J7 EMPORIUM, PAKISTAN

ELECTRICAL SPECIFICATION

PART 1 – MV INSTALLATIONS

TRANSFORMERS, GENERATORS & GIS PANEL

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DOCUMENT CONTROL RECORD

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DOCUMENT CONTROL					
Report Title	Electrical Specification (Part 1) – MV Installations				
Document ID	HDG-EMP-SPEC-E-01		**Project Name**	J7 Emporium	
Client	J7 Group		**Client Contact**	Mr Kamran Ghazi Mr Azhar Abbasi	
Revision	**Date**	**Status**	**Prepared by**	**Verifier**	**Approver**
0	18th October 2021	For Information only	DA	TS	TK
1	12th January 2022	For Review and Pricing	RP	DA	TK
Current Revision	**Revision 1**				

Approver Signature	
Name	Tahir Khurram

Contents

Abbreviations

AC	Alternate Current
ACB	Air Circuit Breaker
BS	British Standard
BMS	Building Management System
CB	Circuit breaker
CT	Current Transformer
DB	Distribution Board
DC	Direct Current
DN	Nominal Diameter
ELV	Extra Low Voltage
GIS	Gas Insulated Switchgear
HDHC	Hard Drawn High Conductivity
HV	High Voltage
HRC	High Rupturing Capacity
ID	Interior Designer
IDMTL	Inverse Definite Minimum Time Lag
IEC	International Electrotechnical Commission
IP	Ingress Protection
LV	Low Voltage
MCB	Miniature Circuit Breakers
MCCB	Moulded Case Circuit Breaker
MV	Medium Voltage
NEC	National Electrical Code
SPD	Surge Protective Devices
UVT	Under Voltage Trip
WAPDA	Water & Power Development Authority

1. General Section

1.1 General Information

1.1.1 Extent of Contract

The Contract includes the design review, manufacture, supply, testing, packing for transport, delivery to site, unloading, installation, connections, final testing and commissioning, handing over in approved working order and maintenance thereafter for the Maintenance Period as specified in the main contract, the whole of the Contract Works as detailed hereunder and as shown in the drawings.

The work to be carried out under this Contract shall include the whole of the materials (except equipment specified as supplied under other Contracts) and all necessary labor for the completion of the Contract in every detail ready for continuous operation whether such be directly mentioned in this specification or not. The Contract Works including all equipment and materials shall be suitable for the purpose of the Contract Works.

1.1.2 Definition of Terms

In this Specification, the word **“E” shall be as described in the “Engineer”** and any such person or persons as may be deputed by him/her in writing to act on their behalf.

The words “supply” and “provide” in this Specification shall be deemed to include in each case the term “fix”, as usually understood, unless otherwise stated.

Words importing the singular only shall also include the plural and vice versa where the context requires.

2. Electrical MV Installation

2.1 MV Switchgear and Auxiliaries

2.1.1 General

The Medium Voltage Gas Insulated Switchgear Panels under this contract shall include manufacturer's design, Factory Test and Site Test, including supply, delivery, install, testing and commissioning and complete with all MV termination kits, batteries unit, auxiliaries, ancillaries, and all associated works.

The Switchgear panels shall comprise of indoor Metal Clad floor mounted, extensible type, dust proof, insect proof, vermin proof, modular cubicles, comprises of single set of three-phase insulated busbars switchgear panels complete with status mimic displays, withdrawable type circuit breakers, bus couplers, earth switches, surge protective devices, earth fault indicators, current & voltage transformers, protection relays, ammeters, voltmeters, HRC fuses/MCCBs, tripping & closing devices, wiring and connectors, control and auxiliary switches, labels, cable jointing boxes or sealing ends, electrical & mechanical interlocks, floor frame, and all other items of equipment necessary for the safe and reliable operation of the switchgear. Room dehumidifiers of the appropriate capacity shall be provided in the switchgear room.

In this type of switchgear, all the components of this can be brought together in an extremely restricted area by enclosing through the gas-tight metal area as well as SF6 gas can be used as insulation among existing parts of the devices & earthed metal enclosure. In gas-insulated medium-voltage switchgear, SF6 gas works like an insulation material whereas the vacuum technology is mainly used for the purpose of interrupting. Even though, for both insulation and interruption, the SF6 gas can be used in several medium voltage gas insulated switchgear systems.

Each Switchgear Panel shall be provided with a mimic panel to display all conditions of selected positions such as ON, OFF, connected to Earth, etc. The design of the modular cubicles and associated equipment shall be such as to enable extensions to be made at either end with minimum disturbance to the installed equipment and without complete shut-down of the Switchgear Panels.

The numbers and layout of the switchboard are as shown in the drawings. The requirements of each switchgear panel are detailed as follows:

a. MV Feeder Panels

- Each panel shall comprise the following:
- 3-pole busbars
- 3-pole motor charged spring operated withdrawable type, circuit breaker as specified
- 3-pole connectors (CB to BB, CB to cable box)
- Current transformers for overcurrent and earth fault protection
- Current transformers for metering
- 3-phase Voltage transformer
- Complete set of interlocking gear
- 3-pole main cable box c/w gland suitable for receiving vertically descending or vertically ascending (as appropriate) cable as shown on drawings
- Control cable box complete with glands
- Protection relay – 5-Amp rating
- Set of IDMTL overcurrent and earth fault relay with high set instantaneous adjustable element (4 to 20 times)
- Kilowatt hour meter with summator to register total power consumption of the Incoming feeders

- ❖ kW maximum demand meter to register the overall maximum demand of the Incoming feeders. The meter should incorporate alarm unit with adjustable alarm contacts to initiate alarm or to shed selected non-essential loads, if required.
- ❖ Ammeter
- ❖ Voltmeter
- ❖ Neon potential indicators

The current ratings of the busbars, circuit breaker & connectors and the CT ratios, Volt-Amp & types of class of the various current transformers shall be as indicated in the drawings.

b. MV Transformer Feeder Panels

- ❖ Each panel shall comprise the following:
- ❖ 3-pole busbars of rating as specified
- ❖ 3-pole motor charged spring operated withdrawable type circuit breaker as specified
- ❖ 3-pole integral circuit earthing device
- ❖ Current transformers for overcurrent and earth fault protection
- ❖ Current transformers for current indication
- ❖ Complete set of interlocking gear
- ❖ 3-pole main cable box suitable for receiving vertically descending or vertically ascending (as appropriate) cable as specified
- ❖ Control cable box
- ❖ 3-pole IDMTL overcurrent and earth fault relays with high set instantaneous adjustable element (4 to 20 times)
- ❖ Temperature alarm and trip relay with flag indicator
- ❖ Ammeter
- ❖ Set neon potential indicators

The current ratings of the busbars & circuit breaker and the CT ratios, Volt-Amp & types of class of the various current transformers are as indicated in the drawings.

2.1.2 Rating

The 12kV switchgear shall be suitable for operation on a working voltage of 11kV, 3 phase, 50 Hz and capable of withstanding as a whole, without damage due to the electrical, mechanical and thermal stresses produced under short circuit conditions equivalent to 1,000 MVA or the fault level to be confirmed by WAPDA at the rated voltage for 3 seconds as defined in the schematic diagram as per BS EN 62271.

The whole of the switchgear shall comply with BS EN 62271-200, type tested and certified by A.S.T.A., K.E.M.A. or other recognized National or International Testing Authority. Test reports are to be submitted in technical submission.

2.1.3 Construction

The 11kV switchgear shall be of the indoor, floor mounted, extensible, metal clad design as defined in BS EN 62271 and shall be of robust construction in sheet steel, dust proof and vermin-proof, and shall comprise two portions:

(i) The fixed portion housing busbars and connections, fixed isolating contact system, safety shutters, current transformers, voltage transformer where required, cable box, relay and instrument panel, etc.

(ii) The moving or circuit breakers portion with integral carriage comprising operating mechanism, elevating system, isolating equipment, moving isolating contacts, etc.

The fixed portion shall consist of a rigid welded cubicle fabricated from sheet steel not less than 12 s.w.g., the lower compartment of which houses the withdrawable circuit breaker and the upper compartment having

separate sections housing the relays and instruments, busbars, current transformers, etc. The voltage transformer, if required, shall be mounted on rails above the back portion of the upper compartment.

The circuit breaker compartment shall be provided with a hinged door with Perspex windows for circuit breaker position with handles and lock and shall be readily removable when necessary. Internal lighting shall be provided. Floor frame and guide rails shall be provided at the base to ensure proper installation and smooth entry of the circuit breaker carriage into the cubicle.

Each switch panel shall comprise a circuit breaker, single busbars, current transformers, Voltage transformers where specified, cable box, protective relays, auxiliary relays, meters, wiring and other necessary accessories whether specified in details or not.

The end switch panel shall be so designed that extension panel, if required at a later date, can be placed in position and connected up with minimum interference to the busbars or other components of the existing panels.

Relay and instrument chamber shall be provided. Flush-pattern type instruments shall be fixed to the hinged door and for the lower compartment projecting pattern relays shall be mounted on the internal hinged frame. Easy access to the relay terminals shall be made available.

The Low Voltage compartment shall be fully segregated from the circuit breaker compartment by metal partition.

Openings with beaded edges shall be provided in the door to coincide with the relay covers and provide a flush appearance when a door is closed. Tripping-supply fuses shall be accommodated inside this chamber.

The busbar chambers shall contain three-phase hard drawn, high conductivity copper busbars of ratings as shown on the drawings, fully-insulated throughout their entire length with epoxy castings. Direct panel to panel busbar connections shall be made without the use of interconnecting links; the joints shall be encased in insulating shrouds. The busbar and feeder orifice insulators, which shall also incorporate the vertical connectors shall be encased in epoxy resin; the connectors shall terminate in silver-plated plug type the circuit breaker. Busbar and covers shall be fitted internally with the fixing screws accessible from the top of the chamber.

Circuit cable-boxes shall be mounted at the back of the panels. These boxes shall be provided with gland arrangements to take vertically descending or ascending cables of the types and sizes indicated on the drawings.

Vent pipe and enclosure over-pressure relief device shall be provided for each of the switch panel enclosures. Cable entry shall be from top or bottom according to the drawings.

2.1.4 Circuit Breakers

The circuit breaker shall be withdrawable version designed for single or multi-breaks and shall be mounted on a carriage with wheels for location within the lower portion of the switch panel. The carriage shall be provided with the necessary orifice shutter, operating mechanism, earthing contacts, secondary circuit plugs and other necessary devices for the safe operation of the circuit breaker. Circuit breakers shall be either the horizontally or vertically isolated withdrawable type. A horizontal isolated circuit breaker shall be provided with racking handles where necessary for case of insertion or withdrawal of the circuit breaker. For vertically isolated circuit breakers, motorized raising & lowering mechanism shall be provided on the carriages. The insulating medium used for the circuit breakers shall be Gas.

Gas circuit breaker shall be provided with a visual indicator showing the degree of the wearing of the contacts.

It shall be possible to locate any circuit breaker in the following positions:

(i). 'Service' position

(ii) 'Disconnected' position

(iii) 'Test' position

(iv) 'Removed' position (maintenance Position)

(v) 'Earth' position

It shall be possible to leave the circuit breaker within the switchgear compartment in the disconnected, test and earth position to enable the panel door to be closed.

When in service, disconnected, test and earth positions, the circuit breaker carriage shall afford the specified degree of protection with the panel door in the open position.

The fixed contacts of the circuit breaker shall be self-aligning comprising a cluster of spring-loaded segments with a retaining-ring, the assembly being retained to the fixed arcing contact shall be of copper-tungsten-tipped copper and the three main contact segments of silver-plated copper. The curved moving contacts shall be of connected to brass adaptors on the moving arms and driven to the fixed hinge-blocks shall be affected by means of spring-loaded hinge-contacts. The kick-off spring and the dashpot mechanisms shall be accommodated on the underside of the top-plate. The contacts shall be arranged to current carrying contacts in a closing operation and break after the main current carrying contacts in a break operation.

The circuit breaker shall be provided with an arc control device to ensure high speed arc extinction and adequate control of pressures during current breaking operations. Excessive over-voltages shall be limited by the design and careful considerations shall be given to the switching of low capacitive or inductive currents.

2.1.5 Operating Mechanism

a. Construction

The circuit breaker operating mechanism together with the circuit breaker truck and interrupter housing shall constitute an integrated unit.

The closing and tripping mechanism shall be of robust construction using stainless steel and other non-corrodible materials for bearings, pins, etc. The connections between the actuating level or bolt of the mechanism and contact-bars shall be designed to ensure positive drive in both directions and the operations of the mechanism and moving contacts shall be in unison. The contacts of all phases shall make or break simultaneously; the maximum difference between instants of contacts touching during a closing operation and the maximum difference between the instants of contacts separation during opening operation shall not exceed one tenth of a cycle of rated frequency. The operating mechanism shall be 'trip free' type as defined in BS EN 62271. The important operation procedure of the switchgear shall be stenciled on a plate to be fixed at the location to be agreed by the Engineer.

b. Power Closing

Closing mechanism shall be spring operated power closing by means of energy which has been previously stored in a motor-charged spring with electrical release in compliance with the following requirements:

(i) It shall not be possible for the circuit breaker to close while the closing spring is being charged.

(ii) It shall be necessary for the spring to be fully charged before it can be released to close the circuit breaker.

(iii) The mechanisms shall be so arranged to ensure that the circuit breaker shall always open at normal operating speed even if the mechanism fails to latch on closing.

(iv) It shall be possible to charge the spring with the circuit breaker in the

closed position and if the spring can be and is released, the circuit breaker shall not open.

(v) A visual mechanical indicating device shall be provided to indicate the state of the spring and inscribed "SPRING CHARGED" when the mechanism is in the position to close the circuit breaker and "SPRING FREE" when it is in any other condition.

(vi) Mechanisms shall be provided with means for charging the spring by hand.

c. Power Tripping

Tripping of the circuit breaker shall be by means of a spring or springs charged up during the closing operation. Each mechanism shall be provided with a shunt release and the necessary auxiliary switches. A counter shall be fitted to summate all "opening" operations of the interrupter.

The local tripping push button shall be shrouded to obviate inadvertent operation of the circuit breaker and means shall be provided for pad-locking of the manual tripping of the circuit breaker. It shall not be possible to gain access to the tripping toggle or any part of the mechanism which would permit defeat of the locking of the manual tripping. Where earthing is done through the circuit breaker provisions shall be made to ensure that the electrical tripping of the circuit breaker is inoperative both during closing and when closed in the earth position. The electrical tripping shall be restored automatically when the circuit breaker is moved from the earthing position.

d. Control Facilities

The motor-charged spring-operated power-closing mechanisms shall be provided with the following control facilities:

(i) Remote electrical closing-release and trip suitable for connection to a Control Supervisory Panel.

(ii) Local electrical closing-release and trip with selection at the circuit breaker.

(iii) Local manual closing-release and trip preferably by push buttons shrouded to prevent inadvertent operation.

(Iv) Automatic re-charging of the spring after the completion of a closing operation, with a control switch on each panel to cut off the AC supply to disconnect this facility.

e. Position Indicators

The following are the minimum position indicators that shall be provided on the circuit breaker:

(i) Spring charged

(ii) Spring free

(iii) ON

(iv) OFF

(v) Earthing device

All above indicators shall be operated through mechanical means. If the mechanical indicators are not visible to the operator without opening the front cover or door, additional electrical indication by LED showing the "ON" and "OFF" positions for the circuit breaker shall be provided on the front of the switch panel. Supply to these electrical indicators shall be fed from the battery charger through an independent circuit.

2.1.6 Orifice Safety Shutter

Busbar and circuit shutters shall be provided to cover each three-phase group of stationary isolating contacts. Each set shall be capable of being individually operated and padlocked. The shutters shall open and close automatically by a positive drive.

The shutters shall be automatically in closed position when the circuit breaker is in the following position:

(i) 'Disconnected' position

(ii) 'Test' position

(iii) 'Removed' position (maintenance position)

For circuit breakers with integral method of earthing, the shutters for unearthed stationary isolating contact shall be in closed position when the circuit breaker is in earthed position.

To facilitate testing, an integral device shall be provided for fixing (but not padlocking) the shutters in the open position and subsequently for releasing them to the closed position and this device shall be designed so as to be concealed by the moving portion to ensure restoration of the automatic features of the shutters.

The mounting of the shutter shall be so designed that it is not possible to interchange the busbar and circuit shutters.

Busbar shutters shall be painted "Signal Red" colour 537 to BS 381C and shall be clearly labelled "BUSBARS" in large white letters. Circuit shutters shall be painted "Lemon" colour 355 in B.S. 381C and shall not be lettered.

On bus-section panels both sets of shutters shall be painted "Signal Red" colour specified above and labelled "BUSBARS" in large white letters. An arrow shall be painted in white on each shutter of bus-section panel to point towards the section of busbar with which the shutter is associated.

2.1.7 Earthing Facilities

Each switch panel shall be arranged to permit earthing of the circuit side of the equipment. Earthing shall be carried out by means of one of the following methods:

(i) Through circuit breaker after it has been transferred to the appropriate earthing location within its compartment, without the use of loose equipment.

(ii) By means of 3-phase quick-acting fault-making earthing switches installed at the circuit side of each switch panel. The switches shall be closed by a manual-charged spring. There shall be a minimum of 3 seconds time delay in the operation cycle, i.e. time between close and opening of the earthing switch.

Busbars and WAPDA incoming cable earthing are not required.

2.1.8 Interlocks

Each switch panel shall be provided with complete interlocking facilities to prevent any dangerous or undesirable operation. The following shall be the minimum interlocks provided:

(i) A closed circuit-breaker from being withdrawn or inserted into its 'service' position (mechanical interlock).

(ii) The operation of circuit breaker unless it is in its 'service', 'disconnected', 'removed', 'test' or 'earth' position (mechanical interlock).

(iii) Closing of the circuit breaker in the 'service' position when the secondary connections between the fixed portion of the switch panel and the circuit breaker are not complete (mechanical or electrical interlock).

(iv) A circuit breaker from being put into service unless all its pole parts are in their normal position (mechanical interlock).

(v) The operation of the tripping mechanism when an attempt is made to isolate a circuit breaker from its 'service' position (mechanical interlock).

(vi) The insertion of circuit breaker into its 'service' position when the quick acting fault-making earthing switch is in its 'closed' position (mechanical interlock).

(vii) The operation of the earthing switch when the circuit breaker is in the service' position.

2.1.9 Cable Termination

Cable boxes shall be provided for each of the switch panel suitable for the terminations of the types and sizes of cables routed from below or above the switch panel as shown in the drawings.

Cable boxes shall be rated to match the insulation level of the switchgear. Cable boxes shall be provided with copper cable sockets or lugs, glands suitable for the sizes of cable used, earthing clamps, etc. Where appropriate for termination boxes shall be provided to each switch panel as required.

Cable termination kit(s) shall be provided for every panel and shall be of the shrinkable type with proven performance records. The termination kits shall offered be designed for use on 11 kV cables specified and shall be subject to review by the Engineer.

Each termination kit shall include three 2' lengths of 25 sq. mm each of tinned copper braids for the earthing of the metallic screen of the cables.

2.1.10 Current Transformers

The current transformer shall be epoxy-resin insulated of the bar or wound primary type to BS 3938 and IEC 60044.

The current transformers shall have the specified output, ratio and accuracy under ordinary load condition as shown in the Schedule of Technical Requirements and Drawings and shall also be capable of withstanding for a specified time, the effects of the short circuit fault currents within the breaking capacity rating of the switchgear.

The current transformers shall be mounted in their own chamber in the fixed portion of the switch panel on the circuit side. Special precautions shall be taken to ensure good connection of the secondary loads to the protective relays on the fixed portion of the switchgear. An interlock shall be provided to prevent the circuit breaker being put into service when the secondary leads are not correctly or effectively connected to the relays. The secondary leads shall be automatically shorted out when the current transformers are disconnected.

Provisions shall be made such that primary injection test on the current transformers can be made after the main cables have been connected to the switchgear without dismantling the switch panel.

All current transformers shall be calibrated before installation. Current transformers for tariff metering are to be calibrated by WAPDA and manufacturer's test reports are to be submitted to the Engineer.

2.1.11 Voltage Transformers

Voltage transformers shall be accommodated on top of the cubicle and shall be of the 3-limb or 5-limb type with ratios to suit the system Voltage to IEC 60044.

The primary windings shall be epoxy cast-resin insulated and connected to the circuit side of the current transformers remote from the busbars so as to be included in the zone of the equipment controlled by the circuit breaker.

The connections from the main circuit to the point of isolation of the voltage transformers shall be capable of carrying, without damage, the rated short-time current of the circuit breaker equipment and shall also be suitable for carrying continuously a minimum current of 200 Amps for the purpose of primary-injection testing of the protection apparatus.

The voltage transformer carriage shall be readily removed from the circuit breaker panel when required and padlocking facilities shall be provided in both the service and isolated positions.

Links shall be provided on the primary side to isolate the Voltage transformers for the purpose of power frequency Voltage withstand test on the circuit breaker. The secondary winding shall be protected from external short circuit by MCB.

Voltage transformers for tariff metering are to be calibrated by WAPDA and manufacturer's test reports are to be submitted to the Engineer.

2.1.12 Surge Arrester

Gas-insulated surge arrester shall be constructed from a stack of serially connected – extremely non-linear metal-oxide (MO) resistors in a metallic enclosure under pressurized SF6-gas. The special design with high-field blocks allows reduction of the size of the surge arrester, which is an important factor for GIS.

These surge arresters shall be designed and type-tested according to IEC 62271-203 and IEC 60099-4.

Surge arresters are used to protect the insulation of gas-insulated switchgear as well as the connecting cables and transformers against transient lightning and switching overvoltages.

2.1.13 High-Speed Earthing Switch (HSES)

A high-speed earthing switch (HSES) of a gas-insulated switchgear (GIS) performs a secondary role in protecting the power system in the event of an accident. After being interrupted by a circuit breaker (CB), the short-circuit current remaining in the network should be earthed by the HSES.

2.1.14 WAPDA Incoming Feeder Protection

The WAPDA incoming feeder panels shall be provided with two protective systems or as per other WAPDA requirements:

(i) Solkor "R" or DPDL 120 pilot wire protection or as approved by WAPDA engineer to operate in conjunction with similar equipment at the remote end of the WAPDA sub-station.

(ii) An inverse definite minimum time lag (IDMTL) non-directional protection system employing three overcurrent and one earth fault relay of the heavily damped induction disc type with high

set overcurrent elements to provide instantaneous protection under maximum short circuit conditions.

The current setting range of the overcurrent relays shall be between 50 and 200 percent in six equal intervals of 25 per cent. The earth fault element shall be between 20 and 80 per cent in six equal intervals of 10 per cent. The definite minimum time for both overcurrent and earth fault relays shall be continuously variable between 0.3 to 3 seconds. The time/current characteristics shall be the 3/10 category in accordance with B.S. 142. High set instantaneous element shall be adjustable from 4 to 20 times the full load rating of the circuit breakers. Final protection setting shall be subjected to WAPDA or WAPDA engineer approval.

2.1.15 Relays

All protective relays offered for consideration shall be acceptable to the WAPDA and/or the Engineer. The relays shall be of the electro-mechanical or static transistorized versions or a combination of both types. Relays offered shall be Class S3 with respect to their ability to withstand the mechanical shocks and vibration in compliance with BS 142.

Relays shall be the draw out, flush mounted in dust-proof casings, complying with BS142 or equal. Relay cases shall generally be finished in bright black enamel. Relays of the hand reset type shall be capable of being reset without opening the case. Relays, where appropriate, shall be provided with flag indicators, phase coloured where applicable. Flag indicators shall be of the hand reset pattern. Where two or more phase elements are included in one case, separate indicator shall be provided for each element.

Suitable means shall be provided on the relay panels for the testing of protective relays and associated circuits.

To minimize the effect of electrolysis, relay coils operating on DC shall be so connected that the coils are not continuously energized from the positive pole of the battery.

MCBs shall be provided for all voltage transformer secondary circuits, DC circuits and meter supply circuits.

All relays shall be suitably marked to indicate function, phase characteristic curve, rated current and Voltage, rated making capacity of contact where appropriate.

2.1.16 Transformer Protection

Each Transformer Panel shall be provided with the following protective systems:

(i) Winding temperature protective system. The switch panel shall be provided with trip alarm and indication relays.

(ii) IDMTL protective system employing two overcurrent and one earth fault relay with high set instantaneous elements. The requirements for IDMTL relays shall be similar to those as specified for the WAPDA incoming feeder protection.

2.1.17 Indicating Instruments

Indicating instruments for external panel mounting shall be of the flush pattern, with square escutcheon plates finished matt black and pressed steel cases. Indicating instruments shall be to BS 89 1st grade, moving iron spring controlled with 4” diameter dials (240-degree scale) with cyclometer registers. Instruments connected to double ratio current transformers shall be provided with reversible scales. The instruments shall not be damaged by passage of fault currents through the primary of their corresponding instrument transformers. Instruments shall be located on the front of the switch panels at a convenient position.

Meter panels shall be hinged to provide ready access to connections and small wiring shall be enclosed in flexible plastic conduit. All meters shall be fully tropicalized. All terminals shall be completely insulated and potential circuits shall be suitably fused.

2.1.18 Indicating Lamps and Fittings

All indicating lamps shall be the transformer operated type. Indicating lamps fitted to the fascia's of switch and instrument cubicles or panels shall be adequately ventilated. Lamps shall be easily removed and replaced from the front of the panel by manual means not requiring the use of extractors.

The bezel of metal or other appropriate material holding the lamp glass is to be of good quality finish and to be easily removable from the body of the fitting so as to permit access to the lamp and lamp glass.

The lamps shall be clear and suitable for fitting to an accepted standard form of lamp holder. The rated lamp Voltage should be 10 Volts in excess of the DC supply Voltage. Alternatively, low Voltage lamps with series resistors will be acceptable.

The lamp glasses shall be in the standard colours, red, green, blue and white etc. The colour shall be in the glass and not an applied coating and the different coloured glasses shall be interchangeable. Transparent synthetic materials may be used instead of glass.

2.1.19 Auxiliary Switches

Sufficient numbers of auxiliary switches shall be provided in each switch panel for indication, protection, metering, control, interlocking, supervisory and other services specified. Auxiliary switches shall be wired up to a terminal board on the fixed portion of the plant, whether they are in use or not in the first instance.

All auxiliary switches and mechanisms shall be mounted in accessible positions clear of the operating mechanisms and shall be suitably protected. The contacts of all auxiliary switches shall be strong with a positive wiping.

2.1.20 Terminal Boards

All terminal boards shall be mounted in accessible positions and, when in enclosed cubicles shall be inclined towards the door. Spacing of adjacent terminal boards shall be not less than 4" and the bottom of each board shall be not less than

8" above the incoming cable gland plate. Separate studs shall be provided on each terminal strip for the cores of incoming and outgoing cables including all spare cores. Separate terminal boards shall be used for circuits of different Voltages and they shall be spaced / segregated to the requirements of the Engineer.

Brass bolts and studs shall be of not less than O.B.A. size but stainless steel and bronze down to 2 B.A. may be used provided that the current carrying capacity is adequate. All studs shall be provided with nuts, washers and lock nuts or lock washers. Where pinch type terminations are provided these shall be subject to review by the Engineer.

These are to have adequate current carrying capacity and shall be provided with locking devices. Insulated carrier shall be fitted between adjacent terminals.

Terminals shall be fitted with non-inflammable transparent plastic covers to prevent contact with any live parts. They are to have warning labels with red lettering mounted thereon in a conspicuous position.

All connections shall be made at the front of the terminal boards and no live metal shall be exposed at the back.

2.1.21 Control Switches and Push Buttons

Control switches for electrically operated circuit breakers shall be of pistol grip type arranged to operate clockwise when closing the circuit breakers and anti-clockwise when opening them. They are to be designed to prevent accidental operation and interlocked to prevent two successive operations in the “close” direction

Switches for the other apparatus shall be operated by shrouded push-buttons or having handles of the spade type, the pistol grip type being reserved for circuit breaker operation only. Control, reversing selector and test switches shall be mounted, constructed and wired so as to facilitate the maintenance of contacts without the necessity for disconnecting wiring.

Control switches for circuit breakers and for motor operated setting devices, shall be of the non-locking type with spring return to the ‘neutral’ position. Such switches shall be controlled by independent springs, the use of contact springs alone for restoring not being acceptable.

All push-buttons shall be of the non-retaining type made on non-hygroscopic material, non-swelling and fitted to avoid any possibility of sticking. All push-buttons provided for remote stopping of motor control gear and all emergency trip push-buttons shall be of the “hold-in” type requiring to be reset by being pulled out, or by a separate release device which may be the associated “start” push-button.

The contacts of all switches and push-buttons shall be strong with positive wiping action when operated.

All control switches shall be provided with labels complying with the relevant section of this Specification in addition to clear indication as to the direction of each operation for example “Open”, “Close”, etc.

2.1.22 Service Contactors

Contactors shall comply with B.S. 5424: Part 1 with uninterrupted ratings (U.R.), mechanical duty Class II and making and breaking category A4.

Contacts shall be renewable butt type, solid copper hard silver faced, fully shrouded main and auxiliary contacts and the design shall be such as to ensure effective freedom from contact bounce and sticking of the fixed and moving portions of the magnet assembly. Auxiliary contacts shall be provided as required by the Specification and/or Drawings.

Contactor coils shall be fully tropicalized and wound for continuous operation at phase Voltage with Class F insulation to B.S. 5000.

Magnets shall be fabricated from silicon alloy rivetted electrical steel sheet with shaded pole and magnet/armature assemblies shall be fully floating and self-aligning.

Arc chutes and magnetic blow out coils shall be fitted to the larger sizes as necessary.

2.1.23 Anti-Condensation Heaters

Anti-condensation heaters shall be provided for each switch panel suitable for electrical operation at 230 Volts. AC 50 Hz single phase of sufficient capacity to raise internal ambient temperature by 5 degree Celsius. The electrical apparatus so protected is to be designed so that the maximum permitted rise in temperature is not exceeded if the heaters are energized while the apparatus is in operation. A suitable terminal box and control switch, with indicating lamps, shall be provided and mounted in an accessible position. All such equipment, whether fitted with a heating device or not, shall be provided with suitable drainage and to be free from pockets in which moisture can collect.

2.1.24 Fuses & Links

All fuses and links associated with electrical instrument, protection and control circuits shall be grouped as far as possible according to their functions. They shall be clearly labelled, both on the panels and the associated wiring diagrams.

Fuses and links shall be connected to enable all or any of the control circuits to be isolated for maintenance purposes.

Fuses and links associated with tripping circuits shall preferably be mounted on the outside of panels in suitable positions, whilst the remainder shall be mounted internally.

All fuses shall incorporate HRC cartridges Cat. 440/AC4 Class 'Q' to B.S. 88. Rewireable fuses will not be accepted.

Carriers and bases for fuses shall be black. Link carriers and bases shall be white.

2.1.25 Miniature Circuit Breakers (MCB) & Moulded Case Circuit Breakers (MCCB)

MCBs & MCCBs where used shall be as specified elsewhere of this Specification.

2.1.26 Motors & Control

All motors shall be in accordance with B.S. 5000 and, unless otherwise specified, shall be suitable for single phase 230-Volt 50Hz operation and of the totally enclosed fan cooled type, rated for continuous operation and suitable for direct-on-line starting.

They shall be suitable in all respects for service including a damp tropical climate. Main conductor and slot insulation are to be non-hygroscopic and in accordance with Class F of B.S. 2757.

Motors shall be capable of operating continuously at rated output at any frequency between 48 and 60 cycles per second and at any Voltage within 6 percent of the nominal value. Motors shall be designed to operate for a period of not less than 5 minutes and at normal frequency without injurious over-heating.

The motors shall be capable of accelerating the driven load to full speed in a time in seconds not exceeding 0.25 times the rated B.H.P. plus 15.

All terminal boxes shall be fitted with sealing chamber, conduit entry or adaptor plate as required together with the necessary fittings to suit the type of cable specified.

2.1.27 Labels

All cubicle doors shall be appropriately labelled to indicate the service. Labels shall also be provided to identify all items of equipment, circuits, cables and where applicable current rating of fuses and setting of relays. Labels on the exterior of equipment shall be clear Perspex, reverse engraved, filled flush with black (or red as suitable) filling and the back painted the same colour as the equipment. Labels shall be attached by means of machine screws and nuts or machine screws driven into drilled and tapped holes.

2.1.28 Secondary Wiring

All secondary wiring shall be of 600/1000 Volt grade multi-strand copper conductors of not less than 2.5 sq. mm section insulated with PVC to B.S. 6231 and shall be grouped and fixed securely without strain by cleats of the compression type. For the purpose of identification different insulation colours shall be provided to distinguish the various circuits and each connection shall terminated at a terminal block placed in an easily accessible position for testing at site with acceptable coded ferrules at both ends of each conductor. Wiring between fixed and moving portion of the switch panel shall be so secured at both ends and covered in polyethylene spiral wrapping to prevent any damages to them when the panels are moving. No connectors or

soldered joints shall be permitted in the wiring. The wiring shall be formed in a neat systematic manner, with cables supported clear of panels and without crossovers. Bushes shall be provided as necessary to prevent chafing of cables.

Each wire shall be terminated in crimped type of terminal studs. All wires associated with tripping circuits shall have red ferrules marked 'Trip'. Bus wire shall be fully insulated and run separately along the top or bottom of the panels. Circuits of different Voltages and usages shall be kept physically separated and the working Voltages and service of each circuit shall be marked on the associated terminal boards.

All external wiring between the various switch panels, battery unit, and control panel shall be in Class 'B' galvanized steel conduit to B.S. 4568 or in steel cable trunking to be carried out in a manner acceptable to the Engineer.

2.1.29 Control Panel

The control panel shall incorporate the AC and DC distribution boards, control for battery charger and all controls and indications where specified. The control panel shall be compartmentalized according to usage, fabricated from sheet steel of thickness of not less than 16 s.w.g. and finished to match the colour of the switch panels, dust-proofed with hinged covers, the free end of which shall be secured by lockable handles, designed for wall or floor mounting as appropriate. Labels of engraved Perspex type of appropriate descriptions shall be provided on the front of the panel and for all items of equipment and circuits in the control panel.

All control wiring within each panel shall be carried out and fixed in a neat and systematic manner; proprietary make PVC strap and studs shall be used to bundle the cables. Terminals of different Voltages shall be segregated and clearly labelled.

2.1.30 DC Supply Unit

a. General

The DC supply unit shall be self-contained, free-standing type housed in a ventilated, anti-alkaline treated sheet steel cabinet complete with automatic charger unit, battery units & all necessary instruments, controls, indications, etc.

The charger and battery compartments shall be accessible from the front of the cabinet by means of hinged doors. Key locking of hinged doors shall not be required.

The compartment housing the electrical and electronic components shall occupy the top section of the cabinet and shall be fully segregated from the bottom compartment which shall contain the battery unit. The battery cells shall be so arranged within the battery compartment such that the battery electrolyte levels of each battery cell will be visible and also the arrangement will enable ease of topping up the electrolyte.

b. Battery Unit

The battery unit shall consist of a series connected nickel cadmium cells with an output nominal voltage of 30 Volt and with the Ampere-hour (AH) capacity to meet the following minimum requirements:

(i) The capability to trip at least four (4) switchgear panels simultaneously and

(ii) To deliver the required current at a minimum Voltage of 80% of the nominal Voltage (i.e. 30 Volt) after 50 consecutive tripping operations with the tripping mechanism working under load conditions under the requirements of BS EN 62271.

When sizing the AH capacity of the battery, the effect of ageing shall be taken into consideration. Notwithstanding the actual AH capacity as computed to meet the above requirements, the AH capacity of the battery supplied shall not be less than 25 AH. The AH capacity of the battery unit should also account for the future spare switchgear panels if these future panels are indicated in the Specification and/or Drawings.

Only the tripping coils and the closing coils shall be connected to the battery unit. Other loads such as lamps for the circuit breaker 'on/off' indication shall be taken from a separate rectifier or from an AC source through a step-down transformer. Indicators using LED maybe connected directly to battery units provided the calculated loads consumed by the indicators for all switchgear panels is negligible and that the above minimum AH capacity requirements as stated above for the battery unit are accounted for.

c. Automatic Charger Unit

The automatic charger unit shall be designed to provide a regulated DC supply to the load while float-charging or quick-charging the battery. The charger shall be the constant potential current limiting fully automatic type. The charger shall automatically switch to float-charge after the battery is restored to 80% of its nominal capacity under quick-charge. Quick-charge shall be 'on' automatically after an emergency discharge and the duration to quick-charge the depleted battery unit to full capacity shall be less than 8 hours.

The float charge Voltage shall be adjusted to give minimum electrolyte/water consumption and long maintenance interval. The float charge Voltage shall not vary by more than +2% of the set value irrespective of AC input Voltage variation of +10% and of load variations from 0% to 100%. The root mean square (rms) ripple Voltage across the battery shall not exceed 1% of the nominal output Voltage.

The charger shall be protected against low battery Voltage and short circuit at the output by employing current limiting feature. It shall also be protected against reverse battery Voltage. High speed fuses shall be used for protection on DC output, transformer secondary, rectifier or thyristor stack.

The following instruments and control shall be provided on the charger:

(i) Mains on/off input circuit breaker with 'Mains On' neon or LED indicator.

(ii) Boost selector switch.

(iii) On/off push button for quick checking of the condition/capacity (good/bad indication) of the battery. When the push button is depressed, the battery shall be allowed to discharge through a resistor for a duration of three seconds. If the Voltage drop is negligible for that duration, the battery shall be considered as in good condition.

(iv) Voltmeter to measure charger/battery output. (v) Ammeter to measure charger output.

(vi) Earth fault alarm indication.

(vii) Under Voltage alarm indication.

(viii) Battery overvoltage alarm indication.

(ix) Electrolyte level low alarm indication.

(x) Terminals for outgoing DC bus wires to the switchboard and for incoming AC supply.

All visual alarm indication shall be of the LED type with its function clearly indicated. The use of embossing tape for labelling is not acceptable.

2.1.31 AC Control Panel

For each switchboard, a main AC panel with suitable rating MCB and terminals for an incoming supply lead and outgoing bus wires to the switchboard shall be provided.

2.1.32 Padlocks

Individual padlock shall be provided for each of the circuit breakers. Keys shall be of incorporable metal of Yale type and non-interchangeable. Three keys shall be provided for each padlock.

2.1.33 Remote Trip Push Buttons

The remote trip push buttons for the transformers shall be the proprietary make, heavy duty, surface mounted, push locked type with giant red colour head actuator, guard ring, self-locking legend plate with suitable description, enclosure, etc. suitable for operation on 230 Volts AC supply. Remote trip push button shall generally be mounted at a height of 4' 7".

2.1.34 Remote Status Indication

A central terminal box shall be provided in the HV Switch room comprising all necessary relays, auxiliary switches/contacts, terminal boards, wiring, etc. to facilitate connection of outgoing cables (by others) for remote indication of each 11 kV switch panels as detailed in the Schedule of Specified Technical Requirements. The wiring between the HV switchgears and the terminal boxes shall be provided under this Contract.

2.1.35 Remote Control Panel

A remote-control panel shall be provided in the HV Switch room comprising 'On' and 'Off' control switches for each of the feeder and transformer panels to facilitate remote closing and opening of the associated circuit breakers. All the necessary wiring shall be provided under this Contract.

2.1.36 Toolbox

A wall mounted lockable toolbox shall be provided in the 12kV Switch room to keep all the keys, special tools, logbook etc. associated with the switchgears. The toolboxes shall be constructed of aluminum frame with glass front complete with all necessary key/tool holders, labels etc. Three keys for each toolbox shall be provided.

2.1.37 Factory Tests

Prior to dispatch the switchgear out of the factory, each panel of the switchgear shall be tested in the presence of representatives of the client, if client chooses to go on this path. All cost associated shall be deemed included in the sub- contract. The factory tests to be performed shall include the below tests and other tests as recommended by the IEC/BS EN standards and manufacturer:

(i) Functional Tests to confirm the functions of the electrical control, interlock, local/ remote selector, Circuit Breaker indicator at rated control Voltage. The wiring of control and protection circuit shall be checked against the relevant control wiring diagram.

(ii) Mechanical operation tests to confirm smooth operation of circuit breaker trip / close, spring charge, disconnecting switch and earthing switch close / open for a minimum of 5 times. To confirm the mechanical interlock of circuit breaker, disconnecting switch and earthing switch for a minimum of 5 times.

(iii) Key interlock and electrical interlock tests for the couplers.

(iv) Primary Injection Tests to verify the polarity, correct CT ratio and measurement of secondary meter reading.

(v) Secondary Injection Tests to confirm the relay operations.

(vi) Contact Resistance Tests to confirm the resistance of busbar including the circuit breaker and the busbar and cable termination for each panel.

(vii) Power Frequency Voltage Test.

(viii) Dielectric Test on auxiliary and control circuit, insulation resistance shall be measured before and after the test.

(ix) Gas tightness Test, if applicable.

Prior to delivery of transformer to site, the Contractor shall carry out a site survey and make all necessary co-ordinations with the Main- contractor as regard to access for the safety transportation of transformer to the designated location.

Each panel of the switchgear shall be labeled as required by the Owner.

2.1.38 Site Test

The Contractor shall provide all the necessary testing equipment to perform all Site Testing and Commissioning.

In addition to the tests required by the Local Authority and those recommended by the Manufacturers, the following tests shall be carried out.

(i) Insulation Resistance Test.

(ii) Functional Test

(iii) Mechanical Operation Test.

(iv) Dielectric Test

2.2 Dry Type Transformers

2.2.1 General

The scope of the contract shall include design and factory testing, supply, delivery, storage, installation, testing and commissioning of all transformers. When transformers are in parallel operation, transformers shall be paired up with same vector, voltage, impedances group.

All transformers shall be of the dry type, non-inflammable, high insusceptibility to moisture, compact and cast resin insulated complete with all the necessary fittings and fittings whether specifically detailed hereunder or not but are deemed necessary by the Engineer for safe and satisfactory operation. Each transformer shall be supplied with appropriate degree of protection in accordance with IEC 60529 for installing in its respective totally enclosed Transformer Room with forced ventilation as shown in the Drawings. The rating of each transformer shall be as shown in the drawings. HV/LV Cable/Busduct termination box shall be provided and be air-insulated in construction and complete with all necessary accessories for the operation, protection and maintenance of the transformers including bonding and earthing.

Power Transformer shall comply with the service conditions in accordance to BS EN 60076-1. The cooling air (ambient temperature) shall not exceed 40^0C and the average temperature of the cooling air for any 24hr. period shall not exceed 30^0C.

The altitude shall not exceed 3300’. The whole of each Transformer shall comply with BS EN 60076-11 for Dry Transformer, BS EN 60076-1 and shall be type tested and certified by A.S.T.A., K.E.M.A. or other recognized

National or International Testing Authority. Test reports are to be submitted in Technical Submission for each Transformer.

2.2.2 Connection

All transformers shall be connected in Delta/Star in accordance with the Vector Group Reference Dyn 11 of BS EN 60076-1. The star point of the secondary winding is to be solidly bonded to earth.

2.2.3 Voltage Ratio

The standard Voltage ratio of the transformers at no load shall be as shown in the Schedule of Technical Requirements & Particulars.

2.2.4 Phase & Frequency

The transformers shall be designed for three phase operations at frequency of 50 Hz.

2.2.5 Continuous Rating

Transformers shall be the indoor type, designed and constructed to operate at the continuous maximum ratings (CMR) stated in the Schedule of Technical Requirements & Particulars and drawings, on all tap positions when the voltage on the lower winding is maintained at its nominal Voltage.

When operating on the tap/link position on which the maximum losses occur and when otherwise tested in accordance with BS EN 60076-1 under conditions corresponding to maximum continuous rated output, the winding and/or core temperature rises shall not exceed the values stipulated in the Schedule of Technical Requirements and Particulars.

'AN/AF' transformers where specified, shall each be equipped with an ancillary ventilation fan together with associated control/protection circuit, etc. so that the fan shall start automatically to boost up the maximum continuous rating of the output to 140% of the rated output as specified when the power drawn exceed its rated 'AN' power output.

The transformers No-load and load losses shall be high-efficiency complying with IEC 60076. The transformers shall be high-efficiency type with no-load loss at 75^{o}C complying to Class C0, and load losses at 75^{o}C complying to Class Bk in accordance with IEC 60076.

2.2.6 Magnetic Cores

Magnetic Cores shall be built from non-aging, high-grade alloy, low loss grain orientated, high permeability cold rolled silicon steel complying with IEC 60076-1. The laminations shall be produced from accurate dies so that filing or scraping of slots after cutting and punching is not necessary, and all the while shall be annealed to relieve internal stress after these operations; the laminations shall be coated on both sides with resistant inorganic insulation. The limbs of circular core section and multi-stepwise arrangement shall be carefully interleaved with the yoke without buckling of plates. The whole core shall be coated with resin with all iron parts hot tinned. The whole magnetic circuit shall be rigidly clamped to ensure that noise and vibration is maintained at a minimum level under all service conditions.

2.2.7 Windings

The windings shall comprise high conductivity copper conductors completely cast in glass fiber reinforced epoxy resin insulating material to B.S. 2757. The class of insulation shall be as specified in Schedule of Technical Requirements and particulars. The winding shall withstand the short circuit forces as outlined in IEC 60076. Transformers windings shall be suitable for terminations to copper conductor cables/busduct system. The impregnation and casting procedures shall be under vacuum and high pressure so that the spool can be manufactured free of air bubbles. The insulation shall not deteriorate, become brittle or crack when subject

to expansion, contraction and local weather conditions and shall be constructed to allow the heat losses to be effectively conducted away with the transformer working under full load conditions without forced using pressure studs and disc springs to absorb any mechanical or thermal forces that may occur. Thermal sensors of the PTC thermistor type shall be molded into the low Voltage section of the spool to provide warning and tripping signals. The temperature protection equipment comprising sensors, relays, indication lamps, etc., shall be located in each transformer switch panel and shall be designed to ensure that the maximum continuous temperature permissible for the insulating material is not exceeded. The insulation shall be moisture proof and shall be capable of being switched-on even after a prolonged period of service interruption without pre-drying. Insulation materials shall be at least Class F.

Average Power Loss for transformers rating from 1,000 kVA to 1250 kVA shall be no more than 0.01 kW/kVA , from 1600 kVA to 2000 kVA shall be no more than 0.009 kW/kVA and from 2,500 kVA onwards shall be no more than 0.008 kW/kVA.

2.2.8 Tapping

Tapping shall be provided on the high Voltage windings of all transformers to provide variation of transformation ratio by +5%, +2.5%, -2.5%, and -5%. Off-load tap changing shall be affected by means of position tap indication. The tap changing switch/link shall be capable of withstanding without damage to the same stresses imposed on the windings by short circuit conditions.

2.2.9 Transformer Mounting

All transformers shall be installed according to Manufacturer's recommendation and according to IEC60076. The transformers shall be isolated from the supporting structure by restrained steel springs in series with 2 layers of 5/16" thick, 40 durometer neoprene waffle pads. The minimum total static deflection of these springs shall be 2.5".

2.2.10 Protective Housing

Each transformer shall be provided with a proprietary make IP 20 housing constructed from plain sheet steel with louvres. Hand-hole covers shall be provided at the sides of the housing to facilitate the tapping to be changed. Limit switches shall be provided on every panel of the housing to trip the associated H.T. feeder upon opening of the panel. The extent and arrangement of the limit switches shall be subject to WAPDA's approval.

2.2.11 Transformer Fittings

All necessary fittings including the following shall be provided for each of the transformers:

(i) Dial thermometer.

(ii) Four flat tread rollers with tommy bar holes.

(iii) Skid base, lifting and jacking lugs.

(iv) Suitable neutral and earthing terminals.

(v) Rating and terminal marking plates.

(vi) All protection for the safe operation of the transformers in accordance to IEC 60076 with suitable terminals for external connections.

2.2.12 HV Termination

The primary of each of the transformers shall be provided with a cable sealing end of the heat shrinkable type suitable for terminating a 20kV, 300 sq. mm 3 core or single core, cross linked polyethylene (XLPE) insulated

copper screened, single steel wire armoured / Double steel tapes and polyethylene (PVC) sheathed cables. The terminations shall be suitable for vertically descending or ascending cables as shown in the Drawings. All exposed terminations shall be insulated and/or shrouded to the satisfaction of the Engineer.

HV cable Box shall comply with IEC 50464-2.

2.2.13 LV Termination

For the secondary terminations, each of the transformers shall be equipped with a four-pole terminal box with removable front cover plate, suitable for direct reception and connection to the overhead busduct system of rating as shown on the Drawings. The details of terminal box shall be subject to review by the Engineer/Engineer.

2.2.14 Transformer Noise Level Measurement

The noise level of each transformer shall be measured in accordance to IEC 60076-10:

Noise measurements shall be made at the Manufacturer's premises (in the presence of representatives of the Employer if so required) and the results supplied to the Engineer. The noise measurements shall be sound pressure method in accordance to ISO 3746 or sound intensity method in accordance with ISO 9614-1. The sound level meter shall carry a certificate giving its overall calibration, and means should be provided for checking the gain of the meter both before and immediately after each test. For the purpose of this Specification all readings should be taken at 'A' weighting.

The transformers shall be excited at rated Voltage and frequency. Noise measurements shall be taken at no load only unless otherwise required. Measurements shall be taken at reference points not exceeding 1.0 meter apart, subject to a minimum of six readings, in a horizontal direction along the major sound producing surfaces with the microphone at a distance of approximately 1' from an imaginary string passed around all major projections from the transformer.

For the purpose of this specification the value of average surface noise level shall be rounded off to the nearest whole number, decimal values of 0.5 dB and above being rounded off to the next higher whole number.

The background noise level shall also be determined and should be at least 7 dB and preferably 10 dB below the noise level of the transformer at that point.

The average noise level of each transformer when measured shall not exceed the value specified in the Schedule of Technical Requirements and Particulars.

The vibration level of the transformers shall also be kept to a minimum and shall not produce excessive stresses on any of the components, parts or materials of the transformers.

The engineer reserves the right to reject any transformer not complying with specified noise level or vibration level requirements.

2.2.15 Off-Load High Voltage Isolator

Off load isolators shall be suitable for isolating the high Voltage supply to the primary of the transformers at off load condition. Mechanical key interlocks shall be provided to prevent isolation on load unless the associated transformers feeder panel has been isolated. Each isolator shall be housed in a cubicle and shall be designed for front access arranged as shown on the Drawings with provision for cable entries as appropriate.

Neon potential indicators shall be provided at both the supply and load side of the isolator to indicate the presence of the incoming supply and the status of the isolator respectively.

2.2.16 Neutral Earthing Resistors

The neutral earthing resistors shall be of proprietary design comprising grid type resistors when required. The enclosure shall be of sheet steel of IP 20 Class of protection in a floor standing enclosure/cabinet. The resistor shall be selected and designed to limit the earth fault current of the associated transformer to the maximum full load current of the transformer.

2.2.17 Factory Tests

Routine, Type, Special and Quality control tests at the Factory and site are to be carried out in accordance with the BS EN 60076-1 and WAPDA requirements.

Prior to dispatch the transformer out of the factory, each transformer shall be routine tested in the presence of representatives of the Employer and all cost associated shall be deemed included in the sub- contract. The factory tests to be performed shall be:

(i) Measurement of each winding resistance. The temperature of the windings shall be recorded when resistance measurements are made.

(ii) The Voltage ratio shall be measured on each tapping. The polarity and vector group shall be checked.

(iii) The impedance Voltage shall be measured in accordance with IEC 60076. The impedance Voltage shall be corrected to the reference temperature of 75 deg C.

(iv) The load losses of the transformer shall be measured in accordance with IEC 60076. The load losses shall be corrected to the reference temperature of 75 deg C and the value shall not exceed the specified value.

(v) The no load current and loss shall be measured in accordance with IEC 60076. The no load loss shall not exceed the specified value.

(vi) The transformer shall be subjected to separate source Voltage withstand test. No collapse of the test Voltage shall occur.

(vii) The transformer shall be subjected to induced overvoltage withstand test in accordance with IEC 60076. No collapse of the test Voltage shall occur.

Prior to delivery of transformer to site, the Contractor shall carry out a site survey and make all necessary co-ordinations with the Main- contractor as regard to access for the safety transportation of transformer to the designated location.

Each transformer shall be labeled as required by the Owner.

2.2.18 Site Test

The Contractor shall provide all the necessary testing equipment to perform all site testing and commissioning.

In addition to the tests required by the Local Authority and those recommended by the Manufacturers, the following tests shall be carried out.

(i) Ratio and Polarity Tests.

(ii) Insulation Resistance Test.

(iii) Operation Tests on temperature, oil level and gas pressure gauges by simulation tests. Verification of the proper functioning of the switchgear panel shall be performed concurrently.

(iv) The insulation of all power cables and alarm/control cables shall be tested with an insulation tester before and after cable installation.

2.3 Diesel Generator

2.3.1 Quality

(i) Inspection

Give sufficient notice so that inspections may be made of complete set and associated systems at the manufacturers or suppliers factory before delivery to site.

(ii) Submissions

a) Product Data

Submit product data for test, manual and auto modes, including the following:

- Technical description and specifications of each generating set, including output curves for stand- by conditions, alternator and engine data, automatic Voltage regulator, synchronizing and load sharing modules and auxiliaries
- Type test reports for the tests listed
- Net standby rated output
- Voltage regulation grade
- Generating set efficiency at 50%, 75% and 100% load
- Calculations that the set will start at lowest temperature and operate at maximum temperature
- Calculations for performance of acoustic enclosures and silencers
- Evidence that the engine type has previously passed cold starting tests at the minimum ambient site temperature.

b) Shop Drawings
Submit shop drawings indicating the following:

- Maximum mass and overall dimensions of package set
- Access clearances for operational maintenance and dismantling
- Control diagrams
- Alarms and shutdown annunciator text engraving schedule
- Details of mounts required
- Details of weatherproof and acoustic enclosure

c) Test Results
Printed in Operations and Maintenance Manuals.

2.3.2 General Specifications

Rating - 2500 kVA (Prime Rated)

Cooling - Standard set-mounted radiator cooling

Voltage - 11 kV

Type - Open set

Quantity - Refer Drawings

2.3.3 Internal Combustion Engine

(i) General

Cycle: 4 strokes

Speed: 1500 rpm maximum

Cooling: Water

Fuel: Diesel

(ii) Governor

Electronic, self-lubricating (actuator) suitable for automatic operation with digital control system

Overspeed Control: Electronic.

Filtered to prevent harmonics and switching spikes interfering with governor operation, under-speed and overspeed cut-out devices.

Provide adjustments for:

- Speed droop
- Stability
- Maximum speed
- Acceleration rate & Load gain within the engine capacity, minimum ±50%

(iii) Protection

DC operation including:

- Overspeed
- High jacket water temperature
- Low engine water level
- Low lubricating oil pressure
- Crank case high oil pressure
- Very low fuel in day tank

"Fail safe"; such that a fault results in the solenoid preventing fuel entering engine

Require system be reset manually at the control panel.

(iv) Starting

Automatic by 12VDC or 24VDC return starter motor plus engine mounted generator / rectifier for starting battery boost.

(v) Fuel System

Capable of the lift required from the day tank to the engine fuel inlet.

(vi) Filters

Include:

- Dry type air-cleaner
- Lubricating oil
- Diesel fuel

(vii) Jacket Heater

Sufficient to keep engine at a high enough temperature so that it can accept load within 10 seconds.

(viii) Instruments

Engine mounted including:

- ❖ Tachometer
- ❖ Service hour recorder
- ❖ Oil temperature
- ❖ Coolant temperature
- ❖ Oil pressure
- ❖ Manual override starter button
- ❖ Engine low level water alarm
- ❖ Engine shutdown emergency pushbutton
- ❖ Fail to start and alarm

2.3.4 Alternator

(i) General

Type: Synchronous
Winding Configuration: Star
Temperature Class: F
Stator Winding Pitch: 2/3
Short Circuit Capacity: 250% for 5 seconds minimum
Enclosure: IP23 standard
Total Harmonic Distortion at rated load: 5% with resistive load.
Tropic Proof Windings
Voltage: 11kV

Class H windings are typical for standby applications, for sets that must operate continuously use a higher class (B/E) that have more stringent requirements for temperature rise.

Stator Pitch of 2/3 gets rid of third harmonics, for other high harmonic loads, specifies pitch to suit. 2/3 also has low zero sequence reactance so P-N fault currents are high – should easily trip circuit breakers.

(ii) Automatic Voltage Regulator

Solid State

Remain within ±1% of set value over 46-54Hz Frequency range steady state

RMS Sensing on all phases

The regulated Voltage shall be taken as the average of the phase to neutral of the 3 phases excluding cases where the current ratio is greater than 2:1 between any 2 phases.

Built-in overload protection

Adjustable to ±10%, adjusted to generate correct Voltage at output switchboard.

Include Voltage transient protection

Voltage shall be re-established within 2 seconds of removing short circuit or restarting machine.

On start up under automatic Voltage control and with a resistive load of 30% rated capacity applied the set output Voltage shall be achieved within 3 seconds of the unit reaching a shaft speed corresponding to 46Hz.

(iii) Excitation

Type: Brushless Permanent magnet exciter

Torque matching characteristic

Voltage transient protection for rotating diodes

Failure of a single diode shall not prevent machine operation

(iv) Overspeed Withstand

1.2x unit rated speed for both engine and alternator

(v) Under speed Withstand

Normal operation at net continuous rated output at a speed of 90% rated, without overheating.

(vi) Sustained Short-Circuit Withstand

Maintain at least 300% rated current for 10s to allow operation of protection relays.

Output shall collapse on short circuit in a manner that does not prevent operation of protection relays.

If electronic trip units are used then collapse during short circuit should not be a problem, the generator circuit breaker is supposed to protect the alternator in any case and should trip if the fault is sustained too long.

(vii) Winding Thermistors

General: Provide separate thermistors to alternator stator windings for alarms and engine shutdown functions.

Thermistor type: Positive temperature coefficient.

Thermistor temperatures:

- Engine shutdown: To suit engine maximum operating temperature and provide warning
- Winding temperature high pre-alarm: To suit winding insulation class and provide warning

(viii) Circuit Breaker

Include suitable Moulded Case or Air Circuit Breaker for alternator protection.

(ix) Terminal Boxes

Construction: Provide metal terminal boxes. Size to allow the current transformers, power and control cables and cable lugs to be neatly installed and terminated with necessary clearances between live parts and the box, and without placing undue strain on termination points.

Supply cable terminal box: Provide removable lid, side covers and cable gland plates.

Terminals: Provide star connected windings. Bring both ends of each winding out to separate terminals. Establish a neutral terminal.

Sealing: Provide neoprene or bonded cork gaskets between terminal boxes and their frames and covers.

(x) Anti-Condensation Heaters

General: Provide anti-condensation heaters within the winding enclosure.

Rating: Rate heaters to maintain the windings and insulation above the dew point when the alternator is at rest and one heater is in service.

Location: Locate at least 1 heater at each end of alternator windings in a position which allows heat transfer to the winding insulation by convection, without exceeding maximum allowable insulation temperature. Do not fix heaters to windings.

Terminations: Connect heaters to separate identified terminals within a separate accessories terminal box which is connected to a permanent supply.

Connection diagram: Provide a connection diagram for the heaters. Locate within the terminal box.

2.3.5 Operation

(i) General

Provide automatic and manual modes to start and shut down generating sets in the selected sequence and, if operating in parallel, share the load in proportion to their rated kW and kVAR capacities.

(ii) Automatic Start Control

Provide for the following:

- Upon receipt of a "start" signal, for generating set to start automatically, come on-line and connect to the load.

(iii) Automatic Engine Shutdown

Provide for generating set to run to suit the load demand until receipt of the mains "restored" signal. At this point the automatic sequenced engine shut-down signal must be activated after an adjustable time delay of 0 - 30 min.

(iv) Engine Shutdown

Provide a shutdown control system which disconnects the alternators, and shuts down engines upon the occurrence of fault conditions, such that:

- Engine cannot be restarted before safety devices have been manually reset and system alarm sensors have returned to the normal state
- The overspeed shutdown acts directly to disconnect the fuel supply independent of the governor
- The shutdown control system may be reset by the operation of one reset switch, after safety devices have been manually reset

(v) Emergency and Fault Shutdown

Provide for the following conditions to register as audible and visible alarms and to cause each generating set main circuit breaker to open immediately and generating set to immediately shutdown:

- Emergency stop push-button: Pressed
- Generating set: Over Voltage
- Generating set protection: Activated
- Generating set: Over current
- Engine: Overspeed
- Engine oil pressure: Low
- Jacket water temperature: High
- Day fuel tank: Critical low

(vi) Automatic Synchronizing

Provide synchronizing modules which automatically synchronize each incoming alternator supply frequency and phase angle to the live busbars.

2.3.6 Control Panels

(i) General

Provide control panels, switchgear and control gear assemblies which accommodate equipment operating in parallel and stabilise load sharing between each generating set at all load steps. Include reverse power interlock.

(ii) Engine Local Control Board

For each generating set, provide the following:

- Key operated local engine start/stop control
- Controls for auto/off/manual
- Emergency manual shutdown
- LCD indication for
  - Speed
  - kVA
  - Power (kW)
  - Reactive Power (kVAR)
  - Voltage, L-L & L-N (V)
  - Current (A)
  - Frequency (Hz)
  - Power factor (average and per phase)
  - Hours run
- Indicators showing generating set under local control or remote control.
- Oil pressure indicator
- Coolant temperature indicator
- Adjustable protection for
  - Undervoltage protection
  - Overvoltage Protection
  - Reverse Power protection
  - Overcurrent Protection
  - Under frequency protection with two stages
  - First stage: Adjustable 47-50 Hz with time delay 0-10 s
  - Second stage: Adjustable down to 40 Hz and with instantaneous trip
  - Low Coolant level
- Day fuel tank low level, indicator and alarm
- Unit running on load, indicator
- Unit running off load, indicator

- Failed to start indicator and alarms
- Anti-condensation heater indicator
- Lamp test button for all lamps
- Volt free contactors for
  - Generator started and ready to accept load
  - Generator running
  - Common alarm/shutdown
  - Cooldown time complete

2.3.7 Starting

(i) Electric Starting

General: Provide starter motors, batteries and chargers, and associated control equipment to automatically start each engine.

Wiring: Wire starter motors so that starter motor solenoid contacts are on the active side and field windings are at earth potential when the motor is de-energized. Provide an interlock, connected directly to the engine, to prevent the starter motor operating when the engine is running.

Starting interlock: Provide a starting lock out system, which prevents further starting attempts after 3 (adjustable) successive unsuccessful attempts.

(ii) Batteries and Chargers

a) Starting Batteries

Location: Locate in proprietary battery holders within the package set and constructed of timber or other corrosion resistant material. Isolate batteries from vibration.

Covers: Provide a high-impact resistant transparent cover for each battery.

Capacity: Sufficient to crank the engine for 6 successive attempted starts, repeated at 10 second intervals.

b) Starting Batteries Chargers

Mains power: Connect chargers to the generating set auxiliary supply so that mains power is maintained when the generator system is in operation.

Alarm outputs: Provide the following local audible and visual alarms together with facilities for extending them via a common alarm output to a remote location:

- Mains off
- Over Voltage
- Over current
- Low battery Voltage
- Insufficient charge rate
- Charger failed
- Battery Voltmeter marked to show normal range
- Battery charge rate marked to show normal range
- Battery boost 'ON' status indicator
- Mains 'ON' status indicator

2.3.8 Installation

(i) General

Mounted in line and direct driven

Engine, Alternator and control panel bolted to a common rigid steel base

Coupling: Directly connected to engine fly-wheel housing.

(ii) Resilient mounts

Prevent the engine base frame from moving on package floor by resilient mounting blocks between the frame and the plinth.

These shall be to suit the acoustic requirements and seismic requirements

(iii) Coupling

Directly couple the engine and generator shafts using a self-aligning type coupling, capable of transmitting the engine maximum output torque under operating conditions, including starting and overload.

(iv) Signs

Warning: Provide the following on each side of each generating set:

- "WARNING: This set may start at any time without notice." Lettering: 2” high, red on white background.

(v) Emergency stop push-buttons

Generating sets < 7’ long: Provide one push-button per generating set.

Other generating sets: Provide 2 push-buttons per generating set. Locate one on each side or locate one of the push-buttons in the engine local control board.

Type: 1 37/64” diameter red, palm operated latched mechanical type mounted in a metal wall box fixed to a free standing "U" channel pedestal. Wire to disconnect the generator and immediately shut down the engine when the controls are in the automatic or manual mode.

(vi) Fuel connections

Stop valves: Provide stop valves on the inlet to, and outlets from, the daily service tank.

(vii) Safety Guards

Provide safety guards to prevent contact with any rotating or high temperature parts, at least complying with the relevant Occupational Health and Safety Authority.

2.3.9 Acoustic Treatment

Will be in an acoustically treated room. Room soundproofing is under the scope of MEP main contractor.

Sound Pressure Level: 75 dB(A) at 12 locations 3’ 3” from the room exterior surface, at 5’ above floor or roof levels, measured with the generating set operating at constant maximum rated full load output, with doors closed and service penetrations sealed.

2.3.10 Engine Air Intake

(i) General

Provide dry type air intake filters of sufficient capacity to permit continuous engine operation for 200 hours before filter servicing becomes necessary.

2.3.11 Exhaust System

(i) General

General: Provide exhaust piping from the engine complete with silencers, piping, ductwork, supports and expansion devices.

Exhaust piping: Grade 304 Stainless steel.

Diameter: Match engine exhaust manifold connection.

Connections: Provide stainless steel flanged connections to silencers and pipe interconnections.

Vibration isolation: Provide a stainless-steel flexible connection to the engine.

(ii) Weatherproofing

Provide weatherproof flashing, sleeves and acoustic seals where the exhaust system penetrates the roof or external walls.

(iii) Exhaust Drainage

Grade the exhaust line away from the engine to drainage pockets, or connect to a suitable drainage outlet.

(iv) Lagging

General: Lag internal exhaust piping and ductwork using calcium silicate insulation sheathed using zinc-coated steel sheet.

Lagging thickness: to achieve a touch temperature of maximum 50°C, maximum, 2” (minimum)

(v) Silencer

Type: Absorption/reactive

Backpressure: Not to exceed engine manufacturer limits

Construction: 304 grade stainless steel outer housing, the internal steel work and reactive chambers shall be stainless steel or HRCQ mild steel. Absorption material shall be covered with a 304-grade stainless steel perforated sheet.

2.3.12 Marking

(i) Rating Plates

Temperature-rise limits: If temperature-rise limits are achieved by de-rating an oversized generator, state the de-rated value.

Alternator mass: State alternator mass.

(ii) Thermistor Detector Identification and Warning Plates

Thermistors: Provide details of thermistor type classification and reference temperature.

Warning: Provide a warning engraved in 5/32 ” high lettering as follows:

- "WARNING - Do not apply more than 2.5 V across the protection thermistor devices"

Anti-condensation heater identification and warning: Locate next to heater terminals. State the number, Voltage and power rating of the heaters, and the following separate warning engraved in red letters on a white background:

- "WARNING - Anti-condensation heater. Circuit is live when the set is off"

(iii) Auxiliary Wiring

Provide ferrules to wiring ends identifying each conductor.

(iv) Engine Direction of Rotation

General: If driving shafts or associated rotating parts are accessible, clearly and permanently mark the direction of rotation on an adjacent fixed surface.

Rotation identification: Provide a label within the supply cable terminal box identifying the relationship between the direction of rotation and the marking of terminals.

(v) Charger Enclosure Markings

General: Provide enclosure with:

- Main nameplate engraved in 25/64" high lettering
- Minor nameplates engraved in 5/32" high lettering to interior and exterior components
- Manufacturer's rating plates
- Plate material: Stainless steel.

(vi) Enclosure Signage

Fit the following signs to doors:

- "Wear hearing conservation protection"
- "WARNING: This machine may start at any time without notice", in red lettering on white background

2.3.13 Completion

(i) Testing

Acceptance Tests Generally

General: For each generating set carry out the following:

- Check tightness of connections and securing devices.
- Verify correctness of operation of protection devices and systems including sensor settings. Simulate actual conditions as far as possible, in order to test responses to faults imposed.
- Provide fan-cooled resistive test load tank if not installed permanently.
- Cold start with the engine having been at rest for the previous 24 hours, timed from receipt of mains failure signal to acceptance of full rated load in 3 load steps to within the limits of output Voltage and frequency. Record Voltage waveforms. Jacket water heaters are to be operational.

- Continuous operational trial consisting of:
  - 4 hours at 100% rated power
  - 1 hour at 110% rated power
  - 1 hour at 100% rated power
  - 30 min at 75% rated power
  - 30 min at 50% rated power.
  - Record fuel consumption for each step of the continuous trial
  - During testing measure ambient temperature and coolant temperature and submit calculated performance for maximum ambient conditions
- Sample engine oil from engine sump before and after tests
- Perform laboratory analysis and submit a report on each oil sample
- Continuous operational trial: During the trial, measure the following at maximum intervals of 30 minutes:
- Generator kW and kVAR output
- Generator output Voltage
- Generator output current
- Generator output frequency
- Power factor
- Oil pressure and water temperature
- Electrical power requirements of continuously running electric motor driven ancillaries
- Each battery charger current and Voltage readings
- Noise level

Acoustic Performance

At the completion of the installation carry out thorough testing to demonstrate compliance with the above requirements. Submit for approval noise test results from a recognised testing authority.

Temporary Test Loads

Provide test loads including power and control wiring, ancillary equipment and test instruments to achieve the kW and necessary load steps.

Final Tests

Submit reports from manufacturers or suppliers verifying the performance of safety and control functions of each system.

Charging

Fill tanks with fuel, and top up immediately before practical completion after generator testing.

(ii) Maintenance

Call out

Respond to call outs for breakdowns or other faults requiring corrective maintenance within 2 hours. Attend on site if required to rectify faults and replace faulty materials and equipment.

2.4 Diesel Generator – Liquid Fuel System

2.4.1 Quality

(i) Contractor's Submissions

Valves

Valve Schedule: Submit a detailed schedule of valve types showing manufacturer, figure number, materials, pressure rating and application.

Fuel Level Indicators

Submit details of ultrasonic level indicators

(ii) Pre-completion Tests

Site Tests

Discharge and suction piping: Pressure test to 350 kPa. During tests keep tanks freely vented so that they are not subjected to the test pressure.

Fill, dip and vent lines: Air pressure test to 35 kPa. Fit a safety device to ensure that this pressure is not exceeded, and remove the device after the test is completed.

On completion of testing: Remove water and other contaminants from tanks, valves and pipe fittings. If necessary, lubricate valve seats and poppets and seal inspection plugs with black pipe jointing.

Pressure Testing Method

Preparation for Testing

- Isolate items of equipment and instruments not designed to withstand test pressures
- Use spades or plugs for isolation rather than valves
- Secure pipes and fittings in position to prevent movement during tests
- Restrain expansion bellows
- Leave pipe joints exposed to enable observation during testing
- Fill piping prior to testing and allow it to come to room temperature and for condensation to evaporate

Test Material

Piping type	Test material
Fuel oil piping	dry nitrogen or dry air

Test pressures: Test systems at 1.5 x working pressure or 1 MPa, whichever is the greater, held for 8 hours.

Test criteria: No leaks or loss of pressure over the test period after taking account of any change in ambient temperature.

(iii) Inspections

Witness Points

Give notices of inspection at the following hold points:

- Hydrostatic testing: At the commencement of each pressure test and prior to release of test pressure for each section to be tested, all to be conducted prior painting or insulation
- Inspection of underground tanks and associated fittings and pipework prior to backfilling
- Flushing and pre-treatment of pipework prior to final filling up

2.4.2 Tanks

Bulk Storage

Design

Design tanks to accommodate the static heads equal to the height of the vent pipe above the tank.

Underground: Double skin tank of Steel / Fibreglass construction – UL listed

Aboveground tank: Single skin steel tank

Fittings

Provide the following:

- Personnel access
- Fill connection with internal pipe connection
- Dipstick indicating system
- Suction connection, complete with internal pipe, check valve and anti-vortex device
- Return connection and internal pipe
- Vent connection
- Drain connection for above ground tanks
- Fuel Level Contents Sensors and Alarms

Personnel Access

Provide a manhole (min. 2’ dia) in the centre of the tank at the top to facilitate access for pumping out of sediment and water.

Fill Connection

Fit an approved copper fill pipe within the tank to within 1/2’ of the bottom of the tank. Steady the fill pipe by welding a foot to the bottom of the tank.

Extend the fill pipe from each tank to the fill point terminating an approved lockable type cap.

Dip Stick Connection

Provide and install a dip pipe and a flexible dip stick. Extend the dip pipe to within 1/2’ of the bottom of the tank and incorporate an air relief hole at the highest level. Fit the tank with a striker plate. Fit lockable cap to the top of the dip pipe.

Suction Connections

Take the suction connections from inside each tank near the bottom, fit with an approved suction stub and screen.

Provide a suction line from each tank in each tank group to a common suction header for the fuel transfer pumps for the respective tank group. Provide solenoid valves on the suction line from each tank to allow automatic selection of which tank to draw fuel.

Provide a separate suction line, solenoid valves and header for the fuel laundering system

Return Pipe

Provide a fuel overflow pipe from the daily service tanks to the return header and then to the bulk storage tanks.

Vent Connection

Connect the vent pipes for each group of tanks and extend in stainless steel from the tank room to the vent point external to the building. Finish the vent pipes in a goose neck with insect proof cowl.

Sludge Drain

(Above ground tanks only)

Provide a drain pipe for draining sludge from the tank.

Fuel Level Contents Sensors and Alarms

Provide ultrasonic contents gauges for each tank.

Calibrate the indicators to give the following level indication/alarms.

Primary Indicator

97% full - “High Level Alarm" an audible and visual alarm with remote monitoring by the Building Management System

5% full - “Low Level" initiate change-over to the next tank in the group.

3% full - “Low Level Alarm” an audible and visual alarm with remote monitoring by the Building Management System

Secondary Indicator

99% full - “Extra High-Level Alarm" an audible and visual alarm with remote monitoring by the Building Management System

1% full - “Extra Low-Level Alarm” an audible and visual alarm with remote monitoring by the Building Management System

Provide alarm indication and relays with Voltage free contacts wired to a terminal strip on the transfer pumps control panel for monitoring by other (BMS). All wiring between the transfer pumps control panel and the BMS system will be carried out by others.

Tank Supports

Locate supports close to the ends of the tank. Provide doubling plates (120-degree coverage) fixed to the underside of the tank, of the same material and thickness as the tank. Form box type stools from 15/64" mild steel plate, and weld to the doubling plates. Make provision for tank expansion.

2.4.3 Daily Service

Construction

Open: Welded construction, reinforced around the top edge. Provide a lid fabricated from zinc-coated steel 3/64" thick with rolled edge.

Closed: Welded construction. Provide a bolted inspection cover.

Double-walled.

Tank Stands

Provide a welded frame stand at least 3' high, fabricated from mild steel angle.

Tank Connections

Drain connection: DN 25 boss and screwed plug.

Flow connection: ≥ DN 20.

Supply connection: ≥ DN 25.

Overflow return connection: Sufficient to allow 125% of pump capacity to be returned to the main tank without overspill.

Vent connection for closed tanks: ≥ DN 40.

Controls

Provide liquid level switches set to start the liquid transfer pump at low liquid level (half full), and cut the pump out at high level (full).

Provide liquid level switches to shut down the engine at 10 minutes of fuel left.

Provide overflow alarms.

Auxiliary Contacts

Provide Voltage-free contacts set to close on a fall in the liquid level to one-third full.

Indication

Provide a fuel level indicator with calibration in litres.

2.4.4 Finishes

External

General: Blast clean steel tanks and associated steelwork, including hold-down bolts and straps, to class 2, and apply coating systems within 4 hours of blast cleaning.

Tank Finishes Table

Tank type	Coating system

Underground tank	Tar free high build polyamide cured epoxy. Minimum coating thickness: 8”.
Above ground tank	Inorganic zinc silicate to GPC-C-29/8, followed by polyurethane to GPC-C-29/11
Tank enclosed in chamber	Inorganic zinc silicate to GPC-C-29/8
Service tank	Inorganic zinc silicate to GPC-C-29/8

Internal

Remove debris and clean.

2.4.5 Piping and Accessories

Pipes Inside Tank

Heavy steel pipe.

Filling and Service Piping

General: Medium steel pipe.

Filling: ≥ DN 75.

Service: ≥ DN 25.

Joints for Steel Piping

Welded.

Cleaning

Flush out piping with fuel, only when the system is complete.

Underground Piping

Provide double skinned pipes.

Temporarily support the piping in the trench before backfilling. Provide at least 1/2’ of backfilling all around piping. Comply with Sand backfilling in Underground tank installation.

Gradients

Lay piping to permit self-draining and avoid air locking, and to the following minimum gradients:

- Fill pipe: 1:50 down in the direction of flow
- Gravity return pipe: 1:100 down in the direction of flow

Corrosion Protection

Wrap steel pipe and screwed or welded joints with anti-corrosive grease impregnated tape or other purpose-made vapour barrier adhesive plastic tape. Extend the tape 1/2’ from the extremity of any thread or weld.

Lock Boxes

General: Provide 1’ diameter cast iron boxes with lockable cast iron cover flaps, to each filling and dip point and buried valves.

Installation: Set boxes with the top 1" above the adjacent finished pavement or ground surface. Surround and support the box with concrete, at least 1/2' thick. Provide gravel underlay to drain the box.

2.4.6 Design

Design piping and supports to accommodate fluid pressures, weight of full piping, seismic loading, thermal expansion, building movement and plant vibration.

Performance

Design Pressure

- Not less than the maximum hydrostatic head at the location plus the pump shut off head at the maximum impeller size

Hydrostatic test pressure: 1.5 times design pressure or 1 MPa, whichever is the greater measured at the lowest point of the system.

Piping Installation

General

General: Install piping in straight lines at uniform grades. Arrange to prevent air locks or liquid trapping. Provide sufficient unions, flanges and isolating valves to allow removal of piping and fittings for maintenance or replacement of plant.

Layout: Run piping parallel or at right angles to adjacent building elements. Coordinate to clear other services.

Arrangement: Arrange and support piping so that it remains free from vibrations whilst permitting necessary movements. Minimise the number of joints and fittings.

Spacing: Provide at least 2" clear between pipes and between pipes and building elements.

Concealment: Conceal piping in occupied areas where possible.

Cleaning

General: Before installation, clean piping and remove loose scale, burrs, fins and obstructions.

Protection: During construction, prevent the entry of foreign matter into the piping system by temporarily sealing the open ends of pipes and valves using purpose-made covers of pressed steel or rigid plastic

2.4.7 Supports

Support piping without sag, with falls for complete venting and drainage, with flexibility for expansion, contraction and vibration isolation. Provide clamps, hangers, spreader beams, trapeze hangers, secondary steelwork, guides, pipe anchors, expansion devices, brackets, fixings and the like.

Arrange supports to prevent pipes from transferring stress to connected equipment.

Provide independent supports for metallic valves and fittings in non-metallic pipelines.

Support of Multiple Pipes

Horizontal pipes: Use trapeze hangers, support brackets or pedestals.

Vertical pipes: Anchor risers not subject to expansion to galvanised steel channels at all floors. Anchor expanding risers centrally or at base and provide guides at all floor levels

Support Spacing

Metallic pipe: As tabulated.

2.4.8 Vibration Isolation

General

Minimise the transmission of vibration and noise from equipment through piping to the building structure and occupied areas.

Support of Piping at Pumps

Ensure that piping does not impose loads on equipment connections.

Extend pump floating bases to accommodate supports for pump suction and discharge elbows.

2.4.9 Valves and Accessories

(i) General

Function

Provide all valves, fittings and accessories necessary for operation, control and maintenance of the systems.

Components

Valve size: Generally, the nominal pipe size, unless a smaller size is necessary for throttling purposes or flow measurement.

Connections

Handwheels and handles: Removable, with the direction of closing marked permanently on handwheels. Drain cocks and vents may have diamond head.

Valve closure: Clockwise unless required otherwise by statutory authority.

Flow direction markings: Cast arrows on valve bodies.

(ii) Materials

Galvanic Compatibility

Select materials for valves and fittings which are less susceptible to corrosion than adjacent piping.

(iii) Selection

Pressure rating: Minimum 1.4 MPa, and to suit system pressure requirements.

Temperature rating: To suit system requirements.

Limitations on size and type:

- Isolating valves:

- Gate valves: No limitation
- Ball valves: ≤DN 50

❖ Throttling valves:

- Globe valve: No limitation

Gate Valves

Description: Straight-through flow, solid wedge type, inside screw design, medium pattern.

Ball Valves

Description: Full bore pattern with handle parallel to the direction of flow when the valve is fully open.

Non-return Valves

Swing type

❖ Water supply - metallic gate, globe and non-return valves
❖ Body: Bronze alloy or cast iron, Cast iron non-return valves for general purposes
❖ Plates: Bronze alloy or stainless steel

Dual flap type

❖ Body: Cast iron
❖ Pin and spring: Stainless steel
❖ Seat: Integral nitrile rubber
❖ Plates: Bronze alloy or stainless steel

Pressure Relief Valves

Description: Direct acting, spring loaded with adjustable setting.

Standard: Safety valves, other valves, liquid level gauges and other fittings for boilers and unfired pressure vessels.

2.4.10 Fuel Oil Pumps

Size

Sufficient to ensure that the duty pump can refill the daily service tank at not less than four time the rate of full load consumption of the engine.

Configuration

Duplex in duty / standby configuration for each engine.

Type

Self-priming positive displacement internal gear type pumps with mechanical seal and direct driven by totally enclosed motor.

Bypass

Provide an automatic built-in overpressure bypass with adjustable spring relief.

Mounting

Mount the motor and pump on a common base plate.

Material

Casing and rotor: Cast iron or cast steel.

Shaft: Hardened steel.

Drip Tray

General: Provide a 2" deep drip tray under each pump.

Material: 0.06" thick copper with brazed joints.

Control

Method: PLC within dedicated pump control panel, Tank level sensors and line pressure/flow switches.

Operation of the fuel transfer pumps shall be as follows:

- Duty pump shall operate to fill the day tank from the bulk tank in the event of a low day tank signal
- Duty pump shall stop filling the day tank in the event of a high day tank signal
- Standby pump shall operate in the above fashion in the event of duty pump failure, whether the failure occurs with duty pumps in manual or auto mode
- Designation of duty/stand-by pumps shall be alternated at each start call on the local generator control panel to average out pump debilitation
- Fuel pumps shall be provided with a means of manual operation from adjacent the respective set of service tank(s)

Each Control Panel shall:

- Contain all the control equipment for the pumps and valves, including the automatic control modules to suit the mode of operation described, including all interface equipment, apparatus and circuit protection devices
- Comprise, but not necessarily be limited to the equipment and functions described in this specification and associated drawings, required to fulfil the intent of the specification
- Incorporate an audible alarm and mute switch for notification of any faults in conjunction with the fault indicators
- Contain terminal strips for all interface wiring to the BMS and generator control panels

Wiring

External Type: MIMS

Internal to Control panel: V75

2.4.11 Installation

(i) Underground Tanks

Excavation and Backfilling

Keep excavations free of surface water. After placing the tank, backfill with sand or pea gravel as recommended by tank manufacturer

Sand Backfilling

General: Use chemically inert sand or pea gravel, free from foreign matter such as salt, organic matter and clay lumps, and graded.

Placing: Place sand backfilling in layers not more than 7 7/8" thick, and compact to a minimum density index of 75%.

Sand grading table

Sieve aperture (mm)	Sieve aperture (Inch)	Percentage passing (by mass)
9.5	0.37	100
4.75	0.19	70 - 100
2.36	0.09	50 - 100
0.425	0.017	15 - 70
0.075	0.003	0

Ballasting

If ballasting is necessary to prevent flotation, fill the tank with water before backfilling.

EITHER

Provide a concrete ballast collar at least equal to the weight of the full tank.

OR

Provide Deadman weights and certified tie down tackle as per tank manufacturer's recommendations.

(ii) Trench Covers

General

Provide covers for fuel pipe trenches in concrete floors.

Cover Material

15/64" thick mild steel chequer plate, cut to fit floor trench rebates, galvanized after fabrication.

(iii) Cathodic Protection

System

General: Provide a cathodic protection system for underground steel tanks, using either a sacrificial anode or an impressed current, designed and installed by a suitably qualified person.

Characteristics: Provide the following:

- Monolithic insulating couplings in the suction, vent return and fill lines immediately next to the tank
- Power supply, anodes and interconnecting wiring, incorporating a facility for periodic testing
- Insulation to the return connection

Power supply: Provide solid state regulated DC power supply with balanced outputs and ammeter.

(iv) Contents Indicators

Dipsticks

Form from brass section or anodized aluminium extrusion, with the bottom 4" coated with nylon or equivalent non-conducting coating. Stamp or engrave calibrations at intervals of not more than 5% of nominal tank capacity.

Contents Gauges

Provide a remote-reading contents gauge. If the vent pipe is not visible to the filling operator, locate an additional the gauge next to the filling point.

2.4.12 Marking

Identification of the contents of pipes, conduits and ducts.

Method: Apply self-adhesive pipe markers with colour identification blocks and flow chevrons to prepared surfaces. Remove redundant flow chevrons.

Wording: Identify pipe contents using complete words matching contract drawings. Include "FLOW" or "RETURN" for recirculating systems.

Display piping hazard identification where applicable.

2.4.13 Completion

(i) Charging

General

Fill tanks with fuel, and top up immediately before practical completion after generator testing.

2.5 HV Cabling

2.5.1 Description of Works

This section of the specification includes the supply and installation of all 11 kV power cables between the WAPDA 11 kV switch panels and the customer's 11kV switchgear panels and all 11 kV cables from the customer's 11 kV switchgear panels to all the power transformers.

Details of cable layout, cable trenches with MS Gratings covers, and cable supports shall be submitted to the Engineer for review.

2.5.2 Erection of Cables

Rates of erection of cables shall include the following:

(i) All measuring off and cutting to length.

(ii) Temporary sealing of cable ends where necessary and testing of cut ends prior to connection.

(iii) Supply, delivery and erection of all racks, clamps, saddles, trays, supports/framing system, bushes and other items required for erection and fixing of cables including excavation where necessary.

(iv) Design, provision, erection and painting of all additional supporting steelwork.

(v) Sheath bonding in the case of single core cables including supply of

necessary materials.

(vi) Forming of necessary bends, surface fixing at intervals and phase identification of cores by suitably coloured PVC sleeving.

(vii) Sealing of cables in pipes and/or ducts where called for.

(viii) Tests at site during installation and on completion including continuity, phasing out and sheath employing a 5000 V 'megger' tester or another acceptable test equipment.

On all horizontal runs, cables shall be routed on galvanized steel cable ladders supported from floor slab above or on walls, as shown on the Drawings, using proprietary steel supporting system similar to 'UNISTRUT SYSTEM' or equivalent; the spacing of the supports shall be as recommended by the Supplier but shall be no case be more than 3'. Cables on the ladder shall be neatly spaced and secured using 'snap-apart' cable retaining ties at close intervals in accordance with the current edition of IEC 60364: Electrical Installations in Buildings (BS 7671). The types & sizes of cable retaining ties used shall be subject to review by the Engineer.

Cables run in the vertical riser duct shall be supported at close intervals in accordance with the current edition of IEC 60364: Electrical Installations in Buildings (BS 7671) by means of proprietary make steel framing system and claw cleats like that manufactured by UNISTRUT/BICC or equivalent.

For terminations at the transformers where cables are descending from above, proprietary make steel framing system such as 'UNISTRUT' or equivalent shall be provided to support the cables from both the floor and the roof slab.

Notwithstanding the cable routes indicated on the Drawings the Contractor shall be entirely responsible for the supply of correct lengths of the cables to be installed and for all allowances for terminating and connecting the cables to the switchgear and transformers. The Contractor shall check all cable lengths by measurements at site to establish the correct lengths of cables required.

2.5.3 Cross-Linked Polyethylene (XLPE) Insulated Cable

Cross-linked polyethylene (XLPE) cables shall be of 12kV grade comprising 3 core or single core high conductivity stranded copper conductors, cross-linked polyethylene insulation, copper tape screen, polyethylene tapes, single or double steel wire armored as shown on the Drawings and high-density polyethylene sheathed manufactured and tested to the requirements of B.S. 5468.

The HV cable shall comply with IEC 60502 and shall be type tested and certified by A.S.T.A., K.E.M.A. or other recognized National or International Testing Authority. Test reports are to be submitted in Technical Submission.

Fire retardant XLPE cables shall be comply with relevant BS and IEC standards.

2.5.4 Jointing & Jointing Accessories

Termination of XLPE cables shall be carried out by accredited and fully experienced jointers and evidence of this shall be produced to the satisfaction of the Engineer before jointing of cables is being carried out.

The accessories shall be the cable manufacturer's standard design which have been tested and proven in service. Details of all designs and equipment offered shall be submitted with the tender. The accessories shall include all necessary fittings, insulating materials, cable lugs and glands, armour clamps, stress relief cone, etc. The cable manufacturer's drawings showing detailed arrangement of cable terminations, jointing

instructions shall be submitted to the Engineer two months before the commencement of the installation. Straight joints will not be permitted in any section of the cables.

A record is to be kept of all terminations made and is to include the name of the jointer and mate, the date of jointing, etc. Three copies of this record signed by the Contractor shall be supplied to the Engineer.

2.5.5 Supports and Racks

Cable supports and racks together with fixing bolts, clamps, nuts and screws shall be of galvanized steel unless otherwise specified.

2.5.6 Sealing & Drumming, Tests During Laying etc.

For other requirements on cable installation and installation materials i.e. sealing & drumming, tests during laying, cable identification tags, cable pulling, test certificates from manufactures, cable record drawings, cable trays and cable ladder etc., refer to the relevant clauses under 'LV Mains and Sub-Mains Distribution' for details.

2.5.7 Sealing & Drumming

Immediately after works' tests, both ends of every cable length shall be sealed by means of a metal cap plumbed to the sheath. The ends of the factory lengths are to be marked 'A' and 'Z' in accordance with B.S. 6480 Part 1.

The cable end projecting from the drum is to be adequately protected to prevent damage during handling and in transit, and a thick PVC wrapper shall be placed over the cable to prevent the ingress of dirt, dust and grit, etc.

Cable drums shall be lagged with closely fitting battens. Each drum is to be bear a distinguishing number which is to be branded with hot irons or neatly chiseled on the outside of one flange. A painted identification number will not be accepted.

Of the cable, i.e. Voltage, lengths, conductor size, number of cores, lengths number, gross and net weights are to be clearly shown on one flange of the drum. The direction of rolling is to be indicated by an arrow.

Cable drums are to be non-returnable and are to be thoroughly treated with Cuprinol or equivalent insecticide and wood preservative.

2.5.8 Tests During Laying

Where required by this Specification, and as required from time to time by the Engineer, the Contractor shall subject completed portions of the cable installation to Voltage tests to prove the soundness of the conductor insulation and the soundness of the protective servings.

2.5.9 Cable Identification Tags

All cables shall be identified at both ends by lead labels with 3/16 inch high (minimum) stamped cyphers securely wired on to the tinned copper wire.

2.5.10 Cable Pulling

Winching of cables through ducts shall only be carried out with the consent of the Engineer in which event a pulley eye shall be attached to the conductors.

A cable sheath stocking may be employed on cables where no undue stress in the sheath is likely to occur.

Care shall be taken to ensure that the draw strain is applied to the armouring and that the armouring and serving are protected during drawing against damage.

2.5.11 Test Certificates from Manufacturers

The Contractor shall submit to the Engineer for review, prior to dispatch of cables from the place of manufacture, test certificates in respect of all cables supplied under this Contract.

2.5.12 Cable Record Drawings

Cable record drawings or "As-Installed" Drawings showing the exact route of cables and positions of all joints, etc. shall be submitted for the Engineer's review.

2.5.13 Cable Ladders

All cable ladders shall be heavy duty manufactured from epoxy coated electro-galvanized mild steel of not less than 5/64″ thickness similar to BICC Vantrunk or other equivalent.

Cable ladders should have a minimum 5" high longitudinal side members and minimum 2" wide rungs with slots of 2.48" x 0.47" covering the whole length of the rungs. Each cable ladder shall be in 10' length and supplied complete with coupling sets consisting of fishplates, splinted bolts, nuts and locking washers.

The whole of the cable ladder installation is to be provided with all necessary proprietary factory-made elbows, risers, reducers, tees, crosses, drop-outs, etc. and any site fabricated items will not be allowed.

Cable ladders shall be supported from roof/sidewall using frame system similar to UNISTRUT.

16 sq. mm copper jumpers are to be installed from section to section.

2.5.14 Underground Cable Installation

a. Excavation of Trenches

The excavation of trenches shall include, by way of Amplification but not of limitation, all timbering, pumping and baling required and the provision of all necessary labour, plan, tools, additional soil, fuel and motive power for such purposes and the cost of this service and of the supply of expendable materials shall be included in the Contract Price.

All trenches shall be of enough width to enable the following minimum spacing between cables to be maintained:

Between HV & LV cables	-	1'
Between LV cables	-	3"
Between HV & ELV cables	-	6'
Between LV & ELV cables	-	1'

Before the cables are laid, the bottom of the trench shall be lined with sifted soil which is to be punched down to a thickness of 2" to form a bed. After the cables are laid, the first 3" depth of cover back fill shall consist of sifted soil over which shall be placed protective covers specifically made for cable protection.

b. Backfilling and Reinstatement

After all cables and protective covers have been laid, the trenches shall be refilled in 1/2' layers, each layer being well rammed and consolidated.

The surface of refilled trenches shall be temporarily reinstated and maintained in a thoroughly safe condition until complete consolidation of the solid is achieved.

The Contractor shall supply backfill materials necessary for the replacement of unsuitable excavation material and the cost of this material together with the backfilling, reinstatement and removal of surplus material shall be included in the Contract Price.

The Contractor shall include for all materials and labour to reinstate the ground to the same condition as existed prior to excavation.

c. Cable Covers & Markers

Protective cable covers shall be of reinforced concrete and shall be 3’ long, 1/2’ wide, and 2” thick. They shall be arranged for interlocking one with the other both vertically and laterally.

Plain flat concrete cable markers minimum size 18” by 4” thick shall be provided and installed with the top surface flush with ground level to identify cable routes of cables laid direct in the ground. Markers shall be inscribed with indented lettering reading HV cables.

2.5.15 HV Cable Enclosure

The entire HV cable route including all horizontal and vertical runs shall be protected and segregated by means of galvanized perforated sheet steel and angle irons constructed to form a box up around the cables and ladders. Appropriate danger signs shall be placed at intervals along the enclosure. Vertical HV cables where installed within dedicated HV risers need not be further protected.

2.5.16 Site Tests

The following site tests shall be carried out upon completion of cable laying and before energization of the circuits,

(i) Sheath Integrity Test to confirm whether there is any damage to the outer sheath.

(ii) Insulation Resistance Test.

(iii) High Voltage DC test.

3. Busduct System

3.1 General

Busduct system shall be consisting of vertical and horizontal busducts of proprietary make of copper or aluminium (material type as specified in the drawings) busbar type with continuous dedicated internal earth bar – 5 bars configuration enclosed in steel sheet trunking and shall have the current ratings as shown in this Contract.

The Busduct System shall be proposed to suit for the environment in this Contract, requirement of a min IP 65 or totally waterproof shall be adhered whether the environment call for particularly in sprinkler protected spaces and exposed to external weather even in sheltered areas.

Weatherproof Busduct System where deem to be required by the environment in this contract shall incorporate gaskets, drain holes etc. suitable for outdoor installation.

Cast resin type busduct shall be provided where car park and atmospheric pollution areas as per IEC 61439 (1 & 6)

The Busduct System shall be slim designed and of low impedance type and shall operate on 230 / 400 V at 50 Hz and shall be manufactured in compliance and accordance to BS EN 61439-6, and of equivalent other international standards and is type tested and certified. All material, components and accessories (such as elbows, joints, flange end / flange end box, tap-off units, end cap, expansion units, seismic mounting accessories, etc.) used for the complete Busduct System shall be of the same origin of manufacture.

3.2 Busduct Construction

The Busduct enclosure shall be made of electro-galvanized sheet steel coated with epoxy powder paint to a grey colour or the nearest manufacturer's colour of standard production. Phase indication of busduct system shall be provided on the busduct metal enclosure.

The construction shall be of folded mild steel channel construction, of not less than 5/64". The casing ends shall be identical to minimize the fittings required and to simplify installations. A splice plate shall be furnished at each joint to mechanically join the casings assembly.

Busbars assemblies shall be suitably enclosed, vermin and insect proof and designed to prevent unauthorized access to live metal. Busducts shall be supplied complete with all external galvanized steel supports and brackets suitable for fixing to walls/ceiling.

All metal works shall be treated against corrosion, painted with primer undercoat, and finished with grey synthetic enamel. Metal casings shall be treated to prevent corrosion and finished in the same manner as the busbar trunking. Red oxide primer shall be used for steel casing, and the remaining steelwork including machine parts are to be sherardized or subjected to an equivalent process.

The Busduct System shall be able to accept tap-off units of current ratings up to not less than half the current rating of the busbar trunking.

Expansion units shall be capable of taking up the thermal expansion or contraction when busduct system operates at full rated current and the ambient temperature changes. In particular, expansion units shall be provided where both ends of the busduct are fixed and where the busduct is installed across a building expansion joint.

Internal Earth bar (non-insulated) size per Drawings of phase bus bars shall be provided inside the busduct enclosure. Busduct system shall be terminated by end cap / end closure.

3.3 Rating

The complete Busduct System shall be capable as a whole of withstanding the short circuit capacity to the electrical installation without damaging by the electrical, mechanical and thermal stresses produced under a short circuit condition equivalent to the respective protective circuit breaker kA rating as shown on the Drawings at 400 Volt for 3 seconds as defined in BS 5486 unless otherwise specified.

3.4 Busbars

Busbars shall be of rectangular cross section HDHC copper, having current ratings in accordance with BS 5486 for a temperature rise not exceeding 40-degree Celsius and shall be fully insulated with a thick layer of continuous seamless PVC and further wrapped with non-ageing glass filled polyester film with good heat conducting properties. Busbar trunking of 300 Amp rating and below may be of the air insulated type but shall be totally enclosed in steel trunking.

High grade insulators shall be used to support the busbars. Full size neutrals shall be provided for all busbar trunkings. Phase indication of busbars shall also be provided. All busbar trunkings shall be built to withstand expansion and contraction and shall be capable of operating continuously at rated current for ambient temperature not exceeding 40-degree Celsius without derating.

Busbars supports shall be suitably insulated and Ample clearance shall be allowed between conductor surfaces and busbar casing. Insulation materials shall be of high-resistivity, non-hygroscopic, non-ignitable, non-tracking, strong and so shaped to avoid accumulation of dust and dirt.

Busbars forming long stretch run shall include proprietary made expansion joints. Such joints shall be the laminated copper having current carrying capacity not less than that of the conductors to which they are attached. Movement of the expansion joints or of conductors shall not encroach on a minimum clearance required.

3.5 Joints

Joints shall be accomplished by means of an insulated bolt passing through conductors. Joints shall not be affected by deforming the casing. Inspection covers shall be provided on each side of the joint and shall be usable without disturbing the joint pressure.

Contact surfaces in busbar joints, ends, and tap-off points shall electrolytically tinned all over and joints shall be properly tightened. Proprietary make standard bend, elbow and tee units of correct sizes shall be supplied complete with all fixings necessary for assembly with straight lengths of Busduct System. Samples of the units shall be submitted to the Engineer for review prior to installation.

It shall be possible to tighten a busduct joint from one side in the event of the busduct is installed against a wall or ceiling. All bolts shall be tightened up by means of a torque wrench to a strength figure as recommended by the manufacturer.

For Waterproof, Weatherproof and Fire Rated Busduct System, the jointing integrity shall abide with its full application properties.

3.6 Fire Barrier and Fire Ratings

Fire-resisting barriers of 2 hours fire rating shall be incorporated in the Busduct System whenever the busbar trunking passes through floor slabs or fire rated walls; min 2 hours or more fire resisting barriers shall also be provided around (external) the Busduct System trunking shall be Fire Rated compliant to the requirement Fire Compartmentation of the building, and to local authorities requirement.

Fire Retardant Busduct System shall be fire retardant for Essential Services, and where it runs into another Fire Compartmentation Spaces as defined by the local Engineers.

Fire Rated Busduct shall be provided for all circuitries incoming and outgoing from the Emergency Main Switchboard. The conductors of Fire Rated busduct shall be insulated with double layers of mica tape and polyester films. All joint sections shall be protected with fire protective materials.

The rating of fire rated Busduct System shall suit the Fire Protection environment.

Both Busduct straight feeds and Busduct joints shall be type-tested for fire resistant IEC 60331, BS 6387 with Fire Rating of 950 degree C and testing methods adopted by independent testing authority. Type test certificates shall be submitted for approval / endorsement.

The whole of the Busduct System shall be type tested and certified by A.S.T.A., K.E.M.A. or other recognized National or International Testing Authority. Test reports are to be submitted in Technical Submission.

3.7 Conductor

3.7.1 Copper Conductor

The conductors shall be three phases with full size neutral and internal earth made of hard drawn high conductivity solid copper bards to, ASTM B187M, BS EN 13601 and other relevant quality standards. The conductors shall be silver or tin plated at all electrical contact surfaces.

The cross-sectional area (CSA) of copper conductors shall be in accordance to the following table as a minimum.

Current Carrying Capacity (A)	CSA (mm^2)
600	240
800	300
1000	450
1200	600
1500	750
1600	900
2000	1110
2500	1500
3200	1800
3500	2100
4000	2250
4500	2700
5000	3150
6000	3330

The maximum operating temperature of busduct system shall comply with IEC 60439-1 and IEC 60439-2. The temperature rise at any points of the insulated conductors shall not exceed 70°C above ambient temperature when operating at rated load current. Busduct System shall be able to operate at full rated current at a maximum ambient temperature of 40 °C without derating.

3.7.2 Aluminium Conductor

The conductors shall be three phases with full size neutral and internal earth made of aluminum bars (Grade 1070, 99.7% purity). The conductors shall be silver or tin plated at all electrical contact surfaces.

The cross-sectional area (CSA) of aluminum conductors shall be in accordance to the following table as a minimum.

Current Carrying Capacity (A)	CSA (mm^2)
600	300
800	450
1000	600
1200	750
1500	900
1600	1110
2000	1440
2500	1800
3200	2220
3500	2880
4000	3150
4500	3330
5000	4320

3.8 Flange End / Flange End Box

Flange end or flange end box shall be provided for each Busduct System. The rated current and rated short time withstand current of the flange end shall not be less than that of the Busduct System to which it is connected.

The removable bottom cover of flange end box shall be made of non-ferrous material for the ease of cable termination works.

Where connections are to be made to a switchboard or transformer, flange end shall be coordinated, such that the phase sequences at connected switchboard and transformer are matched. Bi-metal plates are recommended for the connections of copper and aluminum materials.

Braided type of copper flexible link bar shall be connected between the transformer LV terminals and busduct flange end. Laminated type of flexible link bar shall not be acceptable.

3.9 Feed-In Units, Tap-Offs and Tap-Off units

Tap-off units shall be of the same manufacture as Busduct System, comprising MCCB, MCB, HRC fuses and neutral link with circuits' ratings as indicated on the Drawings. The short circuit breaking capacities of the MCCB, MCB and HRC fuses shall not be less than the maximum prospective fault level at the point where the tap-off unit is installed. All HRC fuses must be in accordance with British Standards and of the type readily available locally. HRC fuses of other standards will not be accepted.

Tap-off units shall be proprietary make, totally enclosed in casings having securely fastened hinged covers, and provided with screwed conduit entries or cable glands as required to suit the type of cables used. Glands or cable entries are to be located in either base, back or sides of the units as required to suit site conditions.

Tap-off units shall be the plug-in type suitable for all sizes of busbars with adequate contact pressure. Beams shall be provided for fixing the casing to the Busduct System. All tap-off units shall be suitably earthed. The earthing contact shall always be made before that of the active conductors.

For Vertical Busduct System, provisions shall be made in the Busduct trunking for tap-off units at intervals of 600 mm; tap-off points where not used shall be provided with proper outlet covers. Tap-off openings shall be of the safely type and in conjunction with the tap-off units shall have interlocks provided which prevent additions or removal of the tap-off unit when the switching mechanism is in the 'ON' position. Metal parts of the tap-off units shall be designed to contact the steel casing before the plug fingers contact the busbars. 'Danger' warning signs shall be provided at all tap-off points. Feeder busbar trunkings utilized for the interconnection between transformers and the main switchboards shall not be provided with tap-off points.

Busbar System on terminal floors shall have sufficient length for installation of at least 3 tap-off units on each terminal floor at the specified interval.

Tap-off units shall be used for branch circuits taken off from the Busduct system. Every tap-off unit shall be of manufacturer's proprietary product to match and to be an integral part of the Busduct System.

Moulded Case Circuit Breaker (MCCB) complying with IEC 60947-2 of appropriate current ratings and short circuit breaking capacities shall be provided as near as practically possible to the tapping position for protection of the branch circuits.

Tap off units shall be equipped with internal barriers to prevent accidental contact with the live parts at the terminals of the protective device.

Tap-off units shall make positive ground connection to the Busduct housing before the plug-in clips make contact to the phase conductors.

Mechanical interlock of rotary handle type shall be incorporated to prevent installation or removal of tap-off nit while the MCCB is in the "ON" position.

Plug-in holes on the busduct system for tap-off units shall be equipped with phase isolator to segregate the tapping position of each phase of the busduct system. For aluminum busduct, the contact part of aluminum conductor shall be protected with a piece of tinned copper sheet.

Tap-off units shall be complete with a removable bottom cover for the ease of cable termination works.

"Danger" warning signs of an approved type shall be provided at the front panel of all tap-off units.

3.10 Mounting method

The vertical busduct system shall be supported adequately by vertical spring hanger / vertical hanger mounted on channel base of each floor. Intermediate supports shall be provided if the floor height exceeds 16' 5"

The horizontal busduct system shall be supported by horizontal hangers at every interval of 5'.

3.11 Requirement for Air-Insulated Busduct System

a) Busduct Enclosure

Enclosure of the busduct shall be rigidly constructed from electro-galvanized sheet steel of not less than 0.06" thickness, formed in such a way as to give a rigid structured of sufficient strength. Both the main portion of the enclosure and cover shall be flanged at the side edges.

b) Conductor Supports

Conductors shall be supported on insulated racks or blocks to IEC 60667 and IEC 60439-1. The conductor supports shall be mechanically strong to withstand the force between the conductors produced by a short circuit between two or more conductors.

3.12 Requirement for Fully Insulated Compact Sandwich Busduct System

a) Busduct Enclosure

The enclosure of the busduct shall be rigidly constructed from electro-galvanized sheet steel of not less than 0.06" thickness and clamped on the rigid side of steel frames by means of bolts and nuts.

The assembly of the steel frames shall consist of not more than two seams to enhance the mechanical strength of the busduct enclosure.

The external surface of busduct enclosure shall be coated with epoxy powder paint finish.

b) Conductor Insulation

Conductor shall be insulated over their entire length expect at joints and plug-in contact positions. The insulation materials shall be "Mylar" polyester film insulation that meets the requirement of Class B material (130 ^{o}C) with the insulation Voltage of 1000 V.

c) Busduct Joints

The busduct joint shall be of the double-bolt joint design coupled with a pair of leaf springs to ensure sufficient electrical contact and mechanical strength.

Bolt-through joint design and joint stack design shall not be acceptable.

The joint shall be covered up by metal cover plates of same type of material and finishes as the busduct enclosure.

3.13 Acceptance Tests at Manufacturer's Works

Completed Busduct System shall be visually inspected for technical execution and conformity with the latest issue of the approved drawings and with the order. Spot checks shall be made to verify:

(1) Outline dimension of busduct enclosure

(2) The degree of protection of the enclosure

(3) Creepage distances and clearances

(4) Proper mounting of components.

(5) Internal connections

(6) The availability of the earth points for connection

(7) Measurement of insulation resistance (Megger Test) on the conductors

(8) Dielectric test shall be carried out with 2.5 kV rms for 1 minute

(9) Testing of the mechanical and electrical operation of a number of functional units on a random basis

3.14 Type Testing and Certification

ASTA type test certification to latest edition of BS EN 60439-6 shall be submitted to the Engineer for approval.

4. Earthing Installation

4.1 Earthing System

Earthing system comprising cables, conduits, copper tapes, electrodes and earth connections necessary to bond effectively and permanently to earth all exposed and extraneous conductive parts shall be supplied, erected and connected under this Section of these Specifications. Earthing shall generally be carried out in accordance with current edition of IEC 60364 and related Pakistan Standard. Tinned H.D.H.C. copper earth bars shall be installed in the Switch room/Standby Generator Room as shown on the Drawings at a height of 1' above finished floor level and connected to the respective earthing points. Insulators for mounting the earth bars shall be the porcelain type.

Earthing connections shall be run and fixed in workmanlike manner generally in square and symmetrical lines using appropriate size for securing tapes at intervals not exceeding 3' and the copper tapes shall be supplied in long unbroken lengths to avoid unnecessary jointing.

The contact surfaces of all tapes at joints etc. shall be tinned before clamping and all the joints shall be tinned, rivetted and soldered. All connections to electrical apparatus shall be made by a bolted connection in a visible and accessible position. Consideration shall be given to jointing of incompatible metals such that they are not in contact physically but have a high conductivity barrier between them.

All joints in exposed sections shall be protected against corrosion and the ingress of moisture by the application of two coats of anti-corrosion paint. Underground joints shall be further protected by wrapping with Denso waterproof tape.

Suitable earthing terminals shall be provided in all switchgear enclosures, relay and instrument casings and all other electrical metalworks for bonding to the earth.

Earth connections for all sections of the installation shall be electrically continuous throughout.

4.1.1 Bonding

The entire installation shall generally be protected against indirect contact by means of earthed equipotential bonding and automatic disconnection of supply. Main equipotential bonding conductors shall be provided to connect to the main earthing bar/terminal of all extraneous conductive parts within and around the building.

In particular, for residential building, the water and gas service pipes to each apartment unit shall be bonded to the earthing terminal of the distribution board serving the apartment by means of a 6 sq. mm PVC insulated green earth cables in conduit.

Local supplementary bonding connections shall be made to metal parts to maintain the equipotential zone where those parts:

(i) are extraneous conductive parts, and

(ii) are simultaneously accessible with exposed conductive parts or other extraneous conductive parts, and

(iii) are not electrically connected to the main equipotential bonding by permanent and reliable metal-to-metal joints of negligible impedance.

In particular all metallic bathtubs, water pipes, faucets, etc. within bathrooms shall be bonded with minimum 6 mm^2 PVC insulated green earth cables in conduit to the nearest earthing terminal. Minimum dimensions of

conductors connecting different bonding bars or connecting bonding bars to the earth-termination system shall be 16 mm^2 PVC insulated green earth cables.

Unless otherwise shown in the Drawings, all connection's minimum cross sections shall be as per minimum bonding cross sections specified in BS EN 62305-3&4.

4.2 Materials

The electrode at the earthing point shall be of minimum 0.63" diameter extensible copper clad steel electrode of sufficient current carrying capacity to meet the requirements of earthing.

The rod section shall consist of 99.9% pure electrolytic copper of minimum thickness 0.01" molecularly bonded onto low carbon steel core with a high tensile strength for resistance to bending and easy deep driving. Couplings shall be manufactured from aluminum bronze and counter bored at each end depth sufficient to completely enclose the threads. Clamps shall be made from cast aluminum bronze alloy and shall be fitted with phosphor bronze screws. Brass accessories are not acceptable.

Driving studs for the rods shall be of high tensile socket head cap screw with a black phosphate finish.

Unless otherwise shown in the Drawings, a concrete earth pit/chamber complete with galvanized steel chequered plate cover shall be provided for each electrode.

For earth chambers where installed in locations subject to vehicular traffic, these shall be of heavy-duty type designed to withstand the loads of the vehicles.

Copper tape shall be of high conductivity annealed copper type of minimum dimensions 1" x 1/8" and complying to BS 1432.

All earth bars shall be made of HDHC copper, electro-turned for the entire length and shall be of dimension not smaller than 1.6" (width) x 0.3" (thickness) complete with porcelain insulators, channel base, disconnecting test links, bolts nuts, washers & locknuts.

Earth bar shall be provided with at least two spare terminations. Termination points shall not be spaced less than 3" intervals. The disconnecting test links shall be provided to permit sectionalizing of the earth bar to facilitate isolation and measurement of earth resistance values.

Earth bars shall be provided in the consumer switch rooms standby generator set room and any other rooms as shown on the Drawings and shall be installed on channel base at the height of about 1' above the finished floor level.

4.3 Standby Generator Earthing

Generator earthing shall be provided with neutral earthing resistors for each and every generator.

The neutral earthing resistors shall be grid type resistors. The enclosure shall be of sheet steel of IP 20 Class of protection in a floor standing enclosure/cabinet. The resistor shall be selected and designed to limit the earth fault current of the associated generator to the maximum full load current of the generator.

The generator neutral star point shall be solidly connected to the standby generator earthing system.

4.4 Transformer Earthing

Neutral star points of the LV secondary windings of all transformers shall be solidly connected to the Sub-Station earthing system as shown on the Drawings.

Transformer body also shall be connected to the earthing system.

4.5 Computer Equipment Earthing

IT, server room and other ELV equipment shall be connected to the earthing system as shown in the Drawings.

4.6 Earthing of Other Services

Earthing points for other services where shown on the Drawings shall also be provided under the Contract. Each of the earthing points shall comprise main earth bar, earthing leads, electrodes, inspection chambers, cover etc.

4.7 Earth Electrode Resistance

The Contract shall be deemed to have included the provision of necessary number and length of electrodes and connections to obtain the earth resistance values as required by the current edition IEC 60364: Electrical Installations for Buildings (BS 7671), IEC 60364, IEC 62305 and other related Pakistan Standard. In any case and unless otherwise stated the resistance of each earthing system shall be less than 5 ohms.

4.8 Labelling

At each of the earth chamber, a red plastic label with the inscriptions ‘Earthing Point - Do Not Disconnect’ is to be provided.

A brass plate with the following information and inscription is to be installed at the main earth bar of each earthing system:

- Type of earthing system
- Value of earth electrode resistance
- Date of test

Each of the earthing conductors is to be labelled at the earth bars, switchgear and transformer with the appropriate inscriptions as required by the Engineer by using unilabel cable markers as manufactured by Critchley.

4.9 Record Drawings

Record drawings showing the whole of the earthing system including locations of all electrodes locations and their interconnections routings are to be submitted to the Engineer for record purpose.

5. Work Tests, Site Tests & Commissioning

5.1 Work Tests

Unless otherwise agreed by the Engineer, all the electrical equipment & plants supplied under the Contract shall be subject to Type Tests, Routine Tests and Sample Tests as called for in the relevant Pakistan or British Standards to determine whether they comply with the Specifications and also to provide the necessary operating data. The items selected for type tests shall be identical to those to be supplied by the Contractor in all details likely to affect its performance during the tests and test conditions shall be similar to those likely to be encountered in service. Not less than one month's notice of all tests shall be given to the Engineer in order that he or his representative may be present if he so desires. Five (5) copies of all test certificates and reports shall be submitted to the Engineer for his review and record. Type Tests which have been successfully performed previously on the equipment & plant to be supplied may be accepted as evidence of the items having satisfactorily tested, at the discretion of the Engineer.

All costs of work tests shall be deemed to have been included in the Contract.

5.2 Site Tests & Commissioning

The complete installation or any part thereof shall be tested, both before and after being connected up to the requirements of the Engineer.

The Contractor shall be responsible for all electrical tests at the site and shall be represented by a qualified and competent Licensed Electrical Worker during the whole of the period required for the tests.

All materials, equipment and plant supplied or erected under this Contract which fail the tests shall be replaced or rectified at once by the Contractor without cost to the Employer and the tests shall be repeated. The final decision to replace or rectify the defective part or parts or the whole of the equipment or plant shall rest with the Engineer.

All tests shall be conducted in the presence of, and to the satisfaction of the Engineer and the Employer. The Contractor shall supply all necessary instruments, apparatus, connections, skilled and unskilled labour required for the tests to be carried out to the satisfaction of the Engineer; the cost of so doing shall be deemed to have been included in the Contract.

The Contractor shall make accurate records of all tests and shall furnish test certificates and a schedule of the test results. A format of the test results shall be discussed & agreed with the Engineer. Five (5) copies of such records and of each test certificate shall be submitted to the Engineer for review.

Any circuit or section of the installation failing to comply with the required standard for acceptance shall be made good by the Contractor and retested to the entire satisfaction of the Engineer without any additional cost to the Contract.

The tests to be carried out on each completed section of the Electrical Installation shall include, the following:

- Oil tests, where applicable,
- Power frequency voltage tests on primary components at a voltage and duration to be agreed by the Engineer.
- Vector group, and phasing tests.
- Check correct CT radio and polarity and correct operation of all protective gear by primary injection tests and system fault tests to check sensitivity and stability.

- Secondary current injection tests for accuracy of relay operations. Protective gear timing tests as may be necessary.
- Rotational tests on all motors.
- Battery tests on specific gravity, correct output voltage, charging equipment, alarm etc.
- Tests to prove correct operation of all interlocks, tripping and closing circuits, alarm indications etc. including operation in conjunction with the standby generators for emergency operation of lifts etc.
- Polarity tests to verify that single pole switches are installed in the phase or live conductor of each circuit and not in the neutral conductor.
- Tests to verify the electrical continuity of all conductors in every ring circuit, correct connection to terminals of all socket outlets and effective bonding to earth of each terminal and socket.
- Insulation resistance tests to earth and between conductors before and after fitting of lamps. The standard of acceptance for electrical insulation tests shall be as recommended in the current edition of the IEC 60364 Electrical Installations in Buildings.
- Insulation resistance test on any electrical plant, equipment, machine and apparatus supplied and/or erected under this Contract before and after connecting such plant, equipment, machine and apparatus to the supply circuit.
- Earth resistivity and earth continuity tests for each final sub- circuit and the completed installation to ensure that the impedance of the earth fault loop is such as to permit compliance with the requirements of the current edition of the IEC 60364 Electrical Installations in Buildings. The suitable instrument is the Ferranti Phase - Earth Loop Impedance Tester (Model 2) and the Contractor shall employ such instrument or equivalent.
- Tests to check the electrical continuity of conductors and earth resistivity and system resistance of the lightning protection system.
- Tests to check the performance of the entire clock system including battery conditions etc.
- Tests on the standby generator sets.

5.3 Fire and Life Safety Clearance Inspection and Test

The Fire and Life Safety FLS Clearance Inspection and Test cover all fire life safety systems and equipment including but not limited to generator, emergency PA, EXIT sign, magnetic door release, fire shutter, gas detection system, security door release, kitchen fire suppression system, smoke control and pressurization, emergency EXIT sign and lighting, fire and smoke compartment, means of escape, fire door and fixture, electrical safety inspection, hydrant/hose reel, sprinkler, other fixed fire protection system, automatic fire alarm and interfacing, ventilation air control, clean agent fire suppression system, fireman's lift, audio and visual fire alarm, interfacing and integration test.

The Objectives of the FLS Clearance Inspection and Testing are:

1. To verify the proper functioning of the FLS equipment/system
2. To verify that performance of the installed FLS equipment/systems meet the specified design intent and performance criteria.
3. To verify the results from the completed T&C by sufficient size sampling
4. To verify the installation standards and adequacy of the FLS equipment/systems and identify the area for improvement.
5. To assess the safety level of the hotel upon opening

In the event where fire and life safety system and equipment is unable to pass the FLS clearance inspection and testing requirement, building shall not be allowed to open and all rectification works required shall be completed and re-tested to the satisfactory of Building Management.

All necessary documentation is to be prepared by Sub-Contractors to facilitate the FLS clearance inspection and testing. The document shall include but not limited to:

- Design documentation, specification etc.
- Updated schematic drawings etc.
- Method statement and T&C forms
- Approved compartmentation floor plan
- "Cause & Effect Matrix" for AFA interface response
- Manufacturer's instructions, acceptance test report etc.
- Local authority requirements
- Others necessary to support the inspection and testing

All necessary equipment and tools are to be prepared by Sub-Contractors to facilitate the FLS clearance inspection and testing. This shall include but not limited to:

- Sound meters;
- Anemometer;
- Door force opening measuring devices;
- Manometers or Pressure differential gage;
- Approved device for the functional test of smoke detectors, heat detectors and gas detectors;
- Smoke bombs, smoke mast for testing smoke control system as per local codes;
- Flow meter for fire pumps performance testing;
- Gauge fixture to measure the pressure at the indoor hydrant outlets without flow
- Appropriate container for measuring the flow rate of hose reel
- Sprinkler head wrench;
- Infrared thermometer;
- Digital multimeter;
- Tape measure > 30 meters
- Necessary equipment and tools for activation testing and discharge testing for the Kitchen hood suppression system;
- Walkie-talkies

6. Servicing & Maintenance

6.1 General

The works covered by this Section is for the supply of all materials, tools, apparatus, equipment and appliances, labour and necessary incidentals for the servicing and maintenance of all the systems and ancillary plant, machineries and equipment supplied and installed under this Contract during the Maintenance Period as well as for the future servicing and maintenance thereof after the expiry of the Maintenance Period.

All works to be performed under this Section shall be in accordance with the best commercial, technical and engineering practice, and must be strictly in accordance with this Specification.

During the Maintenance Period, the Contractor shall replace and/or repair all defective plants, machineries and equipment and installations or any part of parts thereof entirely free of charge to the Employer whenever directed by the Engineer if such repairs or replacements are necessitated by reason of defective design, materials or workmanship or part or parts thereof replaced during the Maintenance Period shall carry a fresh warranty for a period of six (6) months or the balance of the Maintenance Period whichever is the longer with effect from the date of replacement or completion of repair thereof.

For servicing and maintenance after the Maintenance Period, all labour costs involved in the carrying out of servicing, maintenance, replacement and/or repair of defective parts or items and the costs of supplying consumable materials (as listed hereinafter), incidental materials and of using tools, apparatus, equipment or appliances required for carrying out such tasks, shall be deemed to have been included in the prices quoted for future servicing and maintenance after the Maintenance Period.

6.2 Workmanship and Materials

The work described in this Section shall be performed by workmen skilled in the servicing, maintenance and repair (or replacement) of all the equipment, plants & machineries supplied & installed under this Contract, and shall be executed in accordance with the best commercial, technical and engineering practice.

All materials to be supplied in connection with the works under this Section shall be new and unused, and shall generally be of the best quality as regards manufacture and performance.

6.3 Supervision

The Contractor shall have a Supervisor in charge of the servicing, maintenance and repair (or replacement) works required to be carried out under this Specification. For works which required by the local laws and regulations to be performed by personnel who is licensed or registered with the relevant local regulating bodies, the Supervisor as proposed by the Contractor shall deem to have the appropriate license or registration. This Supervisor shall also be **fully competent in supervising, servicing, maintenance and repair** (or replacement) of plant, machinery, equipment of all types, and shall be in direct employ of the Contractor and acceptable to the Employer.

6.4 Scope of Work

All plant, machineries and equipment comprising the complete systems and ancillary equipment supplied and installed under this Contract shall be serviced and maintained strictly in accordance with the requirements/recommendations stipulated by all the plant and equipment manufacturers as well as in compliance with all by-laws, rules, regulations and requirements of the Local Authorities and shall also satisfy

all appropriate Pakistan and British Standards including all relevant Codes of Practice. The Contract includes the preparation of a comprehensive servicing and maintenance schedule to meet these requirements for the entire Works, during and after the expiry of the Maintenance Period; this schedule shall be submitted to the Engineer for review after the award of the Contract. The Engineer reviewed schedule shall be included and form an integral part of the Operating and Maintenance Instructions and parts list specified elsewhere in this Contract.

The Contractor shall liaise with and seek agreement from the Employer on the time and day for carrying out the servicing, maintenance, repair and replacement of all plants, machineries, equipment and installations comprising the whole system under this Contract such that operation of the installation is not unduly disrupted. It is expected that working outside normal operating hours (i.e. overtime) will be required. The Contractor shall also provide emergency repair services at any time of the day (overtime included) if so, requested by the Employer.

The Contractor shall be contractually bound to advise the Employer of any defects or deterioration in any part of the equipment/materials observed during the routine inspection and servicing, and shall repair such defects if required to do so by the Employer.

The Contractor shall include the services of a Registered Professional Engineer and/or Licensed Electrical Worker/Licensed Plumber, as required by the Local Authorities to take complete charge of the entire works and all costs connected herewith including fees payable to the Authorities are deemed to have been included in the Contract and in the Maintenance Prices submitted.

At the end of the Defects Liability Period / Maintenance Period, the contractor shall check the operation of al electrical switchgear including setting interlock and carry out load measurement in each switchboard.

6.5 Servicing & Maintenance

The Contractor shall inspect and service all plant, equipment, machines and installations supplied and installed under this Contract (irrespective of whether or not they are specifically listed in this Section) at least once a month and at other intervals in accordance with the Authorities' and Codes' requirements and/or their recommendations/requirements of the plant and equipment manufacturers except when otherwise directed by the Employer.

During every regular inspection, the Contractor shall, amongst other things, carry out the following:

(a) Check the performance of the complete Electrical Installation, including cleaning and adjusting all control devices as and when technically necessary.

(b) Instruct the Employer's electricians & operators, responsible for the operation of the Installation, in respect of the correct method of operation and on the proper maintenance procedure.

(c) Report in writing to the Employer any defects discovered, coming to light or observed in any part or parts of the Electrical Installation. Such reports shall state fully the cause(s) of such defect(s) and shall include an estimate of the cost of repairs or replacement of the defective part or parts required.

(d) Record in the logbook for each element or section of the Installation kept by the Employer, particulars of all maintenance or repair works carried out and initial all entries in the log books.

(e) Tests as and when necessary, on any item of electrical plant machine or equipment or any portion or the whole of the Electrical Installation. All costs shall be deemed to have been included in the Contract Sum.

(f) Report in writing to the Employer all works carried out in accordance with the Service and Maintenance Schedules.

(g) Submit drawings and written reports to WAPDA as and when necessary.

(h) Monthly maintenance and servicing shall be carried out in accordance with the Maintenance Schedules recommended by the equipment manufacturers.

(i) Maintenance, Testing and inspection shall be in accordance with the regulatory requirements and relevant product standards.

(j) At the end of the Defects Liability Period / Maintenance Period, the Contractor shall carry out a thermal scanning of the switchboards and sub-switchboards by Infra-Red Camera. The test shall be carried out during the peak load of the switchboards. The heat emitted from the surface of the electrical equipment shall be mapped by colours representing the various temperature. The infra-red images are to be submitted in a report format. Report should contain the thermographic images, digital images and identification of the components where loose connections and defects are noted. Contractor shall rectify the hotspots areas and carry out thermal scanning tests to confirm that these defects are cleared.

The Contractor shall include the services of a Licensed Electrical Worker/Authorized Switching Engineer to take charge of all the Electrical Installation of the entire Building including those related to all other building services i.e. air conditioning and ventilation, firefighting & alarm, lifts, sanitary & plumbing, etc. for licensing purpose including payment of licensing fee etc. both during and after the expiry of the Maintenance Period, updating of record drawings and submission of same to the WAPDA etc.

6.6 Consumable Materials

The Contractor shall supply, as and when required, the following consumable materials for all plant, machines, equipment and installation supplied and installed under this Contract:

(a) All oil and grease required for lubrication of the standby generators.

(b) All insulating oil for circuit breakers required for replacement or topping up.

(c) All electric contact points required to replace worn electric contact points in contactors, relays etc.

(d) All electric fuses, indicating lamps, incandescent lamps, fluorescent tubes PL and SL lamps, HID lamps, etc. where applicable, required to replace blown fuses lamps and tubes. The amount of tubes and lamps to be replaced shall be limited to not more than 10% of the total of each type of lamps or tubes supplied & installed in the Contract.

(e) All cotton waste, soap detergent and other cleaning materials required for cleaning purpose.

The costs of these consumable materials shall not be charged separately by the Contractor but shall be deemed to have been included in the Contract and the prices quoted for the Charging servicing and maintenance after the expiry of the Maintenance Period.