VOLUME 2: SPECIFICATION FOR ELECTRICAL INSTALLATION MATERIALS, EQUIPMENT AND WORKS

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1. GENERAL

This section specifies the requirements for plant, equipment and materials forming part of the electrical works of the Contract, and shall apply except where otherwise specified.

Where the word 'Engineer' is used in these descriptions of Materials and Workmanship, it shall in all appropriate cases be used and construed as the 'Electrical Engineer'.

The whole of the electrical work is to be executed by suitably qualified and experienced operatives, and skilled tradesmen employed by the Contractor or by Sub-Contractor and are all to be specifically approved of by the Engineer. All workmanship shall be of good standard and in accordance with the acceptable practices and the relevant Codes of Practice.

1.1 Regulations

The Contract works must be carried out strictly in accordance with the following documents:-

i) The current version of the sixteenth edition of the 'Regulations for Electrical Installations' published by the Institution of Electrical Engineers, London (with local amendments, where applicable).

ii) Local Malawi laws and by-laws and Supply and Local Authority requirements.

iii) Relevant British Standard Specifications and Codes of Practice, published by the British Standards Institution (hereafter referred to as B.S. and C.P. respectively) as implemented in Malawi.

iv) The Specification.

v) Any working drawings produced by the Contractor and approved by the Engineer.

vi) The Engineer's instructions, drawings and details.

The Contractor shall undertake all modifications demanded by the authorities in order to comply with the regulations, and produce all certificates, if any, from the authorities without extra charge.

1.2 Quality of materials and manufacturing standards

Notwithstanding that suppliers may have been named or approved by the Engineer, it shall be the Contractor's responsibility to ensure that all materials and components are up to Specification in respect of manufacture, finish and performance.

Named manufacturers are those on which the design has been based and whose standards of products are approved and intended only as a guide to the Contractor.

All materials shall be suitable for their intended use and shall comply with relevant Standards and be installed in accordance with Codes of Practice, manufacturer's recommendations and the Specification.

Materials and/or apparatus supplied by others for installation and/or connection by the Contractor shall be carefully examined on receipt. Should any defects be noted, the Contractor shall notify the Engineer immediately.

Unless otherwise specified, all materials including equipment, fittings, cables etc., shall be in new condition. Defective equipment or that damaged in course of installation or test shall be replaced or repaired to the approval of the Engineer. Should any replacement, be necessary, the Contractor shall bear the cost of substitution and of all associated builder's work and making good finishes.

All materials to be used shall be fixed or applied in accordance with the manufacturer's instructions.

1.3 Installation requirements

It is necessary that all the Contractor's proposals and working drawings for and in connection with the electrical works shall be submitted early in the Contract period to facilitate co-ordination with others.

The Engineer reserves the right to call for samples of some or all materials and products to be used.

The contractor shall obtain such samples as required and submit them within 14 days and any costs incurred will be presumed to have been allowed for in the tender.

The Contract works shall be of construction, manufacture and finish as to render them suitable for operating throughout their expected life and maintain design conditions. The Contractor shall be deemed to guarantee satisfactory performance of all quoted for items and fixing and operational accessories.

1.4 Standards

The Works shall be constructed and tested in conformity with the standards indicated in these specifications. Wherever reference is made in the contract to specific standards and codes to be met by the materials, plant, and other supplies to be furnished, and work performed or tested, the provisions of the latest current edition or revision of the relevant standards and codes in effect shall apply, unless otherwise expressly stated in the contract. Where such standards are national or relate to a particular country or region, other authoritative standards which ensure a substantially equal or higher performance than the standards and codes specified shall be accepted subject to the Engineer's prior review and written approval. The alternative standards and codes

proposed shall be translated by the Contractor into the English language prior to submission for approval. Differences between the standards specified and the proposed alternative standards must be fully described in writing by the Contractor and submitted to the Engineer at least 15 days prior to the date when the Contractor desires the Engineer's approval. In the event the Engineer determines that such proposed deviations do not ensure substantially equal performance, the Contractor shall comply with the standards specified in the document.

For convenience and for reference purposes, certain equipment, articles, materials, or processes are designated in the specifications by brand name, trade name or catalogue name and number. Such designation shall be deemed, to be followed by the words "or approved alternative" whether such words are shown or not. The Contractor may offer other equipment, articles, materials, or processes which have similar characteristics and which provide performance at substantially equivalent or better than those specified, which will be accepted, subject to the Engineer's prior review and written approval. The burden of providing evidence as to comparative quality and suitability of alternatives shall be upon the Contractor and such evidence must be submitted to the Engineer at least 15 days prior to the date when the Contractor desires approval. No such alternative shall be used without prior written approval by the Engineer."

1.5 Record Drawings

The Contractor shall mark accurately on one set of drawings the conduit or trunking laid during the progress of the work. This information must be made available on site for inspection by the Engineer whenever the Engineer asks for it.

At the completion of the contract, the contractor shall supply the Engineer with two soft copies on 3.5 inch floppy diskettes, one set of transparent originals and two complete sets of prints showing the complete installation. The drawings shall include the location of all apparatus, conduit and cable routes and a schematic of mains distribution.

Where portions of the Works are to be concealed, draft copies of “As installed” drawings shall be supplied to the Engineer before the work is concealed in order to facilitate checking and approval.

The Contractor shall maintain on site a set of drawings for the purposes of progressive marking up of alterations and variations. These drawings which shall form the basis for the Record drawings shall be available for inspection by the Engineer from time to time.

A Certificate of Practical Completion will not be issued by the Engineer if the Contractor fails to undertake the above procedure for the preparation of the Record drawings.

Upon the issue of the Certificate of Completion or Making Good of Defects the Contractor shall issue a final set of Record drawings taking into account any changes, which occurred in the Defects Liability Period.

1.6 Contract Drawings

The drawings forming part of this specification are to be read in conjunction with this Specification to enable the Contractor to prepare a tender.

These drawings are not intended to be used as working drawings unless they are released for that purpose.

1.7 Working Drawings

The Contractor shall prepare working drawings as may be necessary. They shall be submitted to the Engineer for approval before the execution of the works.

Working drawings to be prepared by the Contractor shall be detailed as below but not restricted only to these:-

a) General arrangement drawings showing plant, HV and MV switchboards, distribution boards, consumer units, fittings, switches, switch sockets, etc.

b) Layout drawings of concealed and surface conduit, ducts, trunking, etc.

c) Any other drawings that are not called for in the Specification.

Two copies of all working drawings shall be submitted to the Engineer for approval. Thereafter, the Contractor shall submit copies of approved working drawings for distribution to all parties concerned.

The Contractor shall not be relieved of any of his obligations under the Contract from correcting any errors on site or elsewhere subsequently found in the approved working drawings and no extra financial claims shall be entertained.

1.8 Co-ordination of Engineering Services

All aspects of the Engineering Services installation require detailed coordination to avoid any possible clash or conflict with other trades and disciplines.

The Contractor shall undertake such co-ordination in relation to his Co-ordination and Installation drawings and builder's work information and no extra claim will be allowed due to conflict of works or installations.

The Contractor shall initiate all co-ordination meetings that are necessary and all surveys that are necessary.

1.9 Labels

All switchgear, switch fuses, distribution boards, etc., shall be clearly labeled with Black and White background engraved labels to indicate the name, purpose and position of the gear. All circuits in distribution boards shall be clearly identified in respect of the

number and location of the miniature circuit breakers. The chart shall be securely fixed inside the cover of the distribution boards.

1.10 Instruction of Employer's Staff

The Contactor shall be responsible for arranging a Scheme for Instruction and Training of the Employer's Personnel in relation to the Engineering Services.

Draft proposals of the Scheme content shall be submitted to the Engineer for his approval in writing not less than six months before the anticipated date of Practical Completion. Thereafter the proposals will be finalized and a time table shall be provided for the Scheme.

The Contractor is to include for the provision of attendance by himself and by specialist personnel to assist in the training to suit the requirement of the Engineer.

1.11 Operating and Maintenance Instruction Manuals

Operating and maintenance manuals shall be provided by the Contractor as detailed in the Specification and Bills of Quantities and as stated below.
A draft copy of the operating and maintenance instruction manuals contained in a temporary loose leaf binder shall be issued prior to the testing and commissioning period for approval of content, layout and form. Once so approved, a draft copy shall be handed over prior to the issue of the Certificate of Practical Completion. This copy shall contain all testing and commissioning data results, actual control setting points and the like in draft form.

Within 28 days of The date of Practical Completion, 2 copies of the final document shall be handed over which shall include all testing and commissioning results and final plant duties and control settings, etc. in an approved form.

1.12 Approval/Checking Procedures

All Contractors' Drawings and manufacturers' details shall be approved by the Engineer prior to any orders being placed by the Contractor. The final details including all technical aspects and calculations where applicable shall be submitted in a clear, definable and easily read format with the specified technical details, notes and performance data clearly shown in English language.

All correspondence related to the approvals procedure shall be directed to the Engineer through the office of the Architect.

Unless stated otherwise elsewhere the Contractor shall allow 28 working days from the date of receipt by the Architect of the request for Approval of all data and manufacturers details submitted.

1.13 Equipment Guarantees

Plant and equipment guarantees shall commence at the date of Practical Completion and run for a minimum of 12 months after this date. Any costs associated with this requirement shall be met by the Contractor.

1.14 Plant and Equipment Performance Testing

Major plant and equipment shall be tested at the manufacturers' works or in a recognized and approved testing facility to demonstrate performance compliance with the stated and specified duties. Performance testing shall demonstrate but not limited to the following:-

- Full, Partial and Minimum load
- Response to load change
- Efficiency
- Noise levels

The tests shall be conducted to simulate design conditions and all ancillary plant and equipment needed to support the tests together with all instrumentation shall be provided by the Contractor and included in the tender.

Upon successful completion of the performance tests the plant and equipment shall be thoroughly cleaned and returned to its new condition and correctly packaged for delivery to site.

Full test certificate records of the tests shall be issued in duplicate to the Engineer. These tests are in addition to works tests stated elsewhere in the Specification.

The Contractor is to include all costs for the Engineer's attendance at the tests. The Contractor shall notify the Engineer one month in advance of such tests and shall provide within his programme a schedule of works tests visits. The activities to be completed at the visit shall be programmed for approval.

A signed works test document will be submitted to the Engineer on completion of tests before delivery of equipment to site.

2. SCOPE OF WORK

The works to be executed under Electrical Installation include the supply on site, storage, installation, keeping clean, protecting, connection, testing and making improvements where necessary, energizing, commissioning to the satisfaction of the Engineer and handing over to the Employer in serviceable condition the complete installation as herein specified and measured in the Contract Bills of Quantities or as may be directed by the Engineer during the course of the works, and shall include all the necessary materials and equipment which although not expressly specified, are necessary for completing the installation. The rates given in the Bills of Quantities for the Electrical Installation shall include all related builders works and materials that are necessary to complete the electrical installation.

The Electrical Installation comprises the following:

a) Securing 3-phase power supply and connection

b) Supply and installation of three synchronized 500kVA generators complete with 2500A/415V Automatic/ Manual change over switch.

c) Installation of two 2MVA, 415KVA, 50Hz DYn 11 air cooled Transformer having +-2 x 2.5% Tapping Range, with other attachments and accessories as to ABB manufacture or approved equivalent

d) Installation of Main distribution boards and Cables as per drawings.

e) Internal and External Lighting Installations.

f) Small Power Installation. The small Power installation shall be carried out as per the drawings.

g) Lightning Protection Scheme

h) Mains System Earthing

i) Builders Works and making good to the satisfaction of the Engineer.

j) Related Builders Works

3. POWER SUPPLY

Proposed Mains Power Supply

Proposed power supply to the Site shall include provision of two separate high voltage lines to the complex through a high voltage panel switchboard, for improved availability. The works shall also include the installation of two 2MVA transformers so arranged for redundancy and terminated onto an automatic load transfer switch for scheduled switching of the transformers to ensure sustained and uninterrupted power supply.

3.2 Mains Distribution

From the Low Voltage Main Distribution Panel Board, power shall be distributed through sub-main distribution boards appropriately positioned within the hospital complex. From the sub-main distribution boards, power shall be distributed vertically by means of rising mains busbar ducts contained within lockable electrical ducts and horizontally by means of armoured cables terminating on TPN Distribution Boards.

4. LOW VOLTAGE SWITCHBOARDS AND DISTRIBUTION BOARDS

4.1 Low Voltage Switchgear Standards

The transformer and generator shall supply 415/240 Volts Low Voltage supplies to the low voltage switchgear.

All switchboards shall have a minimum fault capacity of 50kA for one second.

The switchboards for the control of equipment rated 415 Volts shall comply in all respects with BS 5486 (IEC 439), BS 5227, BS 7354, BS 88, BS 5424, BS 7340.

4.2 General Requirements for Switchboards

The main low voltage switchboards shall be of modular cubicle pattern, extensible from both ends, of folded sheet steel construction, and floor standing with operation and switch access from the front and cabling access from the rear. The switchboards shall have fully compartmentalised interior sections with withdrawable switchgear and control gear assemblies, with the design based on IEC 439-1 and related international standards. The Main Switch Boards shall be designed for conductor entry from bottom, unless otherwise required.

All switchgear, distribution boards, motor control centres, and other panels shall comprise factory built assemblies of the multi-cubicle type. Each air circuit breaker, fuse switch, busbar, instrumentation and protective relaying section indicated on the drawing shall be housed in a separate compartment with an individual cover, fully divided from adjacent compartments by the sheet metal housing; circuit interconnection, etc, penetrations shall be contained within ductings or shrouded around. The entire switchboard shall be of fully shrouded type. The busbars shall be

coloured according to phase. All equipment shall have fully shrouded fixed contacts and connection terminals, such that contact with adjacent live metal is impossible when working on individual units. All sections of the board shall be suitable for safe, effective working, for maintenance, cable removal and installation, etc., with the switchboard live and without shutting down adjacent sections.

Panels shall be free standing, of uniform height, flush mounted and totally enclosed to not less than IP 31. When size of starters and other components does not justify this type of construction, wall mounted patterns may be used.

The base of the panel shall be effectively sealed against the ingress of vermin and termites, and all equipment shall be rated for continuous operation in a tropical climate.

Any ventilation louvres shall be backed by brass fine mesh gauze to exclude termites.

Framework for the panels shall be of welded construction, and panels shall be fabricated from mild steel sheet of 2mm minimum thickness, folded and braced where necessary to provide a rigid structure.

All bolts, nuts, screws, hinges, handles, etc, shall be corrosion resistant.

Interiors shall be finished white, and the exterior shall be finished to a light grey shade except the plinth, which shall be black.

Cabling access shall be from the rear by means of gasketed bolt-on plates, which shall be fitted with handles to facilitate removal/replacement.

Access to the cubicles or cubicle compartments for all normal routine maintenance shall be from front with hinged and lockable doors fitted with neoprene gaskets (all gaskets shall be termite resistant) and chromium plated lockable tee type handles. All doors shall be electrically bonded to the main frame, using adequate flexible conductors, protected against mechanical damage. All locks on a given panel unit shall be operated by the same key.

Each multi-compartment control panel shall comprise an assembly of individually constructed cubicles. These shall be assembled to include a metallic sheet between adjacent cubicles.

In each multi-compartment panel at least one empty compartment shall be provided for future use. In single unit panels, enough space shall be available for the addition of at least 10% more components for future use.

Panels shall be readily capable of extension at either end, within the bus-bar rating.

Where panel size is excessive, easily handled sections shall be supplied for site assembly. Sections shall be fitted with eyebolts, which after positioning of the panel, shall be removed and replaced with plated bolts and washers.

Bases shall be of rigid construction capable of withstanding stresses during replacement, such as those imposed by moving the sections on rollers.

4.2.1 Bus-bars

All bus-bars shall be of electro tinned HDHC copper, and shall be of uniform section throughout the length of the panel.

They shall be run in a separate screened compartment, divided with barriers into as many compartments as there are cubicles in the panel. Access to individual compartments shall be via bolt-on cover plates, each bearing the legend in white on a red background:-

"DANGER - LIVE BUS-BARS", also the Red Arrow symbol denoting danger from electric shock.

The neutral bus-bar shall be equal to the cross-sectional area of the phase bars. Phase bars shall be colour coded Red, Yellow and Blue: the neutral shall be black.

4.2.2 Over and under-voltage, phase failure and phase sequence protection

The main incoming 415 volt switchboards and control panels shall be equipped with a relay which detects un-acceptably high or low voltage.

It will monitor all phases and will cause all incoming circuit breaker(s) to trip when the voltage exceeds a maximum or minimum (which shall be selected from a range of settings). Visual indication shall be given of the cause of tripping and an electrical hours counter will record the time during which the supply exceeds the set limits.

Resetting of the relay shall be automatic but re-closure of the tripped circuit breaker shall be manual.

It shall be possible to delay the operation of the relay in order to ride through transient voltage variations.

Phase failure shall cause the circuit breaker to trip immediately and incorrect phase sequence will prevent the circuit breaker from being closed.

The Lovato Electronic Voltmeter Relay type RVT manufactured by the Officine Electtromeccanica Lovato of Italy meets the requirements for this application. Alternatives may be offered for the approval of the Engineer.

4.2.3 Surge Voltage Protection

In order to give protection against transient over-voltages or voltage surges such as result from lightning strike, surge arresters shall be installed on the 415 volt bus-bar of the main LV panel.

They shall be connected permanently between each phase and earth and shall be as near as possible to the incoming circuit breakers.

Each unit shall be sealed and encapsulated with connecting tails and be suitable for continuous operation at 415 volts. It shall also comply with the class 2.5KA requirements according to IEC 99.

All solid state control or electronic devices which may be located within the panel, shall be individually protected by surge arresters.

4.2.4 Terminals

Terminal board insulation shall be polyamide or equivalent. Melamine types are not acceptable.

All connectors shall be of brass or bronze, with screw of similar material. Contact between dissimilar metals is not acceptable. No steel screws, plated or otherwise shall be used. Insulating barriers shall be fitted between supplies at different voltages.

All terminal screws shall be captive.

Terminals shall be mounted at least 250mm above their associated gland plates.

Only one conductor shall be connected to each terminal. Multiple connections shall be effected using links.

Main power terminals shall be stud and nut types, with plain and locking washers. Conductors terminating on these shall be fitted with insulated crimped lugs. Rail mounted terminals for cables in excess of 32mm sq. cross-sectional area are not acceptable.

4.2.5 Gland Plates

Adequately sized blank gland plates shall be provided below each outgoing terminal section to accommodate the requisite glands.

Gland plates shall be positioned 200mm minimum above the base of the cubicle, and shall be solidly bonded to earth.

Suitably sized compression type cable glands shall be provided for all cables. Glands used for armoured cables shall include provision for sealing the armour wires to protect them from corrosion and to prevent ingress of moisture into the cable.

Brass lugs shall be provided for connection of the cable armouring to earth.

4.3 Distribution Boards

The Distribution Board is an MCB-type, and shall be supplied at 415Volts, 3 phase from the existing Main Low Voltage Switchboard located at the Main Load Centre house.

General lighting and power distribution boards shall comply with BS 3817, BS 5861 and BS 5486 and shall be of the metal clad pattern, flush mounted except where otherwise specified on the drawings or Bills of Quantities.

4.3.1 Construction

Enclosures shall be substantially constructed from 16SWG minimum thickness sheet steel having hinged front cover and shall be vermin and insect proof. Each unit shall house MCBs and shall be supplied complete with bus-bars, earthing terminal, neutral bar, circuit chart and any blanking plate for any spare ways. The incoming isolator switch shall be integral with the distribution board in consumer's units only, or as may specifically be requested for. The distribution boards shall be lockable by key.

4.3.2 Mounting

All distribution boards and consumer units shall, unless detailed to the contrary, be mounted with the lower edge 1800 mm from the finished floor level.

Notwithstanding the above, generally, switchboards and distribution boards shall be installed so that any item to which easy access is required such as fuse, circuit breaker, instrument, etc is not more than 2150 mm above finish floor level.

Isolators, switch fuses (other than those mounted on bus-bar chambers or providing local control), cooker control units, water heater controls, etc, shall on the other hand, unless otherwise stated on the drawings, be mounted at 1350mm from the finished floor level to the underside of the fittings.

4.3.3 Miniature Circuit Breakers

All distribution boards shall be supplied with MCBs manufactured to BS 3871 and of a rating as specified on the drawings. The circuit breakers shall incorporate both terminal overload and magnetic short circuit tripping, with a trip-free mechanism.

Three phase circuits shall be controlled by integrally manufactured three pole breakers, with one common operating lever. An inter-tripping mechanism shall ensure isolation of all three poles in the event of an overload or short circuit on any one phase.

5. CABLES

All cables shall be BASEC approved. P.V.C. insulated cables shall be 500V/1000V grade to B.S. 6004. Flexible cables shall be 300V/500V grade to B.S. 6500.

No cables forming sub-circuits connected to different sub-distribution boards are to be drawn into the same conduit or draw-in box.

No reduction of the strands forming the conductors will be allowed at switch or other terminals, but all strands shall be efficiently secured by screws, nuts and washers or other approved means.

Cables may be jointed together at the terminals of ceiling roses and other accessories. Under no circumstances will joints be permitted in the run of the cable.

All cables shall be of stranded copper conductors.

The minimum size of cables on lighting and power final sub-circuits shall be 1.5mm sq. for lighting and 2.5mm sq. for power.

5.1 PVC Insulated Armoured Cables

These shall be 500/1000V grade to BS 6346 and BS 6004 having stranded copper conductors, armoured and PVC sheathed overall. The cores of four core cables shall be distinctively coloured red, yellow, blue and black.

5.2 XLPE Insulated P.V.C. Sheathed Armoured Cables

XLPE insulated P.V.C. bedded galvanized steel wire armoured and P.V.C. overall sheathed twin and multicore cables shall have stranded copper conductors, and shall be 600/1000V grade manufactured in accordance with B.S. 5467. This type of case shall generally be treated in a manner similar to that for P.V.C. insulated and sheathed cables.

The Contractor shall provide suitable glands and accessories for all armoured cable terminations and the cost of these items shall be included within the rates inserted in the Bills of Quantities.

5.3 Installation

5.3.1 Laying of Cables

The work of excavating and back-filling of all trenches for cables is included in this contract and the responsibility for positioning, width and depth of trenches, laying and bedding of all cables and protective covers is included with the Electrical Works covered by this Specification. Unless otherwise stated, all underground cables shall be laid in uPVC conduits with draw pits as shall be indicated on the drawings or as may be required by the Site conditions. The uPVC pipes shall be laid to a minimum of 750mm below ground. The uPVC ducts shall be sand bedded to a depth of 50mm below

and above the pipe. The rates inserted for uPVC pipes shall included the costs of sand bedding.

In case it is required to lay cables direct in ground, the following shall apply:-

Where more than one cable is laid in a trench, cables shall be spaced as follows:-

Between MV cables	100mm
Between MV and telephone cables	400mm
Between MV and LV cables	400mm
Between LV and telephone cables	400mm
Between LV cables	100mm

In straight run trenches, cable crossings shall not be permitted except where a cable branches from the main run.

At every draw-in point, joint or junction box, the cable should be snaked.

Before cables are laid, the bottom of the trench shall be evenly graded and cleared of all loose stones and shall then be covered with an 80mm layer of sand or sifted soil and lightly compacted. A further 80mm layer shall be placed on top of the cables.

The approved cable protection shall then be laid and the trench refilled with excavated materials in 200mm layers, each layer being well compacted by hand or mechanical punners before the next layer is filled.

The width of the trench shall be such that a clearance of 80mm shall be provided between the outermost cable and the side of the trench.

Where cables are disposed in more than one layer, the vertical spacing shall be 400mm between centres of cables or cable groups the depth of the trench being made suitable accordingly. Stones or other hard objects shall not be included in any of the backfilling materials.

In the laying of cables in the uPVC ducts, the internal radius of bends shall be six times the overall cable diameter.

The rates inserted for cables shall be deemed to include for the above requirements.

5.3.2 Protective Covers

The protective covers, manufactured in accordance with BS 2484 shall be provided over cables laid in the ground, each complete with an interlocking device to prevent lateral displacement. The rates inserted for cables shall be deemed to include for the protective covers.

5.3.3 Cable Position Markers

These should be placed adjacent to all points where cables change direction and all intervals of not more than 30 metres and at other positions designated by the Engineer.

5.3.4 Sealing of Cable Entries

Where cables enter buildings, pipes, or ducts, the mouths of the pipes or ducts shall be effectively sealed by means of close fitting solignum impregnated wooden plugs and a mixture of compound and transformer oil, or other approved manner.

5.3.5 Protection Against Mechanical Damages

All cables located in such positions where they are vulnerable to damage by mechanical or other means shall be protected by suitable lengths of steel pipe bushed to prevent damage to the cable.

5.3.6 Rating Plates

Each cable when completely erected shall have permanently attached to it at each end in such intermediate positions as may be considered necessary by the Engineer, metal plates upon which is engraved, or stamped, the identification number of cable together with the voltage, size and make-up, and the service which it supplies.

This information shall be recorded by the contractor so that it may appear on drawings of the completed installation.

5.3.7 Cable Sealing and Termination

The contractor shall be wholly responsible for the sealing and jointing of all cables supplied and erected under the contract.

The cable boxes, looping-boxes and glands for LV cables on all items of equipment shall be provided under the contract.

Sealing and jointing shall be in accordance with the best current practice and of first class workmanship. Where cable armouring is used as earth continuity conductor, the glands shall have the necessary contact surface or provide a low resistance path under fault conditions.

The tender shall include for all cable jointing where appropriate and all labour, joining material and compound, together with the use of all jointers' tools and making off the cable tails to the apparatus terminals.

5.3.8 Cabling Details

The contractor shall submit a schedule of all cables, detailing the following for each cable proposed:-

a) Reference Number
b) Type
c) Cross Sectional Area
d) Number of Cores
e) Origin
f) Destination
g) Cost per metre installed
h) Cost for each termination (glanding and making off)
i) Route Length
j) Operating Voltage
k) Estimated Current
l) Percentage Volt Drop

Rate (g) shall be used to assess costs in the event of any agreed route length variation.

The Contract Price shall include all cables required for a fully operational installation and for laying all the cables in accordance with the requirements in Section 5.3 of this Specification.

6. WIRING ACCESSORIES

6.1 Non-metallic conduit

All non-metallic conduit shall be class "A" heavy gauge, high impact PVC complying with BS 4606 Part 2, type AH.

The minimum size to be on the contract is 20mm external diameter. All conduit installations shall be concealed in the walls and floors or in structural slabs.

Conduits shall be kept at least 150 mm clear of gas piping and colour coded orange when required.

Conduits shall be kept at least 150 mm clear of steam and hot water systems and preferably beneath the aforementioned services.

Conduit runs shall be complete before wiring is begun and shall not be dismantled for wiring operations.

Conduit used in flameproof installations shall be of the solid drawn type.

6.1.1 Bends

Bends and sets in the conduit will be made in accordance with the manufacturer's instructions. The radius of the bend shall not be less 2.5 times the outside diameter of the conduit, or such greater radius which will facilitate easy drawing in of cables.

All conduit bends are to be made on site and not more than two right angle bends will be permitted without the interposition of a draw box.

6.1.2 Expansion

Adequate allowance shall be made for longitudinal expansion and contraction of the conduit under normal working temperature variations as follows:-

a) Expansion couplers should be used in straight runs exceeding 6 metres with a loose or flexible type joint at the long spout end of the coupler.

b) Saddles as supplied by the manufacturers shall include a sliding support tolerance for longitudinal expansion.

c) Saddles shall be installed within 300mm either side of conduit boxes where the free length of conduit exceeds this distance.

d) Multiple saddles shall be used where two or more surface conduits run parallel and adjacent to each other.

e) Special consideration may need to be given to the fixing of accessories where this may prevent natural conduit movements. Oversize or slotted fixing holes may be necessary or introduction of expansion couplers.

6.1.3 Conduit Boxes and Fittings

a) All conduit boxes shall be circular or square pattern of rigid PVC suitable for plan connections conforming to sheet 62 BS 4606, Part 2. Boxes supporting a fitting or accessory shall be fitted with a PVC lid held in position by means of two 2BA round headed screws. Boxes shall have metallic screwed inserts.

b) Circular or square boxes shall be provided at all outlet points, unless otherwise specified; lighting fittings, ceiling fittings, ceiling switches and other accessories will be screwed to the internal lugs of the boxes.

   Care must always be taken when considering the use of totally enclosed fittings with PVC circular boxes where the temperature within the box is likely to rise above 60 deg. C (140 deg. F). In this case, special steel insert clips should be used in conjunction with circular boxes where this problem can arise and also in situations where heavy pendants are used.

c) Looping in boxes of circular PVC pattern to sheet 63 BS 4607 Part 2 may be used in such work as dictated by the structure of the buildings. Conduit entry shall be made by means of PVC bushes.

d) Adaptable boxes shall be of moulded or fabricated PVC of square or oblong shape complete with PVC lids secured by 2BA brass or steel plated round-headed

screws. All adaptable boxes and lids of the same size shall be interchangeable. No adaptable box smaller than 75mmx50mm or larger than 300mmx300mm shall be employed. Boxes shall be of adequate depth in relation to the size of conduit entering them.

e) Conduits shall be terminated at adaptable boxes; fuseboards, switches, sockets or other equipment possessing push-in or threaded spouts, by means of appropriate size female adaptor and PVC hexagonal headed male bush. All cemented joints to be made to a depth of not less than the diameter of the conduit being used.

6.1.4 Earth Continuity

Earth continuity shall be provided by a separate insulated conductor drawn into the plastic conduit and rated in accordance with circuit loadings and appropriate Regulations or as mentioned on the drawings.

Where required under the regulations and earth continuity conductor shall be provided for lighting fittings in which case the control switches shall be equipped with an appropriate earth terminal.

6.1.5 Arrangement of Conduit Layout

The conduit system shall be carefully planned and erected to avoid all unnecessary bends or changes in direction. Conduits shall be laid in straight horizontal or vertical lines with easy sets. Where several conduits follow similar routes, they shall be neatly grouped in multiple runs. Where multiple runs change directions, the radii of the sets shall be laid out from a common centre. Where draw-in boxes for right angled change of direction are required in multiple runs, adaptable boxes shall be used for such sizes as to allow all conduits to enter the box with sets.

Where conduits are concealed or laid on structural floors, they shall be secured by a fixed method to be approved by the Engineer. Where it is essential that conduits cross one another in floors, the chases shall be deepened and the conduits set to create the minimum desirable diversion.

Care shall be taken to ensure that there is no obstruction to cables within the conduits caused by the ingress of plaster, concrete or other matter. Conduit ends must be cut square and cleaned of burrs.

6.2 Final Sub-circuit wiring

All power and lighting wiring cables shall be 600/1000V grade, single core PVC insulated, with stranded copper conductors in accordance with BS 6004. The minimum sizes of lighting circuits shall be 1.5mm sq; and ring main circuits shall be 2.5mm sq.

Installation

No reduction of the strands forming the conductors shall be allowed at switch or other terminal, but all strands shall be effectively secured by screws, nuts and washers or other approved means.

Cables shall be joined together at the terminals of ceiling boxes and other accessories. Under no circumstances will joints be permitted in the run of the cable.

6.2.1 Socket Outlets

In all areas, general power outlets shall be of the 13A 3-pin fused plug type complying with BS 1363. They shall be flush pattern, with white or ivory cover plates unless otherwise specified on the drawings. Where the circuits are supplied from a common feed, two outlets shall form a twin unit in a common box. The earthing terminal of every socket outlet shall be connected to the earth continuity conductor of the final sub-circuit by an appropriately sized insulated copper conductor. Unless otherwise stated they shall be mounted at 300mm above the finished floor level or 200 mm above the worktop.

6.2.2 Telephone Outlets

These shall be of the type as specified in the Bills of Quantities, or in the particular specification for telephone work. Unless otherwise specified they shall be mounted at 300mm above the finished floor level or 200 above worktop.

6.2.3 Fused connection units

All fused connection units shall be of the 13A type with fuse and neon indicator lamp. Boxes shall be flush type with white or ivory cover plates and shall be switched type unless otherwise specified on the drawing.

6.2.4 Fuses

All fused connection units shall be fitted with 13A fuses, unless otherwise specified.

6.2.5 Labeling

The front plates of each fused connection unit shall, unless otherwise specified, be engraved with the name of the appliance connected to it.

6.2.6 Lighting Switches

Lighting switches, unless specified otherwise in the Bills of Quantities, shall be of the all-insulated rocker-operating plate-switch type to BS 3676, and shall be of ample rating. Switch inserts shall be white with ivory cover plates.

Switches controlling points in bathrooms shall be placed outside the bathroom, or consist of a ceiling switch operated by a non-conducting cord, as specified. Switches mounted outdoors shall be of a weather tight pattern.

All flush or surface installed switches shall, unless otherwise specified, be mounted at a distance of 1350mm above finished floor level.

Ceiling switches shall on the other hand be positioned at not less than 300mm from the point which they control.

Switches shall be one-way, two-way or intermediate and where a number of switches are mounted together, they shall be fitted in a common box. All lighting switches shall be connected only in the phase line of all circuits.

6.2.7 Lamp Holders

Lamp holders shall generally be of plastic construction with porcelain interiors and bayonet fitting.

Lamp holders for lamps rated 200W and above shall be of the Edison Screw type.

Batten type lamp holders shall be of the all-insulated bayonet type.

6.2.8 3-Phase plugs and sockets

The plugs and sockets shall be 5-pin suitable for 415 volts, 3-phase, 50 Hz with separate neutral and earth pins. They shall comply with BS 4343 and IEC 309 and be protected to IP 44 or better.

The plugs shall be of polycarbonate material but the sockets shall be of aluminium alloy, suitable for conduit connections. The socket shall be surface mounted at a height of 1.25m AFL.

6.2.9 Consumer Units

All consumer units shall be miniature circuit breaker type for flush mounting as specified in the Bills of Quantities. Covers shall be lockable to restrict removal of the miniature circuit breakers. The boards shall be modular type allowing easy rail mounting of other components such as time switches, contactors, etc. without modification.

Cable entry shall be possible from both top and bottom.

6.2.10 Sub main Power Distribution

Sub-main cables will distribute power from the main switchboards and from the sub-main boards to the consumer units.

Cables shall be routed as per drawings or Engineer's instructions on site. But allowance for cable passage (pipes or ducts, etc) shall be put in place at the earliest possible stage of construction to avoid having to cut walls, floors, roads etc.

6.2.11 Power Installation

All power installations shall be concealed in floors, walls and in space above the false ceiling. However, in offices power installations shall be in three compartment PVC trunking mounted at 300mm above the finished floor level (AFFL). Socket outlets shall be mounted at 300mm AFFL and isolators for various equipment at 1350mm AFFL.

Medical service trunking shall be provided above all the patient beds. The trunking shall be finished with powder coat to RAL 9016 complete with 2 wiring compartments, 1 gas compartment, 3 gang gas mounting plates per patient's bed compartible with standard UK wiring and data accessories, as Marshall Tufflex Conquest or approved equivalent.

6.2.12 Lighting Installation (Internal)

All lighting installations shall be concealed in the walls, space above the ceiling and in floors. All light fittings shall be as specified under individual items of the Bills of Quantities. All fittings shall be complete with all the necessary accessories for proper fixing or mounting. All light switches shall be installed 1350 mm AFFL

6.2.13 Cables and Wires

All cables and wires to be used in the Electrical Installation shall be of stranded copper conductors.

All cables for outdoor installation as well as sub-main cables installed indoors shall be XLPE-SWA-PVC or PVC-SWA-PVC as specified in the Bills of Quantities. Proper glands shall be used for termination.

Unless specifically indicated otherwise, no conductors smaller than 1.5mm^2 shall be used for any purpose.

All conductors for ring main circuits shall not be less than 2.5mm^2.

Generally, sizes of conductors for the various circuits will be shown on circuit drawings.

6.2.14 Fixing/Mounting of Accessories, Fittings, etc

All screws, brackets, saddles, etc used for fixings shall be of galvanized steel or other non-rusting material of equal strength.

Switchboards, distribution boards, consumer units and all other items of excessive weight or subject to heavy use, shall be fixed with properly sized non-rusting expansion bolts.

7. LIGHTING FITTINGS

Luminaires shall comply with BS 4533 and emergency lighting luminaires shall comply with Industry Standard and shall be marked with certification label and shall be installed as indicated on the drawing and the Bill of Quantities.

Tungsten filament lamps shall be of the general service type in accordance with IRR BS 161 and fluorescent lamps shall comply with BS 1853.

The Contractor shall include for the provision of handling, taking delivery, safe storage, wiring, assembling and erecting of all lighting fittings as specified. All means necessary to protect electrical materials and fixtures during transport and before, during and after installation shall be provided to ensure that no damage occurs to the materials or their surfaces. Electrical fixtures shall be supplied in their original packing.

All pendants fittings shall be fixed to conduit boxes with brass screws. Lighting fittings detailed for the purpose of establishing a high standard of finish shall under no circumstances be substituted without prior approval of the Project Manager.

In case of rectangular shaped ceiling fitting the extreme ends of the fittings shall be secured to suitable support in addition to the central conduit box fittings. Supports shall be provided and fixed by the contractor.

The whole of the metal work of each lighting fittings shall be effectively bonded to earth. Where ball and/or ankle joints are not made by the manufacturers, the contractor shall include cost of additional work necessary in his tender. Minimum size of internal wiring shall be 1.5 mm squared. Each lighting fitting shall be provided with the number, type and size of lamps as detailed in the specifications.

Self-contained emergency lighting luminaires shall be of the non-maintained type self contained and equipped with an 8W fluorescent tube and shall be fitted with a means of testing which shall comprise a push-button or similar device that cannot be left in the test position. They shall be provided with a means of isolating the lamp circuit for maintenance purposes.

Unless otherwise indicated, fixed luminaires shall be Class I and hand lamps shall be Class III rated at 50 volts.

Unless otherwise indicated, enclosure to luminaires shall provide a minimum degree of protection of IP20 when located within buildings and IP23 when located outside buildings, but luminaires mounted externally and less than 2m above finished ground of paved level shall be IP44.

The Contractor must order the appropriate type of lamp holder in ordering lighting fittings, to ensure that the correct lamp holders are provided irrespective of the type normally supplied by the manufacturer.

Lampshades shall be of the extra heavy duty and shall be provided for every specified lighting fitting. They shall be heavy brass type (except for plain pendants where reinforced bakelite type shall be used).Lampshades are supported by flexible cable, the

holders shall have “Cord grip” arrangements and in the case of metal shades earthing screws shall be provided on each of the holders.

8. FIRE DETECTION AND ALARM SYSTEM

The works shall include supply and installation of the fire detection and alarm system elements complete with fixing accessories of the Menvier / GENT intelligent addressable fire detection system or approved equivalent.

The system components shall be Loop wired using using 2-core fire resistant OHLS 300/500V stranded copper cables.

The works shall also include preparation of 3 Sets of Hard and Soft Copies of "As-Built" Drawings, Manuals, Testing and Commissioning the System to the Satisfaction of the Engineer.

9. EARTHING

9.1 General Installation Earthing

a) Earth electrodes shall be minimum 1200mm long by 15mm diameter hard drawn copper rod, and shall be located at a convenient position as close as possible to the building. The terminal head of each electrode shall be in a concrete inspection pit, with cover. If the resistance to earth is not satisfactory with one electrode, then additional electrodes or an earth mat shall be provided as directed by the Engineer.

b) Particular attention should be given to conduit and trunking installations to ensure that the earth continuity is reliable and permanent.

c) All apparatus or parts thereof not solidly connected to the earthing system shall be connected thereto in an approved manner by solid copper conductors secured by means of substantial bonding clamps.

d) All services entering the installation at earth potential shall be efficiently bonded to the main earth point.

e) All joints in the earth system shall be made with solder less connectors, or by an approved brazing method.

f) The resistance of the earth continuity system when measured between the main earth point and any other point in the installation, including all metalwork, which may provide a path to earth, such as gas, water pipes, etc, shall not exceed 0.5 ohms.

g) All flexible metallic tubing shall have a bare earth conductor run with the tubing, the ends being securely bonded. The size of the earth conductor shall be as indicated in the current edition of the IEE Regulations.

h) Care should be taken that the neutral conductor does not become accidentally earthed.

i) In accordance with the UEDCL's procedure of multiple neutral earthing, the neutral of the supply is to be bonded to the earth pipe. The mechanics of bonding will be performed by an official of the UEDCL.

j) Earthing shall conform to the 16th edition of the IEE Regulations.

9.2 Distribution System Earthing

All distribution boards shall be earthed in accordance with the IEE Regulations. All metalwork associated with the installation shall be earthed to comply with the Regulations currently in force.

9.3 Lightning Protection

Lightning protection systems in accordance with the requirements of BS 6651/1992 shall be installed. This shall incorporate air terminals down conductors and an earth terminal.

Lightning protection installation shall, in general, consist of copper or aluminium tapes of 25mm x 3mm section with similar clips, test clamps and copper bond earth rods, which shall be mounted in positions in conformance to the 16th edition of the IEE Regulations and as per Standard Code of Practice.

Earth roof tape shall be provided with a similar copper or aluminium down tape to the earth test position and from the earth test position to the earth electrodes enclosed in concrete earth pits.

The earth resistance of the completed system shall in no circumstance exceed 10 ohms. If this value cannot be obtained by means of a single earth electrode, extra rods may be used in parallel and the Contractor should provide for such an eventuality when pricing.

10. STANDBY GENERATORS

There will be two synchronized 750kVA / 415V / 50Hz standby generators permanently installed to provide part of the electricity requirements of the project in case of mains failure however the client may opt to supply it.

Incoming circuit breakers shall be included in the 415 V Main Low Voltage Switching Panel and shall be mechanically interlocked with the circuit breakers for the Electricity Supply Corporation of Malawi (ESCOM) mains supply, so that both supplies cannot be connected simultaneously.

10.1 Particular Specification for the Generator Set

Scope
Supply and transport to site as indicated in the drawings. install and commission the generator sets as per Specification here-below. All ratings are for 40 deg C ambient temperature, 1312 metres altitude above sea level and 66% average relative humidity in accordance with BS 5514. The tenderer shall also state the applicable warranty period for parts and labour.

Engine
Radiator cooled heavy duty diesel continuously rated to BS 5514 with sufficient power capacity to supply 10% over base load in one hour in every twelve hours.

Cooling Radiator
Tropical capacity with engine driven fan complete with protection guards. Radiator shall cool the engine at rated output in ambient temperature up to 52 deg. C.

Engine Filtration
Air - Heavy duty dry type filters with replaceable elements.
Fuel - Filter with replaceable element
Lubrication - Oil filter with replaceable element

Engine Protection
Emergency automatic shutdown facilities for:-

(a) Low oil pressure
(b) High water temperature
(c) High oil temperature
(d) Low radiator water level

Heavy duty residential type exhaust silencer system for installation on site. Noise level better than 40dB (A) at 20m from the generator set. 12/24V starting system complete with high capacity lead acid starting batteries rack mounted on machine base frame, heavy duty interconnecting cables with terminals and direct battery charging system.

Coupling Arrangement
Main drive flexible coupling with flange coupling of engine and alternator.

Base
Generator set and radiator to be mounted on fabricated base frame with a diesel tank, anti-vibration mounting pads positioned between the set and the base frame.

Diesel tank
To be of sufficient capacity for at least 8 hours continuous operation at rated output. Fittings to include fuel fill point, fuel gauge, breather, drain plug and flexible fuel lines.

Alternator

Brush less, revolving field, self regulating, self exiting, screen protected, foot mounted, with grease lubricated end shield bearings continuously rated as specified in the Bills of Quantities, with over load (standby) capacity of at least 10% for one hour in twelve to IEC 34-1, BS 5000, BS 4999/40.

Voltage Regulation
By Automatic Voltage Control via main exciter with a regulation of +/- 1.5% for 0.8 power factor up to unity power factor loads, and 5% speed variations.

Automatic Mains Failure Control
Mains voltage sensing relay with mechanical-electrical interlock changeover MCCBs of appropriate rating. Constant voltage battery charger with charge rate ammeter.

Adjustable timers for engine start/engine stop/ load transfer and 3 attempt start to allow for normal fluctuations in supply.

Duty select switch: Off/manual/auto/test indicating lamps for mains on load/generator on load/mains available. Voltmeter with single or multi-position selection switch as applicable.

3 ammeters

50Hz frequency meter (suitably sealed)
Individual fault indication lights

Battery condition indicator

Hours run recorder

Installation
The price shall include for installation and commissioning complete and ready including installation and maintenance tools and manuals.

Documentation
Operation and Maintenance manuals for engine, alternator, circuit wiring diagrams and factory test sheets will have to be supplied.

Manufacturer's specification for engine and alternator to accompany tender.

Spare Parts
Standard spare parts kit for 2500 hours operation of the set should be included in the tender price.

11. TESTING AND INSPECTION

11.1 Testing of Earthing System

The resistance of the earth continuity system, when measured between the main earthing point and any other point in the installation, including all conduit and metal work which may provide a path to earth, shall not exceed 0.5ohms where steel conduit forms part or whole of the system, or 1.0 ohms if the earth continuity system is composed entirely of copper, copper alloy or aluminium. The Contractor is expected to allow for any necessary additional materials required to achieve the above resistance values.

11.2 Installation Testing

After completion and before commissioning, the entire installation shall be subjected to the following tests and any faults found shall be rectified by the Contractor at no extra cost.

Polarity
All fuses and control devices shall be connected in live conductors only.

Insulation Resistance
When tested with a 500V DC supply, the insulation resistance between conductors of live lines, lines and neutral, line and earth, neutral and earth shall not be less than 1 mega-ohm.

Earth Continuity Resistance
Resistance of earth continuity measured from a control pillar to the farthest end of a circuit shall not exceed 0.5 ohms.

In addition to the above, the following tests and inspection shall be carried out where applicable:-

i) Phase rotation
ii) Earth loop impedance
iii) Operation of over current and earth fault relays by injection test.
iv) Operation of all other protective relays and devices.
v) Levels of illumination.
vi) Correct sequencing of all control equipment.
vii) Visual inspection

The Engineer shall be given full opportunity to witness all tests and shall approve all test results.

The Engineer shall have the right to ask for specific tests to be repeated.

12. COMMISSIONING AND SYSTEM DEMONSTRATION

The whole installation shall be tested to the statutory requirements of the Malawi Wiring Regulations and commissioned in the presence of and to the satisfaction of the Engineer.

Four copies of test reports shall be provided within seven days of carrying out the test; and the reports shall include full details of how each test was carried out and a copy of all readings taken. These shall include in the Operating and Maintenance Manuals as stated elsewhere in the Specification.

Subsequent to the completion of all testing and commissioning to the approval of the Engineer, prior to the date of issue of the Practical Completion Certificate, the Contractor, when required by the Engineer, shall operate the plant and demonstrate that the overall systems function automatically correctly in accordance with the requirements of this Specification. A period of at least one week's full running and operation including cost of fuel and other input shall be considered reasonable for this demonstration and shall be included in the Contractor's price inserted in the Tender documents. During this period the Contractor shall be responsible for the operation and maintenance, if applicable, of the plant and may if appropriate, use this time to instruct the Employer's staff in the operation and maintenance of the systems. The Contractor will provide an operational report of the demonstration.