply failure
- (b) Boost charge operation
- (c) Charger fail
- (d) Low battery voltage - adjustable but set initially at 80%
- (e) High battery voltage - adjustable but set initially at 110%
- (1) DC supply failure
- (g) Battery earth fault

Each alarm is to be indicated by a separate lamp on the front of the Battery Charger panel and in addition, an alarm relay is to be provided, with two sets of changeover contacts wired to outgoing terminals for remote alarm indication. The alarm relay is to be normally energized and become de-energized if any of the above alarm conditions occur. All alarm indications are to be maintained until manually reset, although the fault may clear after alarm initiation. The alarm-reset pushbutton shall be provided for this purpose.

A lamp test facility shall be incorporated which shall test all lamps without interfering with the normal operation of the circuit.

Testing Facility

A testing facility shall be incorporated in manual boost type battery/charger units for testing the condition of the battery by means of a discharge resistor and a meter scaled to indicate battery condition. The battery test switch for applying this test shall isolate the charger circuit during the test condition and shall be spring loaded so as to prevent the switch being accidentally left in the test position.

The meter may be specifically marked scale on the centre zero ammeter in series with the battery.

This facility is not required on units with automatic boost charge feature.

Instruments

The following instruments shall be provided on the battery/charger unit.

- (a) An ammeter in series with the charger output.
 - (b) For a manual boost type battery/charger unit: A battery state of charge indicator.
 - (c) An earth leakage voltmeter scaled with 3 position selector switch, unless automatic earth fault alarm is provided.
 - (d) A voltmeter with a scale suitable to indicate the output voltage.
- Instruments shall be mounted at least 750mm above floor level, and they shall have a minimum scale length of 70mm with a scale movement of 270° and be of the flush mounting type. All instrument scales shall be clearly divided and indelibly marked. Instrument glasses shall be of anti-reflective glass.

Cubicle

Each unit shall be housed in a free standing floor mounted cubicle which shall be vermin proof and dustproof to IEC 144 IP50 to IEC 144 (163). It shall be constructed of sheet metal with a minimum thickness of 3.2mm.

The top section of the cubicle shall house the charging and control equipment, instruments, relays and associated equipment. The charger compartment should be mounted on a removable chassis to facilitate testing. The bottom section of the cubicle shall house the battery cells and shall be provided with a hinged lockable door. The battery cells shall be arranged in tiers, so that the electrolyte level of all cells is visible from the front of the unit with the cubicle door open. The battery compartment shall allow free access to all cell terminals, links, connections, and vent plugs and shall permit topping and cleaning to be carried out.

A sealed partition shall be provided between the charger compartment and the battery compartment to prevent battery fumes reaching the charging and control equipment. Adequate ventilation shall be provided to both the charger and battery sections of the unit and all ventilation openings shall be fitted with bronze gauze to prevent the entry of insects.

DC Panel

The contractor shall provide a DC panel as an integral compartment of the charger cubicle. All DC needs of the plant shall be obtained from this panel.

Fuses and Links

Fuse and link fittings shall be of good moulded insulating materials and shall be supplied complete with FIR fuses or copper links as necessary. Fuse fittings shall be black and link holders shall be white. Painted fittings are unacceptable.

Fuse links shall be of the HRC cartridge type complying with the requirements of AS 2005.

Indicating Lamps

Indicating lamp units shall be of a flush pattern and complete with lamps of a voltage rating to suit the particular circuit application.

Indication shall be so designed that short circuit of any lamp fitting or associated circuitry shall not cause circuit failure, fire or heat damage.

Wiring

Wiring insulation shall be PVC type V75 0.6/1 kV grade shall be of a minimum seven strands with a cross section not less than 2.5mm.

Terminals

Terminals of an approved type shall be provided for all external connections and shall be numbered and grouped according to the circuit function. Not more than two wires shall be connected to any one terminal.

Earthing

All metal parts other than those forming part of an electrical circuit shall be earthed. The earth conductor shall be bolted to the main frame and an external earth stud provided at the bottom of the cubicle.

Labels

All equipment shall be clearly labelled in an approved manner for identification.

All designation labels shall be engraved with black lettering on a white background and shall be of an accepted size and material. 'DANGER' labels shall have white lettering on a red background.

Self adhesive labels are not acceptable.

Accessories

The following accessories shall be supplied:

(i) Maintenance tools	1 set
(ii) Portable DC voltmeter (1.0 class)	1 set
(iii) Syringe hydrometer	1 set
(iv) Vent mounted thermometer (0-100 deg.C)	3 sets
(v) Mixing tanks	1 set
(vi) Funnel (made of synthetic resin)	3 sets
(vii) Bottle (made of synthetic resin)	3 sets
(viii) Requisite quantity of potassium hydroxide with 10% extra	1 set
(ix) Sufficient quantity of distilled water first filling up	1 set
(x) Steel locker for containing accessories	1 set

Spare Parts

The list of spare parts to be furnished by the Contractor as specified in Section 2.1. shall include but not be limited to the following:

30% of diluted potassium (For Ni-CD type)

30% of diluted sulfuric acid (For lead-acid type)

Two (2) cells in seal

500% of actual use of indicating lamps and fuses

Other spare parts recommended by the manufacturer

Factory Testing

See under Tests

2.17 Alarm and Annunciator Systems

General

The group annunciator system shall provide automatic visual and audible alarms to indicate abnormal conditions. Each annunciator shall have white name plate showing device number of the corresponding relay with black letter. Resetting of the annunciators after operation shall be conducted manually by the push button provided on the associated section on the panel. All annunciator equipment shall be suitable for operation on 24 volt DC ungrounded circuits and operate satisfactorily within a range of + or – 15% of selected DC voltage. DC.

Annunciator relay for the equipment shall be of solid-state type.

The annunciator and its associated equipment shall be located in the place on the panel, where operator can easily confirm the information by it.

Design Requirements and Ratings

(i) The audible alarm buzzer for annunciation shall be provided to two kinds of failure.

- Trip
- Warning

Above audible alarm shall have function to be able to adjust sound volume and shall be of continuous rating.

- (ii) Window block unit consisted of several windows shall be arranged on the relevant section on the panel, which is associated with its annunciation items.
- (iii) The visual indicating portion of the annunciation system is in rows of windows of each approximately 5 cm square. They shall be individually removable and suitable for painting and/or engraving of the designations.
- (iv) Window illumination shall be brightly lighted to permit easy reading under the room lighting available in the room.
- (v) At least 25% spare annunciators shall be provided.
- (vi) Windows for each alarm shall be distincted with a different colour plate as below:
 - Trip Red
 - Warning White
- (vii) Each window shall be illuminated by LED lamp.
- (viii) The pushbutton switches for annunciation system mentioned below shall be provided:
 - Annunciator lamp test to be located on the panel.
 - Annunciator acknowledge to be located on the panel. By pressing of the pushbutton, audible alarm will be stopped and indicating lamp window will be changed from flashing to lighting.
 - Annunciator reset to be located on the panel. By pressing of the pushbutton, indicating lamp window will be extinguished if the fault or the failure will be cleared. Under still fault or failure, the lamp will be lighting continuously even if the pushbutton is pressed.

These pushbuttons shall be momentary type with latching relay, not alternative type.
- (ix) Operation of the flasher circuit for flickering associated with the annunciator shall be silent.
- (x) Initiating contact for all annunciations shall close for a sufficient time for proper operation of the annunciator.
- (xi) Annunciation relay to be used to keep instantaneous failure signals shall be solid state with non-mechanical contact.
- (xii) Power failure shall not result in spurious or false alarms. On resumption of power supply. Alarms present before the failure shall be re-indicated along with alarms that may have occurred during the outage.
- (xiii) DC 24 Volt ungrounded circuit is applied for annunciation scheme and it shall be divided into fused sections. The fuses shall be of the type which can give an alarm on blowing.
- (xiv) The failure for all window lamps shall be checked by pressing the “Annunciator Lamp Test”

2.18 Remote Stop Push Button Stations

Where any item of driven equipment is not clearly visible from the switchboard where its starter is located the Contractor shall provide and install mushroom headed red stay put type push buttons for

the purposes of emergency stopping the equipment. The number and location of each push button must be approved by the Employer For each drive and where the equipment for a particular machine is waived written permission must be obtained.

Each pushbutton shall be housed in a surface mounting weatherproof enclosure.

2.19 Lighting and General Power

General Requirements:

The lighting system shall

- (i) Provide adequate illumination on the working place.
- (ii) give good distributed uniform light.
- (iii) avoid glare and shadows and
- (iv) employ simple fittings which can be easily cleaned.

It is necessary to avoid glare not only from the lamp itself but also from any polished surfaces falling in the line of vision.

The design of the lighting installation shall be sectionalized as follows

- (a) Interior Lighting and small power: Which includes pump houses, transformer rooms, electrical switch room, control room, compressor room, chlorination room; maintenance workshop; residential building etc.
- (b) Other open space lighting and
- (c) Street Lighting for main and interior roads.

The lighting system shall provide the minimum average maintained illuminance levels given in the following table. All calculations shall allow for lumen depreciation of the lamps and a maintenance factor of 70% to allow for dust and dirt on the luminaire.

LOCATION	ILLUMINANCE (LUX)
Administration Building	300
Pumping stations (internal)	200
Electrical switch rooms	300
Chemical storage and batching areas	100
Chemical dosing pump areas	200
Filter control desk areas	300
Filter pipe galleries	200
External site lighting	
- along access roads and parking areas	10
- on clarifier units	20
- over filters	50

Miscellaneous Components

The Contractor shall supply all of the miscellaneous components necessary to complete the whole of the works including, but not limited to, lighting fixtures, receptacle, fixture supports, MCCB, MCB, Lighting distribution boards, street light poles, switches, ceiling fans, exhaust fans, air circulators, conduits, wires, cable and miscellaneous hardware necessary for complete lighting and receptacle systems.

Lighting Fixtures

Lighting fixtures shall comply with the following requirements

- (a) Suitable for operation on 230 V, 50Hz, single-phase A.C. supply with voltage variations of $\pm 10\%$.
- (b) Lamp and all other accessories shall conform to the specifications, to ensure satisfactory operation.
- (c) Lamp holders for incandescent and HPSV/HPMV lamps shall be of G type, manufactured in accordance with the relevant standards.
- (d) Lighting fixture reflectors shall generally be manufactured from sheet steel or aluminium of not less than 20 SWG.
- (e) The enamel finish shall have a minimum thickness of 2μ for outside surfaces and 1.5 mils for inside surfaces. The finish shall be non-porous, free of Iron blemishes, blisters and fading.
- (f) Each fixture shall be complete with four way terminal box for connecting and looping of incoming and outgoing supply cables. Each terminal should be capable of accepting two 2.5 sq mm copper stranded conductors.
- (g) All metal or metal enclosed parts of the housing shall be connected to ground satisfactorily. Similarly each lighting fixture shall be provided with a grounding terminal suitable for connecting two 2.5 sq mm earth wires.
- (h) Lighting fixture starters shall be replaceable without removing the lamp or reflector and without using any tools.
- (i) Each capacitor shall be suitable for operation at $230V \pm 10\%$. Single phase, 50Hz supply and capable of improving the lamp circuit power factor to 0.95 lag.
- (j) Lamp holders for fluorescent tubes shall be of the spring loaded, hi-pin rotor type with low contact resistance and resistant to wear: They shall be suitable for operation at the specified temperature without deterioration.
- (k) Fixtures for outdoor post top lantern type lighting shall be dust proof, weather proof decorative type; suitable for accommodating HPSV- lamps; complete with stove enamelled aluminium canopy; opal acrylic Perspex bowl and allied necessary accessories.

Types of lighting fixtures

- (a) Fluorescent Lamp lighting fixtures shall be complete with wiring, mounting accessories, control gear, chokes, starters, power factor improving capacitor (0.95 lag p.1.); mounting channel type, suitable for surface/suspension mounting for the following categories:

- (b) Street light type fixtures (Cobra type fittings) shall be complete with integral semi cut- off lantern with polycarbonate cover; complete with internal wiring, control gear, mounting accessories and with I No. 150/250 W, HPSV - lamp.
- (c) Industrial type dust and drip proof type fitting tot enclosed in sheet metal housing with a heat resistant toughened glass cover or clear acrylic sheet; with internal wiring, control gear, mounting accessories with 2 No. 40W Fluorescent white light tubes. The housing shall be epoxy stove enamelled.
- (d) Out door type flood lighting shall be complete with heavy gauge aluminium body, toughened front glass with weather proof gasket, capable of being rotated in vertical and horizontal plane and locking at any fixed angle. The fitting shall be with MS cradle, base and the main body will be finished in stove enamel, it shall be supplied complete with internal wiring, control gear enclosed in a box and be suitable for 230 V, HPSV-lamp.

Small power outlets

The Small Power Outlets shall be suitable for operation on 230 V, single phase or 400 V. three phase, 50 Hz supply. Each Outlet shall be associated with a suitable switch housed in the same enclosure. It will become live only when the switch is in “ON” position. The enclosure will be provided with the degree of protection of IP-56.

Decorative and Industrial type Outlet of 10A and 30 A rating with switches shall be supplied. They shall be suitable for flush or surface mounting as required.

An adequate number of outlets (receptacles) shall be supplied and installed so as to permit convenient operation and maintenance of the plant. The number and location of Outlet shall be to the approval of the Employer.

Fixing of equipment

The Contractor shall be responsible for the fixing of all switches, fuse boards, switchgear, cables, fittings, cable trays, accessories and all other items comprising the electrical installation.

All holes for fixings shall be made neatly with a rotary drill.

A single shot cartridge tool maybe used only at the discretion of the Employer.

No structural steel, timberwork or concrete shall be drilled for the support of cables or fittings without the prior approval of the Employer.

Threads shall be I.S.O. metric coarse thread.

Mild steel bolts and nuts shall be of the precision cold forged washer faced type. Bolts, nuts and washers used in the construction of electrical equipment enclosures, and for mounting of electrical equipment within enclosures shall be chromate passivated, zinc or cadmium plated steel.

All fastening components for copper electrical connections (excluding lock washers) shall be electro-tinned or silver-plated copper or copper alloy, or stainless steel having a coefficient of

thermal expansion comparable with that of copper. Lock washers shall be phosphor bronze (to 882061) or stainless or electro-tinned steel. Where screws smaller than 8 mm are used to retain covers on switchgear and terminal boxes they shall be captive in the cover.

Lock washers shall be single turn, heavy duty, and square section type.

Re-usable self locking nuts may be used in place of locknuts or nut and lock washer combinations with the approval of the Employer if they are of a type which can be used several times without deterioration, Do not use self locking nuts on electrical connections.

All bolts and nuts exposed to the weather, including holding down bolts and nuts, and all bolts and nuts used for structural steelwork shall be galvanised.

Bolts and studs shall project beyond the outer face of the nut by not less than one full thread pitch and not more than the bolt diameter.

Washers either plain or tapered shall be provided under bolt heads and nuts for all connections. Lock washers or lock nuts shall be provided where connections are subject to vibration or thermal cycling.

Holes tapped directly into panels shall only be used if a minimum of three full threads can be accommodated within the thickness of the material. Where nuts and bolts are used and the nuts are not readily accessible, Nut sets or similar approved fixed fasteners shall be used.

The threads of all nuts and bolts shall be coated with an approved anti-sieze compound.

Self tapping screws shall not be used for equipment mounting.

Equipment to be fastened to concrete or masonry surfaces shall be fixed by means of approved expanding head masonry anchors. In hollow concrete blocks or bricks anchors shall be chemically grouted type (Ramset "Chemset or approved equal). Where installed outdoors galvanised anchors shall be used.

Drawings and Data

The Contractor shall furnish the relevant descriptive and illustrative literature of the respective lighting fixtures, accessories and small power outlets and following drawings and data:

- (a) Dimensional drawings
- (b) Mounting details, cable entry facility and weights.
- (c) Light distribution diagrams (zonal and isocandela), and
- (d) Light absorption and utilization factors.

Emergency Lighting

Self-contained automatically switched emergency lights shall be provided in the following locations:

Electrical switch rooms

Chemical building
Treated water pump station
Raw water pump station
at each staircase within a building.
Emergency lights shall have a minimum two-hour battery backup.

Installation of Lighting Panels, Fixtures and power outlets

The scope of installation work shall include mounting of lighting panels, distribution boards, fixtures and receptacles. The associated work like providing and fixing of wooden blocks, wall sockets, hooks etc. and other related civil works such as scaffolding, provision of ladders etc. together with supply of hardware shall form part of contractor's work. All work items necessary for completing earthing connections shall be included in the scope of work.

Wiring

- (a) The wiring work shall include wiring from mains lighting panel to the various lighting equipment and Light-Distribution Boards (LDB) using 25/20 mm PVC conduits, supported at regular intervals of 1000 mm each on walls/ceilings etc., installation of LDB's with control switches and receptacles housed in boxes, and termination of wires at LDB. Control switches, power outlets, fixtures, etc. as required.
- (b) Contractor's scope of work shall include:
 - (i) All work necessary for fixing boxes, conduits etc. together with supply of necessary hardware.
 - (ii) Supply of 650 V grade 2.5 mm²/4 mm² PVC insulated copper conductor wires, 5A/15A switches, PVC conduits, junction boxes, tees, elbows etc., 16 SWG enamelled sheet steel boxes with gaskets, earthing terminals with bolts, nuts and washers, flexible conduit etc. Earthing wire should be provided with tinned copper lug to make effective connection.
- (c) Receptacle and lighting fixtures shall be connected to separate circuits.
- (d) In large rooms, the lighting system shall be distributed over three phases.
- (e) Switches/receptacles wired to different phases shall be separated by a minimum distance of 1.8 M.
- (f) Separate conduits shall be used for wiring:
 - (i) Different lighting circuits such as normal A.C. /D.C. Emergency lighting etc.
 - (ii) Circuits connected to different phases and
 - (iii) Circuits for power receptacles.
- (g) the internal area of the conduit shall be at least 2:5 times the total area of cables, wires to be pulled through it, with a minimum nominal diameter of 25/20mm and thickness of 2 mm.
- (h) No bare or twist joints will be permitted at intermediate points in the through run of cables/wires. All joints shall be made by means of approved mechanical well insulated connectors in standard approved joint boxes. No joints shall be permitted in the looping back system of wiring; if need.
- (i) The area of the copper conductor for lighting and receptacles will be selected so as to limit voltage drop within 5% of the rated voltage and current density within 2.5A/m²; the minimum

size of the conductor being 2.5 mm². Number of points wired through a single circuit shall be generally limited to 10. To consider the losses in control gear; multiplying factor of 1.25 will be used for the wattage of mercury/sodium vapour lamps. A minimum loading of 100 W and 500 W will be considered for receptacles of single Phase 5A and 15A respectively.

- (j) All light control switches for 5A receptacle units shown at one location shall be housed preferably in one common steel box.
- (k) For Street lighting, steel tubular or concrete poles complete with fixing brackets shall be used. The poles shall be coated with bituminous preservative paint on the inside as well as on the portion to be embedded. Exposed outside surface shall be painted with one coat of red oxide primer. After completion of installation, two coats of aluminium paint shall be applied. Each pole shall be properly earthed.
The Contractor shall supply and erect the poles (including foundation work), mount the assembled fittings and complete the necessary cabling.

2.20 Instrumentation and Control

Scope

This specification sets out the requirements for the supply, erection, testing and commissioning of instrumentation equipment and systems

Contractor's scope of work includes design, supply and erection work and commissioning of instruments. All necessary erection materials such as cable trays, structural steel, nuts-bolts, cables, cable glands air tubing, instrument fittings to be supplied by the Contractor.

Instruments General

All indicating instruments shall be of 270° scale type flush mounted and generally of the same appearance throughout. They shall comply with BS89 and be of industrial grade accuracy. They shall be against ingress of moisture and dirt and shall be hermetically sealed or tropicalised.

Instruments shall have an external zero adjustment. They shall be positioned so that they can be easily read and the dial centres shall be not less than 400 mm and not more than 1800 mm above finished floor level. Meters shall be fitted with an adjustable pointer or shall be inscribe on the scales to indicate the normal circuit tagging for associated plan.

Instruments shall have a square front appearance 100mm wide. All the outgoing leads shall be provided with an ammeter with an ammeter selector switch.

Ammeters fitted in a motor circuit shall have a suppressed scale to indicate maximum starting current.

Kilowatt hour meters shall be arranged to register 3 phase 4 wire unbalanced loads except as otherwise indicated.

All instruments shall be mounted adjacent to the relevant circuit breaker switch or starter unless separate panel suites are specified herein.

At points of connection of potential circuits to LV bus bars, HRC fuses shall be provided to protect the auxiliary wiring. For cubicle gear these fuses shall be housed inside and be readily accessible. Additional fuses to clear individual instrument faults shall be provided and accessible from the front of the cubicle unless otherwise specified.

2.21 Design & Construction Features

The following design and construction features shall be adopted.

- (a) Power supply for instruments shall be single phase 230 V \pm 10%, 50 Hz \pm 1.
- (b) All field instruments shall be provided with wetted parts in SS-316 construction unless otherwise specified. All nuts bolt studs etc. shall be to SS -316 only.
- (c) All flanges shall be ANSI 816.5 RF unless otherwise specified.
- (d) All screwed connections shall be NPT threads.
- (e) All power cables shall be 1.5 sq. mm. 650 V grade annealed copper, PVC insulated, without shielding. All instrumentation cables shall be multi-stranded (7 strands) copper conductor individually shielded and with overall shield, twisted pair/triple. 1.5 sq.mm, PVC insulated and PVC sheathed.
- (f) Panel mounted instruments shall be digital microprocessor based stand alone type. There shall be a provision to have 4-20 mA DC retransmission output (or remote indication for all panels, mounted instruments).
- (g) All instrument impulse tubing shall be 1/2" OD x .049 wall thickness & in seamless SS-316 construction.
- (h) Only double compression fittings shall be used.
- (i) Local indication shall be provided for all field instruments by Contractor.
- (j) All instruments shall be supplied with necessary double compression cadmium plated cable glands if applicable.

2.22 Instrument Control Panel

Control panels and control desks shall be constructed of 2mm (minimum) thick Zinc Anneal sheet steel of totally enclosed welded construction arranged for floor fixing with hinged rear doors.

All cubicle doors shall be fitted with chromium plated car type door handles and not screws. Dust and damp protection shall be to I.E.C. 144 Type 1P42 for indoor panels and IP56 for outdoor panels.

Each desk or panel shall be provided with self-regulating anti-condensation heaters.

Space shall be provided to accommodate cable glands of appropriate size for incoming and outgoing circuits and non-ferrous gland plates shall be supplied. All glands plates and trays shall be adequately earthed.

Terminals shall be clip-on, DIN rail mounted, tunnel type terminals, with flat pressure plates. For all current transformer and voltage transformer secondary wiring disconnect/test terminals shall be provided to permit short-circuiting and disconnecting of wiring for testing purposes.

The Contractor shall terminate all field wiring and inter panel wiring at terminal strips. No more than one wire shall be connected to each side of a terminal. Bridging bars shall be used for paralleling wires.

Terminals shall be grouped according to the working voltage of the circuits. Segregation shall be provided between low voltage and extra low voltage circuits by means of insulating barriers or by physical separation. Transparent insulating covers with warning labels shall be provided on 230 V terminals. All terminal strips shall be safely accessible with the switchgear in the service position and in normal operation.

All terminals and terminal groups shall be identified with numbers in accordance with schematic and termination diagrams.

Control Wiring

All internal control wiring shall be single conductor, 1.5 mm multistrand flexible PVC insulated, copper wire.

Both ends of every cable core shall be fitted with approved marking Ferrules of the interlocking type and identification shall be strictly in accordance with the wiring diagrams. Ferrules shall have black numbers on white background and shall fit firmly over the cable insulation. Ferrules shall be fitted so that on disconnection of cables from equipment the ferrules are retained on the cable. Critchley type Z or flaffoplasi ferrules are preferred.

All main runs of wiring shall be enclosed in slotted PVC ducts. Duct sizing shall allow at least 30% spare space after all wires are installed. When not enclosed in ducts, wires shall be neatly and securely bunched and cleated. Form a loop in wiring runs which cross the hinge side of panels to prevent any strain being placed on the wires or terminations. Do not make joints in runs of wiring.

The Contractor shall terminate all control wiring with pre-insulated crimp terminations of the correct size for the conductor and installed with the manufacturer's termination tool. The tool shall be of the ratchet type which requires the correct pressure to be attained before the terminal can be released. Use pin type terminations for tunnel terminals and full circle tugs for stud or bolted terminals.

Panel Earthing

A continuous copper earth bar shall run the length of each panel with terminals for connection to the main earthing system. The cross-sectional area shall not be less than the recommendations of IEC439- 1.

Control Relays / Auxiliary Relays/Interposing Relays

Relays shall be suitable for operation on a nominal 220V AC or 24 DC supply as required by the circuit design. Relays shall be suitable for operation at plus 10% and minus 15% of their nominal rated voltage.

They will be of the plug-in type only complete with plastic cover and shall be fitted with normally open/normally dosed or changeover contact combinations as necessary.

The contact material shall be suitable for their specific application.

Mixed voltages must not be used on the different contacts of a particular relay. If necessary additional relays shall be used.

Coils shall be vacuum impregnated or guaranteed suitable for the climatic conditions specified. Terminal to the relay bases shall be of the front connected screw clamp type. Relay bases shall be of the DIN rail mounting type.

Relays shall be secured to their bases by retaining bar or clip to prevent malfunction due to the relay being loosened in its base.

DC operated relays shall have a miniature light emitting diode mounted within their clear covers which shall be connected directly across the relay coil to indicate when supply is connected. These indicators shall be easily seen when the relay compartment door is opened. AC operated relays shall be a similar manner each be fitted with a neon indicator.

Relays having different contact configurations or different coil voltages shall under no circumstances be interchangeable.

A permanent means of identification shall be affixed to both relay and base and shall correspond with the circuit diagram reference.

Where remote supply voltages are used then care shall be taken to ensure that all relays and any other equipment involved such as terminals, fuses and the like are completely shrouded and segregated. A warning label shall be fitted onto or adjacent to any such equipment. Similarly where voltages exceeding SSV to earth are employed in relay compartments or non door interlocked sections then shrouding segregation and warning labels shall be applied.

2.23 Approval Prior to Procurement

The Contractor shall obtain prior approval of the Employer before procurement of any instruments.

2.24 Field Instruments

Flow meters

Electromagnetic Flow Meters

Except where otherwise specified, flow meters shall be of the electromagnetic type, consisting of a flanged flow tube and associated signal amplification and transmission equipment. The flow meter shall be sized so as to have a maximum range at least 30% in excess of the design flow rate to allow for future expansion. Re flow meter shall have an accuracy of 0.5% of span.

The flow shall employ a pulsed dc excitation to ensure stable operation without the need for regular calibration. The flow converter shall be housed in a separate enclosure mounted adjacent to the flow

tube. The converter shall provide the excitation for the flow tube and shall produce a 4-20 mA analogue signal for connection to a chart recorder. The converter shall also have a locally mounted digital display of actual flow rate and totalized quantity. The degree of protection for the flow tube and converter shall be at least IP65.

Each flow meter shall be calibrated at the factory for the design flow range and a calibration certificate supplied with the flow meter. Flow tubes shall be complete with electrical continuity straps for connection at the flanged connections to the pipe work.

Totalising flow meters:

For the purposes of this Specification, the follow definitions apply:

- | | |
|---------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Flow Rate: | - The volume of water passing through the water meter divided by the time for this volume to pass through the meter. |
| Maximum Flow Rate q_{max} | - The highest flow rate at which the meter is required to operate in a satisfactory manner for a short period of time without deteriorating. |
| Nominal Flow Rate q_n : | - Half the maximum flow rate q_{max} . Expressed in cubic meters per hour, the nominal flow rate is used for the purpose of designating the water meter. At the nominal flow rate, q_n , a water meter is expected to operate in a satisfactory manner under normal conditions of use i.e., steady or intermittent flow conditions. |
| Minimum Flow Rate, q_{min} : | - The lowest flow rate at which the meter is required to give indications within the maximum permissible error tolerance. It is determined in terms of q_n . |
| Transitional Flow Rate, q_t : | - The flow rate at which the maximum permissible error of the water meter change in value. |
| Flow rate Range: | - The range limited by the maximum and the minimum flow rates (q_{max} and q_{min}). This range is divided into two zones at 'Upper Zone' and 'Lower Zone' separated by the transitional flow rate. |
| Head Loss: | -The pressure loss caused by the presence of the water meter and its fittings. |
| Discrimination: | -The smallest quantity of water which can be indicated. |

Totalizing flow meters shall be high capacity in line rotary "Woltmann" type water meter with precision moulded mechanism.

The flow meter shall exceed the accuracy requirements of BS 5728 part 7/ISO 4064-1 for class B meters, All design, material and workmanship shall comply with the requirements of the latest issue (with up-to-date amendments) of the following standards:

- (i) B.S. 5728 'Measurement of flow of cold potable water in closed conduits

(ii) ISO 4064 'Measurement of water flow in closed conduits.

The water meter shall be suitable for horizontal installation.

The water meters shall be made of suitable non-corroding, non-toxic, temperature resistant materials in accordance with BS 5728 and suitable for use in water supply. The water meter body shall be spheroidal graphite iron to 35 2789

Flanges shall conform to ISO 2531, (Flange type PN 10. Flange drilling shall comply with Table 17 of ISO 2531)

- I) Head Loss: Head loss across the meter shall be no greater than 0.1 bar at the nominal flow rate as defined by Table 2 of ISO 4064.
- II) Pressure: The water meters shall comply with the following pressure requirements:
- (i) Working pressure: 10 bar minimum.
 - (ii) Static pressure test: 1.5 times working pressure for 15 minutes

The water meters shall be designed to operate in water temperatures of the range 10°C to 40°C.

All parts of the meter, electrical output device and cabling must be able to withstand total immersion in water to a depth of 4 m continuously over the full temperature range.

The water meters shall be clearly and indelibly marked, to the requirements of BS 5728

The meters shall have an accuracy of $\pm 2\%$ between the transitional rate of flow q_t and the maximum rate of flow q_{max} as defined in ISO 4064.

The water meter shall be of dry dial or sealed liquid filled dial type with 6 or 7 digit straight reading in cubic metres and centre sweep hand for precision reading. The indicating device of the water meter shall be protected by a transparent window (glass or other material) and provided with a suitable cover. The water meters shall be equipped for the removal of condensation from the underside of the window should this occur.

Ultrasonic flow meters

The ultrasonic flow meter 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 or submerged type as specified in the latest BS standards.

Pressure and Differential Pressure Transmitters

Pressure transmitters shall consist of a measuring element and associated signal conversion circuitry designed to measure pressure or differential pressure and produce a proportional 4-20 mA analogue signal.

Wetted parts shall be grade 316 stainless steel. Process connections shall be 1/2 inch NP F female threads. Transmitters shall have a threaded conduit entry for cables and the terminals shall be accessible via a threaded cap. The degree of protection shall be at least IP65 Transmitters shall be designed for mounting to a 50mm nominal bore pipe and shall be supplied complete with suitable brackets and pipe clamps.

The differential pressure transmitter shall produce a 4 DC signal either in proportion to the applied differential pressure or as a square root functions of the differential pressure. The transmitter shall have screw adjustments for span (over the full range) and zero, and the adjustments shall be continuously adjustable: The zero adjustment should be externally accessible. The transmitter shall have variable damping adjustable tip to 2.5 seconds. Temperature compensation shall be provided. The terminals shall be in an enclosure isolated from the transmitter mechanism.

Accuracy shall be $\pm 0.25\%$ of calibrated span, including the effects of repeatability, linearity and hysteresis.

Each transmitter shall have an integral indicator calibrated in engineering units with an accuracy of $\pm 0.2\%$ of reading.

The process pressure transmitter shall be an electronic unit for gauge pressure measurements. The transmitter shall include easily accessible span and zero adjustments, The terminals shall be in an enclosure that is isolated from the transmitter mechanism. The output signal shall be 4-20mA DC in proportion to the measured pressure.

The transmitter shall withstand an overpressure 1.6 times the specified upper pressure limit. The accuracy shall be $\pm 0.25\%$ of the calibrated span, including the effects of linearity, hysteresis and repeatability. The wetted parts shall be made from 316 stainless steel.

Each transmitter shall have an integral indicator calibrated in engineering units with an accuracy of $\pm 0.2\%$ of reading.

Pressure Switches

The pressure switch shall be a force balance spring activated adjustable differential action type, and shall be fitted with a single pole changeover contact. Minimum switching differential shall be 5% of the span. The over range pressure rating shall be twice the specified maximum operating pressure.

Pressure Gauges

Pressure gauges shall be of die cast steel construction with armour glass front window. Gauges shall be of the Bourden type with a phosphor bronze sensing element. Graduations shall be black engraved on a white background. The full scale deflection of the gauge shall be selected such that the pointer shall be within the range of 60%-80% of full scale under normal plant operating conditions. The dial size shall be 150mm unless approved otherwise. Accuracy of pressure gauges shall be better than 1%. The overpressure rating shall be at least 2.0 times the maximum operating pressure.

Gauges subject to vibration from pipe work or machinery shall be liquid Filled. Where pressure fluctuations in the process fluid cause the needle to vibrate a suitable snubber shall be fitted.

For slurries, viscous and corrosive fluid duty. chemical seal pressure g shall be provided.

Ultrasonic Water and Sludge Level Meter

To determine the level of various media in tanks, channels, chambers, etc.

Services and Deliveries

At this measuring instrument an echo system transmits ultrasonic pulses towards the medium surface from above and receives the returning echo. It determines the level from the speed of sound, the propagation time, and the sensors' height. The complete measuring system consists of the ultrasonic level meter and the fitting-measuring transmitter.

The ultrasonic sensor should provide:

Integrated temperature sensor for compensation
Temperature: -5°C...+80°C
Measuring range: suitable for the required purpose
Degree of protection: IP 68
Connection to transmitter: Via 5 m cable

The measuring transmitter should provide:

Digital display for momentary level (m, %) and volume (cu.m, %), 4 digits
Permanent measurement of the medium level
Field-mounted housing, IP 65
Output signals, 0/4...20 mA, 1 status contact
Power supply, 230 VAC, 50 Hz

The installed meter shall be resistant against gases, humidity and weathering. The function and accuracy of the meter must not be affected by these phenomena.

The sensor has to be mounted according to the purpose. At open channels or tanks it is fitted to a cantilever that is fixed to a pole on the edge of the channel or tank. Closed pipes or tanks must be supplied with a suitable flange fitting with gaskets. The materials of the mounting devices have to be suitable to the material of the respective tank or pipe and have to be thermo-insulating. The distance to the medium surface must be more than the sensors block distance. The measuring

ultrasonic signal must not be disturbed by any fittings inside the channel, tank or pipe to get reliable results. All fittings must be easy to access and to remove for maintenance or repair. All mounting material has to be included. In order to avoid excessive condensation at the sensors membrane, the sensor has to be mounted in a thermal-insulated manner so that the temperature of the sensor follows the air temperature. The membrane of the sensor must be water-repellent and shall be shaped in a way that there is no build-up of water films

Level Switches

Level switches shall be of the electrode type operating on the conductivity principle. Multiple electrodes shall be provided and supported with suitable brackets to ensure the electrodes do not deflect because of surges in the water. The length of electrode shall be adjusted to provide the correct pickup and droop points for the controller.

The liquid level controller shall contain the isolation transformer and voltage source be the electrode supply as well as an output relay for switching the controlling device (pump or valve). The output relay shall have a single changeover contact rated at 5A. 230V AC.

Immersion Type Level Transmitter

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

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

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

- Output signal : DC 4 to 20mA
- Power supply : DC 48/24V
- Type : Diaphragm sensing type
- Accuracy : 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 composed 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 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 required.

Chart Recorders

Chart recorders shall be of the flush panel mounting design having at least two pens. Recorders shall accept 4-20 mA analogue signals directly from the transmitters. Each pen shall be a different colour and pens shall utilize disposable felt cartridges for ease of maintenance.

The nominal recording width of the chart shall be at least 180 mm. Chart paper shall be of the “fan-fold” design. The chart cassette shall be removable for ease of paper changing. The recorder shall store enough paper to ensure that charts do not need to be changed more often than once per week.

The recorder shall be housed in a sheet steel case with hinged front door having a glass panel. The degree of protection of the front door shall be at least IP54. Digital version of recorders with memory, data retrievable and printing facilities are also acceptable.

Each recorder shall be supplied complete with one year’s supply of paper and pens.

Motorised Valve Actuators

The Contractor is to design, supply and install the valves and associated cables, conduit or cable trays. This includes the required interlocking between pumps and valves, together with power supply modules in the switchboards.

The control philosophy will be: Push button to open valve, valve opens and provides interlock to pumps to allow pump to start. Start button pressed on motor control centre and pump starts. If pump stop is pressed - valve closes and provides interlock to motor control centre which shuts down the pump.

If button to start motor is depressed at the motor control centre and valve is closed, the valve will be opened, and when open the pump will start.

Actuators for motorised valves shall consist of three phase electric motor, gearbox and associated limit switches, torque switches, position indicator and manual operation accessories.

Loss of power or control signals shall result in the driven devices being locked in their last positions. Provision shall be made for monitoring such failures and advising the operator accordingly. Actuators shall be provided with means of preventing over-running safe travel limits should the normal limiting devices fail

Torque or thrust limiting devices shall be provided to protect the valve and actuator should the normal end of travel limits fail. These shall be of a type that will reset only when the actuator receives a signal to drive in the opposite direction.

Solid state switches shall be used to control modulating duty actuators. Arrangements in which the power supply systems to the solid state switches are isolated from their sources by appropriate surge suppression equipment will be preferred. Motor ratings for modulating drives shall be matched to the control systems for automatic control under the most arduous operating conditions.

Reversing contactors shall be used for the control of ON/OFF duty actuators. All equipment not mounted on the actuator shall be housed in a cubicle, where two or more associated actuators are installed in a common area their control equipment may be housed in separate compartments in a common cubicle. Remotely controlled actuators shall be arranged so that operation may be initiated and will continue until the travel limit is reached.

Manual override facilities shall be provided such that engaging the manual operating mechanism shall automatically disengage the electric motor drive.

The degree of protection of the actuator shall be at least IP67.

Pressure Tappings

All instruments requiring connections to pipelines or process equipment shall be capable of being safely isolated and drained for testing and maintenance. Each differential pressure transmitter shall be provided with a five valve, double block and bleed manifold. Each pressure transmitter, pressure switch and pressure gauge shall be provided with a suitable valve manifold which will permit the instrument to be isolated and de-pressurized. A tapping shall be incorporated to permit in site testing and calibration of the instrument without disconnection of the instrument.

All impulse piping shall be annealed, seamless tubing of 316 stainless steel. Instrument tapping shall be assembled and connected with approved compression lifting fabricated from 316 stainless steel. Fittings shall be installed strictly in accordance with the manufacturer's recommendations. All threaded connections shall be NPT:

Design conditions for primary isolating valves and associated instrument piping shall be the design pressure and temperature conditions applying to the main plant to which the primary isolating valve is attached. Design conditions for secondary isolating, blow down, equalizing valves, datum reservoirs and fill valves and associated instrument piping shall be the design pressure and temperature applying to the main plant tapping point. Standard installation drawings showing diagrammatic layout, design and material specifications, hardware identification etc. shall be submitted for approval.

The Contractor shall provide permanent access ladders and platforms to all primary and final control elements, tapping and sampling points, field equipment etc. to ensure that maintenance can be carried out in safety.

Transmitters and other measuring devices for liquid parameters measurement shall be located below the relevant tapping points while transmitters and other measuring devices for gaseous parameter measurement shall be located above the tapping points.

Where a transmitter or other measuring device cannot be mounted directly at the point of measurement it may be located in a more suitable position and connected to the measuring point by short runs of impulse piping. The location chosen and its elevation relative to the measuring point must conform with the manufacturers recommendations for the medium to be measured. Where a change in static head results the calibration of the transmitter or other measuring device must be corrected for the difference. Pipe runs shall fall without reversal of slope from the tapping points to the transmitters and other measuring devices used on liquids and similarly from the transmitters and other measuring devices used on gases and steam to the tapping points.

Two isolating valves in series shall be provided for all measurements, one as close to the tapping point as practical and the other at the instrument. Where individual tapping points have not been provided multiple use of a single tapping point will be permitted in approved locations. Where this occurs the Contractor shall provide a bifurcation piece as close to the tapping point as practical and isolating valves shall be provided in each branch as close to the bifurcation piece as practical. Where a transmitter or other measuring device is mounted directly at the tapping point and the pressure is less than 1000kPa only one isolating valve need be provided. Primary isolating valves for instruments providing signals for automatic control systems or safety or sequence interlocks shall be provided with permanent warning labels. Each instrument in every installation shall be identified by a permanent instrument nameplate fixed to the instrument stand identifying the element in the installation.

All tapping points shall be provided by the Contractor. Roding out tees shall be provided on tapping points for pressures below 2000kPa and temperatures below 2

Surge Protection Equipment

All 4-20 mA analogue loops shall be protected against damage due to transient over voltages induced by lightning strikes to the works or nearby areas. Protection shall take thereof a single device which incorporates three stages of over voltage protection. The three stages shall include: gas arresters; metal oxide varistors and zener diodes. The device shall provide protection against transverse and common mode voltages.

Solenoid Valves

All solenoid switches shall be of 230 V. AC +10%, 50Hz \pm 5% type.

2.25 Water Quality Analyzer Devices

pH-Measuring Device if Required

Purpose: For measuring the pH value of water at several locations within the plant

Services and Deliveries

The pH-probe consists of a measuring electrode with membrane glass, a reference electrode and a temperature sensor Pt100 for temperature compensation and temperature measurement, all combined in one sensor. The sensor is mounted inside and protected by a PVC armature. An adequate measuring transmitter is required with automatic temperature compensation and self monitoring.

The pH-probe should provide:

Measuring range: pH 1...13
Temperature range: -5°C...+80°C
Permissible pressure: 6 bar
Shaft length: suitable for the required purpose
Temperature compensation:-10°C...+55°C

The armature should provide:

Shaft length according to on site conditions
Preamplifier and 5 m shielded coaxial connecting cable with watertight and reliable connectors for probe, amplifier and measuring transmitter Submersible armature, self-cleaning, to be lowered into the water from suitable high grade steel fitting

The measuring transmitter should provide:

Display: LCD, range pH 0...14, -5°C...+80°C, status-indication, 4 digits
Output: 2 x 0/4...20 mA for pH value and temperature
Power supply: 230 VAC, 50 Hz
Field-mounted housing
Degree of protection: IP 65
Output signal: 1 status contact, potential-free

Furthermore the service includes one complete spare sensor, spare parts, materials and calibration solutions for two years of operation. All fittings must be easy to access and to remove for calibration, maintenance or repair. All mounting material is also included.

The measuring transmitter should provide:

Self-supervision of function
Display: LCD, 4 digits
Degree of protection: IP 65
Power supply: 230 VAC, 50 Hz
Output: 0/4...20mA
4 signaling contacts, potential-free
Connection-cable to the sensor

Residual Chlorine Analyzer

Purpose -For monitoring of chlorine residual at several locations
Location - Each chlorine contact tank
- Outlet of the treated water tank
- Further locations as required

Services and Deliveries

For each location of chlorine measurement a sample of water is drawn from the main water stream to feed a chlorine analyzing device which guarantees a sufficient stream of water to the analyzer, consisting of a probe for dissolved chlorine and a measuring transmitter. According to the type of chlorine product, which is used for chlorination, a probe for inorganic or organic dissolved chlorine has to be selected. The sampled water should not be returned to the drinking water system.

The probe should provide:

Type: amperometric, for organic or inorganic chlorine,
according to the used chlorine product
Compact design with internal pre-amplifier
Automatic temperature compensation
Measuring range: suitable for the required purpose
pH-range: 3.5 ... 8.0 pH
Output: 0/4...20 mA

The transmitter should provide:

Display: LCD, LED for status signals, 4 digits
Output: 0/4...20 mA, status contact, potential-free
Measuring range: suitable for the required purpose
Measuring interval: adjustable from 1 minute to 6 hours
Power supply: 230 VAC, 50 Hz
Housing: IP 54, resistant against chemicals
Temperature range: 0°C ... 50°C

The service includes the complete necessary sampling analyzing units as pumps, pipes, hoses, valves, fittings, tanks, flanges, etc, as well as the installation including all accessories, mounting material and adjustment.

Chlorine Detection Unit

Purpose: For detection of chlorine gas
Location: - Chlorination House
- Further locations as required

Services and Deliveries

For the detection of chlorine leakage or process faults, all enclosed areas of the chlorination house or chlorine stores have to be supplied with chlorine gas detectors. The detection of chlorine in the air has to cause an alarm on the Central Control Computer and in addition an acoustic and visible alarm inside and outside the building to give a warning to the personnel. The device may be delivered as one unit including the sensor.

Turbidity Analyser (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	:	2.0% of full scale
Response time	:	Approximately three (3) minutes
Output signal	:	Proportional and isolated 4-20 mA DC

All parts of the analyser 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 of a type approved by the Engineer (similar to Type WLS 301 as manufactured by **YOKOGAWA ELECTRIC CORPORATION, TOKYO, JAPAN** or Type **141E1 as manufactured by TOSHIBA CO. LTD., TOKYO, JAPAN**).

2.26 Documentation

General Requirement

The Contractor shall document all aspects of the installation to provide guaranteed performance, operability and durability for the instrumentation equipment installed in the works. Following documents shall be prepared for the installation, operation and maintenance of the control system.

2.27 Instrument Schedule

An instrument schedule shall be prepared to describe specific details for each instrument selected for the project. The schedule shall include details of:

- The instrument tag number,
- The manufacturer, model number and specification code,
- The process service conditions (fluid, pressure etc),
- The operating range and set point,
- The output signal and accuracy limits,
- The power supply,
- The wetted parts materials of construction,

The materials and construction details for the enclosures, transducer bodies and inter connecting cables,
The provision for installation and mounting.

2.28 Loop Schematic Diagrams

A wiring diagram shall be prepared for each instrument. The diagrams shall include the following information:

Cable, wire and terminal numbering,
Connection details for the selected instruments and other loop equipment,
Power distribution wiring diagrams.

2.29 Layout Drawings

A layout drawing shall be prepared for each control desk and panel. The drawing shall include the following information:

Panel dimensions and provision for cable entry,
Construction details,
Layout of panel front and panel interior,
Space allocated for future equipment (if required).

2.30 Instrument Location Plans

An instrument location plan shall be prepared to show where each instrument is located. The drawing shall be based on the mechanical installation drawing and shall show:

Location of panels,
Location and type of pedestals dc,
Location of transducers, transmitters and switches, with reference to pedestal, process pipe or relative level (RL) as applicable.

2.31 Installation Details

An installation detail drawing shall be prepared for each type of installation. The drawing shall include all the features shown in the typical instrument mounting drawings together with:

Installation dimensions,
Details of all devices and accessories needed for the operation and maintenance of the installation, provision for cables and conduits,
Construction details and details of attachments to structures,
Process tapings and instrument piping details.

2.32 Calibration Certificates

A calibration certificate shall be prepared for each instrument. The certificate shall include:

Signatures to guarantee the calibration of the instrument,
Identification of the instrument tested,
Description of the calibration procedure,

Identification of the calibration equipment,
A record of the calibration tests.

2.33 Commissioning Certificates

A commissioning certificate shall be prepared for each instrument loop. The certificate shall include:

Signatures to guarantee the performance and operation of the instrument loop,
Identification of the instrument and associated loop devices,
Description of the commissioning procedure,
Identification of the test equipment,
A record of tests to prove continuity, functionality, accuracy, leak tightness, neatness and labelling of the instrument installation together with associated loop equipment

2.34 Submission of Preliminary Information

The Contractor shall supply to the Employer the following preliminary information within six weeks of commencement of the contract:

Instrument schedules
Typical wiring and connection diagrams
Installation requirements

2.35 Submission of Certified Construction Information

Within twelve weeks of commencement of contract the Contractor shall supply the following certified construction information

Drawings with overall installation dimensions and mounting details
Drawings showing the arrangement for each control panel
Mass of each panel with equipment
Installation, operation and maintenance manuals.

2.36 Submission of Final Information

The Contractor shall progressively supply the following information within one week of the completion of the Contractor's commissioning activity:

As installed wiring diagrams, and panel drawings
Instrument location plans and installation details,
Instrument calibration certificates and commissioning certificates,

2.37 Control and Operation Requirements

Raw Water Pumps

Raw water pumps shall be started and stopped by the operator in response to the requirements of the treatment works as specified under the Employer's Requirement. Pumps shall be Protected against loss of suction, and designed to trip the pump in the event that the current drawn by the motor drops below an adjustable set point. Variable speed drives in combination with squirrel cage induction

motors shall be used for raw water pumps. Where a motorized valve is fitted to the discharge of the pump the valve shall be automatically opened when the pump starts and closed when the pump stops. A limit switch on the valve shall be wired to the motor starter circuit to prevent the motor from starting unless the valve is closed and to trip the pump in the event that the valve closes when the pump is running.

Treated Water Pumps

Variable speed drives in combination with squirrel cage induction motors shall be used for Raw water pumps and treated water pumps as specified under the Employer's Requirement.

Treated water pumps shall be started and stopped by the operator in response to the demand of the distribution system and the levels in storage reservoirs as specified under the Employer's Requirement. Allowance shall be made by future provision of controls for automatic starting and stopping of the pumps in response to telemetry signals from a remote storage reservoir. Pumps shall be protected against loss of suction by an undercurrent relay fitted in the motor starter and designed to trip the pump in the event that the current drawn by the motor drops below an adjustable set point. A low level in the treated water storage tank shall also trip the pump. Where a non return valve of the swing check type is fitted to the discharge of the pump a limit switch shall be provided with the non return valve and wired to the motor starter circuit to prevent the motor from starting unless the valve is closed and to trip (lie pump in the event that the valve closes when the pump is running. Where a motorised valve is fitted to the discharge of the pump the valve shall be automatically opened when the pump starts and closed when the pump stops. A limit switch on the valve shall be wired to the motor starter circuit to prevent the motor from starting unless the valve is closed and to trip the pump in the event that the valve closes when the pump is running

Filter Backwashing

Each filter shall be provided with a locally mounted control desk arranged to provide the operator with a view into the filter. The head loss across the filter shall be measured with a differential pressure transmitter. When the head loss exceeds a preset adjustable level an alarm shall be raised to alert the operator that a backwash is required. The alarm shall consist of an audible signal which continues for 60 seconds or until the backwash is initiated, or until manually switched off, whichever occurs first, and a flashing light which continues until the backwash is initiated or the light is manually switched off whichever occurs first.

Controls shall be arranged to permit a fully automatic backwash to be initiated by pressing a single pushbutton on the control desk. The sequencing of all valves, pumps, blowers etc shall be fully automatic. Provision shall also be made to shutout the backwash manually in the event that the automatic controls are out of service for any reason. All necessary pushbuttons and selector switches for controlling the backwash sequence shall be provided. A single selector switch shall allow the backwash sequence to be changed from automatic to manual. Indicator lights shall be provided on the control desk to indicate the status of all valves, pumps and blowers.

Only one filter may be backwashed at any one time and the controls of all filters shall be suitably interlocked to ensure this.

Plant Monitoring

Where flow meters are fitted or specified, the flow rate in each treated water delivery main shall be measured and recorded on a chart recorder in the treated water pump station. For flow meters on raw water mains the recorder shall be in the raw water pumping station unless otherwise specified. The pressure in each delivery header shall also be measured and recorded in the same location.

2.38 Tests and Test Reports

All equipment shall be completely assembled at the factory. They shall be subject, unless otherwise noted, to each test as specified in the GENERAL and /or TECHNICAL SPECIFICATIONS.

The Contractor shall carry out all necessary testing and commissioning to demonstrate to the Employer that the equipment supplied and installed meets the requirements of this Specification and all relevant standards and statutory Regulations. All testing shall be carried out by qualified and experienced staff using appropriate and correctly calibrated test equipment.

The Contractor shall notify the Employer at least thirty (30) calendar days prior to the manufacturer's factory tests and the field test, and shall submit the test procedure for approval of the Employer. The Engineer reserves the right to witness all tests.

The Contractor shall furnish the service of the manufacturer's serviceman, all special tools, temporary materials, electricity, fuel, assistance, labour, apparatus and instruments as may be requisite and as may reasonably demanded to carry out such shop and field tests efficiently. The Contractor shall provide a safe working environment for shop and field test. Sufficient data shall be obtained during shop and field tests to permit the inspection and to plot characteristic curves for various specified operation conditions.

The tests shall be made at 50 Hz.

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

The tests shall include, but not necessarily be limited to the following

LV Switchboard, Instrumentation and Annunciator panels.

The LV switch boards shall be completely assembled at the factory. Each panel board shall be subjected to the following tests by the Contractor, in addition to all factory routine tests and field tests specified in the respective IEC standards:

- (1) Factory Tests
 - (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 energising:

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

The dates for tests shall be intimated to the Engineer well in advance. The procedure for the tests, the formats for recording of test results and other essential particulars should be submitted to the Engineer and his approval for them should be obtained prior to the tests being carried out. The Engineer reserves the right to witness any of the tests, and during such witnessing the contractor shall provide all necessary assistance and information to enable the Engineer to effectively witness the tests.

Electric Motors

All electric motors shall be completely assembled and tested in factory as follows:

- (i) Construction check
- (ii) Measurement of stator winding resistance
- (iii) No-load tests
- (iv) Calculation of full load characteristics and breakaway 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) Dielectric withstand test of 2 kV.AC for one minute
- (ix) Noise tests
- (x) Vibration tests
- (xi) Measurement of insulation resistance
- (xii) Lock rotor test (Certificate of type test with test report may be acceptable)
- (xiii) Check correct operation of thermistor protection and anti-condensation heaters

Variable Speed Drives (VSD)

VSD shall be fully tested at the manufacturer's works including motor loading. Certificates of compliance shall be available on request.

Battery Chargers

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

Battery Charger Panel

Construction check

Power frequency voltage withstand test

Measurement of insulation resistance

Calibration test for meters
Operation tests including sequence check

Cables

The following tests shall be carried out by the contractor, in addition to the tests specified in the respective standards:

Routine Tests in factory

Construction test
Resistance measuring
Withstand voltage test
Insulation resistance test
High temperature insulation resistance test
Tensile strength test
Coiling test
Thermal shrinkage test
Oil proof test
Non-inflammability test
Shield conductivity test
Impulse breakdown voltage test
AC breakdown voltage test
Chlorine gas measurement
All LV cables shall be meggered before energizing.

Where multiple cables are installed in parallel a suitable test shall be conducted to ensure that no crossover of any phase has occurred. All cables shall be phased out to ensure that alternate supplies may be safely paralleled.

Earthing

The Contractor shall measure the overall resistance to earth of the complete earthing system.

2.39 Spare Parts and Tools

Spare Parts, Lubricating Oils and Greases

The Contractor shall include for the provision of oils and greases as required for efficient lubrication of all plants supplied up to the end of the defects liability period.

Recommended Spares

The Contractor shall set out a list of recommended and required spares as recommended by the manufacturer for five years service under normal running conditions, together with unit prices, in the appropriate sections of the schedule of recommended spare parts. Unit prices shall be valid until the end of the defects liability period. The quantities and types of spare parts shall be subject to the Engineer's agreement. Within the defect liability period the Employer issues the Contractor with a written list of the required items. The Contractor will deliver the items on the list at the specified

unit prices before the issue of the defect liability certificate. A receipt for such delivery shall be retained by the Contractor for the Engineer's examination and approval.

All spare parts shall be strictly interchangeable with the corresponding parts in the Plant. They shall be packed and protected for storage at site over long periods without deterioration due to adverse conditions. Sealed heavy gauge polythene packing or other approved methods shall be used. All parts shall bear clear indelible identification on the packing. The identification labels shall state the part number and the item number of the drawing, as well as the description of the item in English.

Two copies of a detailed list of the items supplied together with their respective part numbers shall be handed over to the Employer with each batch of spares delivered.

Any special tools necessary for the assembly, dismantling, alignment, calibration or maintenance of the equipment shall be separately listed, priced and referred to in the relevant section of the Bill of Quantities.

In order to enable the Employer's staff to carry out all services and maintenance work, common repairs and periodic replacements, the Contractor shall supply the necessary spare parts, tools and equipment including non-standard (i.e. specially made) hand tools or dimensional gauges as required.

The Contractor shall supply necessary spare parts and tools and submit a fully detailed list of the necessary spare parts and tools including additional necessary spare parts recommended by the manufacturer.

Under the respective items "Spare Parts" of the BOQ the following material is to be quoted with lump sum prices which must be supported by an itemized list of spare parts indicating unit price against each spare parts:

General spare parts
Special spare parts; and
Consumable material

The scope of supply shall be based on an operating time of each component of 17.500 working hours (i.e. two years).

Breakdown of Prices

The lump sum prices quoted by the Bidder in the BOQ are to be broken down in separate lists submitted with the Bid giving the following information:

Description of the component;
Number of units;
BOQ item of the spare parts;
BOQ item of the respective equipment; and
Unit price and total price according to the form.

All spare parts to be supplied shall be interchangeable with the corresponding parts of all the equipment supplied under these Specifications and shall be of the same material and workmanship.

All spare parts are to be protected against corrosion and provided with identification labels in the English language. The specifications of the identification labels shall be submitted to the Engineer for approval. All rubber packing must be delivered in endless loops whenever installation in this condition is possible. O-ring type packing shall be delivered properly packed for long duration storage in a predetermined storage place. All spare parts, tools and materials shall be delivered in marked boxes of sufficient sturdy construction to withstand several years of storage and handling.

General Spare Parts

For a number of similar or identical installed assemblies or sub-assemblies the following general spare parts shall be delivered, where “One Set” shall be defined as the total quantity for one assembly or sub-assembly:

Two complete sets of packing, seals, gaskets, bushings, springs, wearing parts of coupling, wear rings of pumps, pump impellers, drive belts, etc., for each identical assembly such as generators, governors, motors, pumps, compressors, valves, internal combustion engines, etc;

One complete set of clamps as well as of seals, gaskets, and packing for each 10 valves, identical in size and type, but at least two sets;

10% of the gaskets and seals identical in type and size of the pipelines, with a minimum number of three;

10%, but at least two assemblies or sub-assemblies, of all heat exchangers, filter elements, measuring and control instruments, limit switches, relays, etc., fuses, signal lights, clamps, installation switches; and

5%, but at least two pieces, of all bolts (except foundation bolts), screws, nuts, washers, etc. The quantity may be taken from the surplus quantity handed over to the Employer after completion of the installation as described under this chapter “Bolts, Screws, Nuts, etc.” of this Section.

In addition, for all items under this Contract, the Contractor shall deliver 5% of the quantity of painting material, with a minimum quantity of one litre, in unused sealed containers, for later repair work other than that carried out by the Contractor.

Consumables

The contractor shall provide all necessary consumable items required for testing and commission all materials and equipment supplied and installed under this contract. The cost of consumable is deemed to have been included in the BOQ.

Production materials such as fuel oil, calcium hypochlorite etc. are excluded; they are to be supplied for final test run only.

General Tools

The contractor shall provide general tools equipment in accordance with following specifications for each sub-project.

All such tools and equipment shall be procured from reputed manufacturers and shall comply with acceptable international standards and ISO 9000 series for quality assurance with prior approval of the Engineer.

Workshop and Pipe Fitters Hand Tools

Sets of pipe fitters hand tools for use by local operating units. Each set of tools shall comprise:

- 1 No 300 mm steels hacksaw frame
- 50 No High Speed all hard cutting blades 18 teeth per inch
- 50 No High Speed all hard cutting blades 24 teeth per inch
- 2 No Wire scratch brush for general use
- 2 No 250 mm flat bastard files with handles
- 2 No 250 mm round bastard files with handles
- 1 No Engineers ball pein hammer 450 grams
- 1 No Engineers ball pein hammer 1kg
- 2 No 600 mm Stillson pattern pipe wrench
- 2 No Chain pipe wrench capacity 25 - 150 mm
- 2 No Foot print adjustable pipe tongs 75 mm capacity
- 1 No Combination pliers 200 mm with pipe grip, side and joint cutters
- 1 No Screwdriver 100 mm long with plastic handle and flared tip
- 1 No Screwdriver 200 mm long with plastic handle and flared tip
- 1 No Screwdriver 200 mm long with plastic handle and start tip
- 1 500 ml capacity pump action oil can
- 1 No Adjustable wrench 15° off set 300 mm long with 35 mm capacity
- 2 No Adjustable wrench 250 mm long with 25 mm capacity
- 1 No Steel tape 3 m retractable with locking device
- 15 m High pressure water hose 150 psi
- 01 No Bearing puller 12"
- 01 No Bearing puller 8"
- 01 No Puller Three jaw
- 01 No Chain lift 05 ton
- 01 No Chain lift 03 ton
- 01 No Hydraulic jack 25 ton
- 01 No Angle grinder 9"
- 01 No Electric hammer drill machine ½"
- 01 No Portable vacuum cleaner 230V
- 01 No Crimping tools kit
- 02 No Manual pipe threading machine 3"
- 02 No Manual pipe threading machine 2"
- 02 No Pipe vice 6'
- 02 No Pipe wrench 24"
- 02 No Pipe wrench 14"
- 02 No Pipe wrench 10"
- 01 No Clamp on meter (Pointer type) 600 V
- 01 No Bench drill machine (Heavy duty) 1"
- 01 No Filter belt wrench vertical socket type
- 01 No Hydrometer to check battery Sp gravity
- 01 No Rochet monkey jack 3 ton
- 01 No Numbering punch set
- 01 No Hammer 02 Lbs

01 No Hammer 04 Lbs

Mechanical Hand Tools

- 1 Set Ring spanners size 6 mm - 36 mm
- 1 Set Open end wrench spanners size 6 mm - 36 mm
- 1 Set LNK spanners size 3 mm - 36 mm
- 1 Set Box - ring spanners size 3 - 36 mm
- 1 Set Torque wrench unit size 12 - 36 mm
- 2 Set Pliers small, middle, and large
- 3 Set Scale measuring units

Electrical Hand Tools

- 1 Set Flat screw drivers size 2 - 10 inches
- 1 Set Cross screw drivers size 2 - 10 inches
- 1 Set Test screw drivers size 2 - 5 inches
- 1 Set Pliers, cutting pliers, and dismantling pliers size 2 - 5 inches
- 1 No Multimeter
- 1 No Clamp meter

Insulation Resistance of the Instrument shall be 500 V.

Special Tools and Appliances

The scope of supply under this Contract shall include all customary and special tools, if and as far as not included in the specified “Workshop and Pipe Fitters Hand Tools” of the Technical Specifications, etc. necessary to replace parts of the supplied equipment. Furthermore, all accessories for maintenance shall be supplied and included in the bid.

The tools, wrenches, etc. shall be new and unused. Customary tools for erection shall be of the forged and polished chrome-vanadium type. Use of special tools and devices for erection shall be allowed, but must be approved by the Engineer in each case. Special tools and devices shall be provided with means for ready identification.

Suitable hardwood or steel boards arranged for wall mounting as well as tool carts and/or tool boxes shall be included in the delivery. An itemized price list and description of all provided tools, auxiliary devices, storage equipment, etc. shall be included in the bid.

Acceptance of any tool or device shall not take place before the Contractor has submitted the complete final detailed list of tools and appliances.

Laboratory Equipment

The contractor shall supply following set of laboratory equipment for each sub-project.

- 01 No Jar tester (06 gun paddle)
- 01 No Turbidity meter
- 01 No PH meter

- 01 No Colour meter
- 01 No RCL comparator

Spare Parts for Instrumentation

Flow meters

02 sets of all PCB's used in the flow meter shall be provided.

Ultrasonic flow meters

02 sets of all PCB's used in the flow meter shall be provided (for each model)
02 No. Ultrasonic sensors shall be provided.

Radio link

01 set of radios (01 transmitter/01 receiver)
01 set of all PCB's used for interfacing and control.

Electrode type level switch

01 No. Sensing relay (per each model)
01 No. Electrode assembly (for each model)

Float type level switch

03 No. Float switching complete with cable.

PLC

01 No. PLC (Programmed and ready for replacement) for each type of PLC installed.
PLC programming software with cables etc.
Hand held programming tool.

Pressure Switch

03 Nos. complete pressure switch

Flow Witch

03 No. Flow switch

Motor Operated Valve

01 No. Complete actuator assembly

Uninterrupted Power Supply

01 set of PCB's for all type used.

Accredited Agents and After Sales Services

All equipment and material supplied and installed under this contract shall be supported by accredited agents in Sri Lanka who shall be equipped with adequate technical support staff workshop facilities and sufficient stock of spare parts in order to render effective after sales services.

Environmental Conditions

The equipment to be provided under this contract shall be suitable for installation and operation in Sri Lanka. Outside ambient temperatures range between 20 °C and 40 °C and water temperature varies between 25 °C and 35 °C. Relative Humidity is expected to range between 60 and 100 percent. Atmosphere is dusty.