

PROJECT SPECIFICATION

Construction of shed for Diesel Generator, including connecting of generator to the electrical powerline in Kikla Hospital and Kikla University, Libya

Material & Commissioning of Generators in Kikla DG Hospital & University



UNDP Libya

2017

9 ELECTRICAL

9.1 ELECTRICAL SERVICES**9.1.1 GENERAL****9.1.1.1 AIMS****Responsibilities**

Provide electrical systems in conformance with the **Electrical Systems Schedule**.

Qualification

Use only persons appropriately experienced and qualified to undertake the electrical design and construction work on the systems documented.

Performance

Carry out verification tests and measurements to show compliance with the specification.

Rates for installation work

Rates for installation of cabling, light fittings, sockets, switches and all other electrical components are to include allowance for fixings, connection, chasing of wiring and any other works required for the installation of the electrical system to a fully operational and safe working condition.

9.1.1.2 Inspection**Notice**

Give sufficient notice so that inspection may be made of the following:

- Underground electrical services conduits prior to concealment.
- Above ground electrical services conduits in walls prior to concealment.
- Switchboards prior to installation.

Inspection and testing on completion

To verify that the requirements of this specification have been met, all electrical installations and any alterations, additions or repairs to an existing electrical installation, after completion and before being energised shall be:

- Inspected as far as is practicable
- Tested

Precautions shall be taken to insure the safety of persons and to avoid damage to property and the electrical installation equipment during inspection and testing.

NOTE: if requires, the contractor is responsible to provide temporary power generator in order to undertake all needed testing.

A visual inspection shall be made when work on an electrical installation has been completed in order to verify that the work complies with the requirements of this specification. The visual inspection shall be carried out before, or in association with testing and shall where practicable be made before the relevant part of the electrical installation is placed in service. Visual inspections shall be carried out prior to the completion of the installation where that part of the electrical installation will be covered by following works.

The following items provide a guide to the matters to be checked during the visual inspection to assess that the relevant requirements of this specification have been met.

General:

- Protection against direct contact with live parts e.g. Insulation and enclosure.
- Protection against indirect contact with exposed conductive parts, e.g. Double insulation or isolating transformers.
- Protection against hazardous part, e.g. Enclosure, guarding or screening of flammable materials, hot surfaces and parts that may cause physical injury.
- Protection against spread of fire, e.g. Penetration of fire barriers.

- General condition of the electrical equipment, e.g. Signs of damage that could impair safe operation, disconnection of unused electrical equipment.

Consumers Mains:

- Current carrying capacity.
- Voltage drop.
- Underground installation conditions, e.g. Enclosure, depth of burial and mechanical protection.
- Aerial installation conditions.
- Connection of wiring.
- Protection against external influences.

Switchboards:

- Location, e.g. Access and egress.
- Protective devices, e.g. Overload and residual current rating, fault current rating.
- Isolating devices, e.g. Main switches.
- Connecting devices, e.g. Neutral bars, earth bars and live links.
- Connection and fixing of wiring and switchgear.
- Identification and labelling of electrical equipment.
- Protection against external influences.

Wiring systems:

- Conductor size, e.g. Current-carrying capacity and voltage drop.
- Identification of cable cores.
- Adequate support and fixing.
- Connections and enclosures.
- Particular installation conditions, e.g. Underground, aerial and emergency systems.
- Segregation from other services and electrical installations.
- Protection against external influences, e.g. Enclosure.

Electrical equipment:

- Isolation and switching devices for protection against injury from mechanical movement devices and motors.
- Isolation and switching devices for protection against thermal effects, e.g. Motors, room heaters and water heaters.
- Switching devices for particular electrical equipment, e.g. Socket outlets and cooking appliances.
- Particular installation conditions, e.g. Locations affected by water, explosive atmospheres, extra low voltage and high voltage.
- Compliance with required standard.
- Connection, support and fixing.
- Protection against external influences.

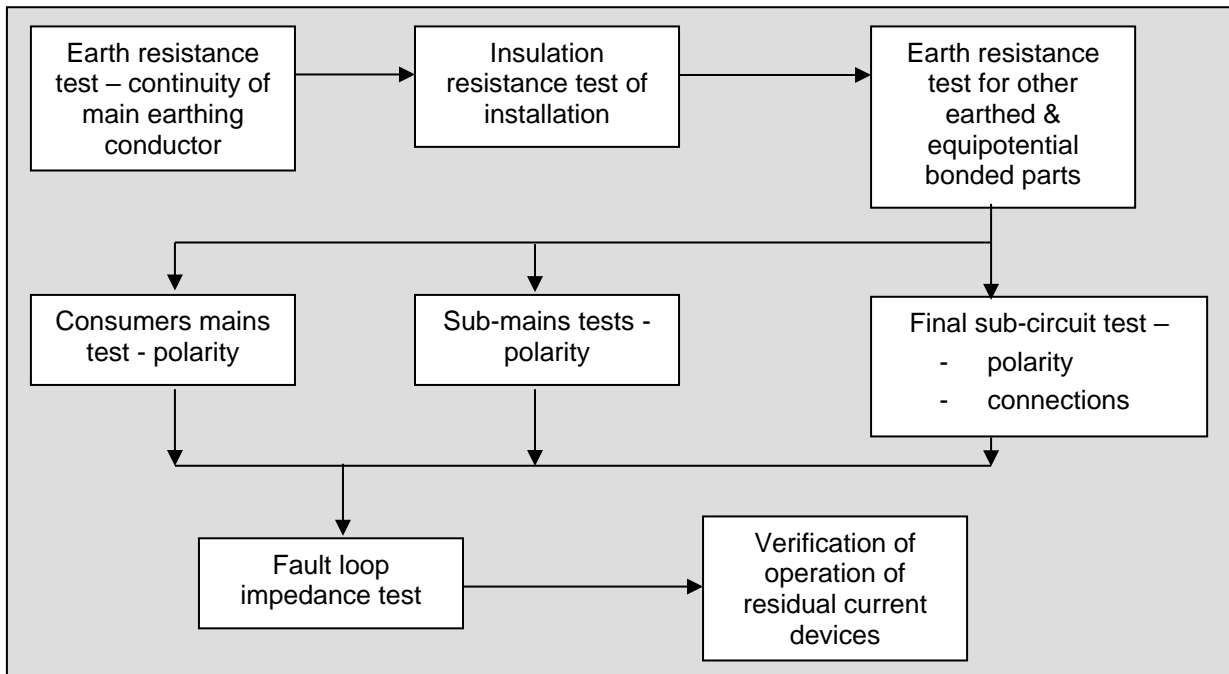
Earthing:

- Multiple earth neutral (MEN) connection.
- Earth electrode.
- Earthing conductors, e.g. Size and identification.
- Equipotential bonding conductors, e.g. Size and identification.
- Connections, joints and terminations.
- Protection against external influences.
- Connection to earthing arrangements for other systems.
- Creation of earthed situation that may require earthing of additional electrical equipment.

Testing:

After completion of, or in association with the visual inspection tests, testing shall be carried out on the electrical installation to verify that it complies with their requirements of this specification and that it is suitable for the use intended.

Sequence of tests as noted:



9.1.2 EXECUTION

9.1.2.1 GENERAL

General

Arrangement: Arrange services so that services running together are parallel with each other and with adjacent building elements.

Installation: Install equipment and services plumb, fix securely and organise reticulated services neatly. Allow for movement in both structure and services.

Lifting: Provide heavy items of equipment with permanent fixtures for lifting as recommended by the manufacturer.

Suspended ground floors: Keep all parts of services under suspended ground floors > 150 mm clear of the ground surface. Make sure services do not impede access.

Samples

Samples: Provide samples of all accessories and light fittings for the approval of the Engineer prior to use in the project.

Installation of accessories

General: Install accessories in conformance with the Installation of accessories table.

Flush mounting: Provide flush mounted accessories except in plant rooms.

Mounting heights: To on-site direction

Restricted location: Do not install wall boxes across junctions of wall finishes.

Surface mounting: Proprietary mounting blocks.

9.1.2.2 Installation of Accessories Table

Wall construction	Installation and concealed cabling facilities
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Rendered brickwork partition	Flush wall box with conduit chased into wall
Double sided face brick partition	Vertically mounted flush wall box with conduit concealed in cut bricks
Concrete wall or slab	Flush wall box or flush mounted outlet with thermoplastic insulated cables in conduit integral with slab. Do not chase into concrete walls without obtaining approval from the Engineer.

Installation of ceiling mounted appliances

Connections: Provide flush mounted outlets on the ceiling next to support brackets.

Fixing: Provide support brackets fixed through ceiling to the building structure. Brace appliances that have excessive bending moments, are heavy or vibrate, to prevent horizontal movement.

Electrical installations

- All cabling and wiring is to be installed in approved PVC conduit or within a metal cable tray for horizontal runs within the ceiling. there will be no exceptions. Any cabling installed otherwise will be removed and replaced correctly at the contractor's expense. All below ceiling level electrical circuits are to be installed in surface mounted conduits.
- International standard connectors (chocolate block) for the wiring and cabling are to be used for all connections, no other method is acceptable.
- All IP ratings given refer to Ingress Protection (IP) Codes to AS1939.

NOTE: Simple twisting of wires as a means of connecting wires and cables with protective electrical tape is not acceptable.

Earthing/Grounding

- All installed electrical fixtures and fittings are to be earthed to the main earth system for the facility, there are no exceptions to this requirement.
- All protective earthing conductors should be incorporated in the same wiring enclosure as the associated live conductors or in the adjacent vicinity.
- Where a 'clean' earth is specified for a particular item of electrical equipment, the manufacturer of the electrical equipment shall be consulted in order to confirm the necessary arrangements.
- Precautions shall be taken against the risk of damage to the earthing arrangement and other metallic part of the electrical installation through electrolysis or galvanic action.
- The size of an earthing conductor shall be such that it meets the requirements of the IEC regulations and is in accordance with the Earth conductor size table.

Earth Conductor Size Table

Nominal size of live conductor (mm ²)	Nominal size of copper earthing conductor (mm ²)	
	With copper live conductors	With aluminium live conductors
1	1*	-
1.5	1.5*	-
2.5	2.5	-
4	2.5	-
6	2.5	2.5
10	4	2.5
16	6	4
25	6	6
35	10	6
50	16	10

70	25	10
95	25	16
120	35	25
150	50	25
185	70	35
240	95	50
300	120	70
400	120	95
500	120	95
630	120	120

* These earthing conductors may be used only where incorporated in a multicore cable or flexible cord.

9.1.2.3 LOW VOLTAGE POWER SYSTEMS

General

Provide a complete operational low voltage power system, comprising the following and to the Electrical supply mains **and** Electrical switchboard design schedules:

- Supply from mains power
- Metering.
- Consumers mains and switchboard.
- Submains and sub boards.
- Final sub circuits.

Submissions

Technical data: Submit documentation to fully describe the proposed installation. As a minimum provide:

- Submain cable routes and support or enclosure method.
- Switchboard cupboard layouts including risers.

Accessories

Provide the following and to the Power accessories **and** Lighting control and fittings schedules:

- General power outlets.
- Isolating switches.
- Three phase outlets.
- Ceiling mounted sweep fans
- Duct heaters
- Wall, window or roof mounted exhaust fans
- Light switches
- Light fittings
- Emergency lighting and exit signs
- Other equipment as identified in the Schedule

Junction and terminal boxes

Shall be manufactured from PVC and rated to IP56. They shall come complete with a rigid PVC cover attached by means of screws.

Switches

All switches are to be manufactured in compliance with international standards IP24. rate is to include allowance for installation of switches recessed into the wall. Switches are to be installed in locations as shown on the drawings.

Wiring systems

Selection: Provide wiring systems appropriate to the installation conditions and the function of the load. All wiring quality to be approved by the Engineer before installation commences.

Power cables

Copper cable generally, multi-stranded except for MIMS. All cabling is to be manufactured to international standard (BS 5467 or BS 6500) and meet all appropriate safety and performance requirements.

Minimum size:

- Lighting sub circuits: 1.5 mm².
- Power sub circuits: 2.5 mm².
- Submains: 6 mm².

Voltage drop: Install final sub circuit cables within the voltage drop parameters dictated by the route length and load.

Dummy load tests

Where electrical tests are required and the actual load is not available, provide a dummy load equal to at least 75% of the design load.

9.1.2.4 SWITCHBOARDS

General

Provide proprietary switchboards to the following and to the Electrical switchboard design schedule:

- Main switchboard.
- Distribution boards.

Distribution boards shall be constructed from steel with a lockable door. Boards shall be sealed to meet a rating of IP56. All cable entry and exit points shall be constructed using suitable sized, proprietary PVC cable glands.

Statutory authority's equipment

Refer to local supply authority service rules to determine their requirements. Install equipment supplied by the statutory authority, and provide wiring to complete the installation.

Cable entries

Single core cables rated > 300 A: Arrange to minimise eddy currents.

Construction

Fixing: Before making interpose connections, fix assemblies and metering equipment enclosures into position, level and plumb.

Cable entries: Neatly adapt one or more cable entry plates, if fitted, to accept incoming cable enclosure. Provide the minimum number of entry plates to leave spare capacity for future cable entries. Do not run cables into the top of weatherproof assemblies.

Single core cables rated > 300 A: Pass separately through non-ferrous gland plates. Do not provide metal saddles.

Cable enclosures: Continue cable enclosures to or into assemblies and fit cable entry plates so that the IP rating of the assembly and the fire rating of the cable are maintained.

Cable supports: Support or tie mains and submains cables within 200 mm of terminations.

9.1.2.5 SWITCHBOARD COMPONENTS

Switch-isolator and combination fuse-switch units

Rated current: To suit unit installed in enclosure.

Rated fault capacity: Provide units selected for short-circuit making capacity that is at least the fault level at assembly incoming terminals.

Breaking capacity: At least the rated full load current.

Rated duty: Uninterrupted in non-ventilated enclosure.

Operation: Independent manual operation including positive 'ON/OFF' indicator.

Locking: Provide for padlocking in the 'OFF' position.

Handles: Removable only when switch is in open position.

Fuse links: Isolated when switch contacts are open.

Moulded case and miniature circuit breakers

Moulded case breakers to International Standards.

Miniature circuit breakers to International Standards

Fault capacity > 10 kA circuit breakers to approval of Engineer

Fault capacity < 10 kA, current rating < 100 A: Miniature overcurrent circuit breakers

Mounting: Mount circuit breakers so that the 'ON/OFF' and current rating indications are clearly visible with covers or escutcheons in position. Align operating toggles of each circuit breaker in the same plane.

Clip tray chassis: For miniature overcurrent circuit breakers provide clip tray assemblies capable of accepting single, double, or triple circuit breakers, and related busbars. Provide moulded clip-on pole fillers for unused portions.

Residual current devices

Integral type: Incorporate earth leakage in circuit breaker protection operation.

Maximum tripping current: 30 mA.

Fuses with enclosed fuse links

Standards: To International Standards

Fault level: Provide fuses suitable for the fault level at the assembly, and which discriminate with other protective equipment.

Let-through energy and peak cut-off current: To suit protected equipment.

Fuse-holders: Mount fuse-holders so that fuse carriers may be withdrawn directly towards the operator and away from live parts. Provide fixed insulation which shrouds live metal when the fuse carrier is withdrawn.

Barriers: Provide barriers on both sides of each fuse link, preventing inadvertent electrical contact between phases by the insertion of screwdriver.

Fuse links: Enclosed, high rupturing capacity type mounted in a fuse carrier. If necessary for safe removal and insertion of the fuse carrier, provide extraction handles. Mount on clips within the spares cabinet.

Identification: Clearly indicate manufacturer or distributor.

Contactors

Standard: To International Standards.

Rated operational current: Full load current of the load controlled.

Minimum rating: 16 A.

Mounting: Mount with sufficient clearance to allow full access for maintenance, removal and replacement of coils and contacts, without the need to disconnect wiring or remove other equipment.

Interconnection: Do not connect contactors in series or parallel to achieve ratings.

9.1.2.6 LIGHTING

General

Provide a complete operational lighting system, tested and commissioned.

Proprietary equipment: Provide only proprietary lights, fittings and accessories.

Modifications and refurbishing: Carry out to the original manufacturer's standards.

Lamps

Lamps: Provide all lights complete with lamps and accessories.

Verify operation: Install lamps in all lights and verify correct operation before completion

Low voltage lamps: Provide lamps strictly in accordance with the light manufacturer's recommendation.

Dichroic lamps: Provide dichroic lamps with integral reflector which match the design specification.

Lighting Control System

Provide the following and to the Schedules:

- Lighting switches.
- Dimmers.
- Automatic control systems.
- External light fittings.
- Internal light fittings.

Documentation: Provide complete technical and operational documentation for the lighting control system where installed.

Installation

Supports: Mount lights on proprietary supports by means of battens, trims or packing material to suit location.

Completion

Verify the operation of all lights.

9.1.2.7 EMERGENCY EVACUATION LIGHTING

General

Provide a complete operational emergency evacuation lighting system, tested and commissioned to International Standards.

Single-point system lights

Visual indicator lights: Provide a red indicator, readily visible when the light is in its operating location, which indicates that the battery is being charged.

Inverter system: Provide protection of the inverter system against damage in the event of failure, removal or replacement of the lamp, while in normal operation.

Local test switches: Provide a momentary action test switch, accessible from below the ceiling, on each fitting to temporarily disconnect the mains supply and connect the battery to the lamp.

Common test switches: Provide a common test switch on the distribution board which disconnects main supply to the lights and tests for discharge performance, after testing, this switch must automatically revert to normal operating mode.

Batteries

Type: Lead-acid or nickel-cadmium batteries capable of operating each lamp at its rated output continuously at least 2 hours during completion tests and 1.5 hours during subsequent tests.

Battery life: At least 3 years when operating under normal conditions at an ambient temperature of 25°C and subjected to charging and discharging at 6 monthly intervals.

Marking: Indelibly mark each battery with its date of manufacture.

Power supply to single-point systems

Provide an unswitched active supply to each fitting and exit sign, originating from the test switch control panel.

9.1.2.8 TELECOMMUNICATION CABLING

General

Provide a complete operational telecommunications cabling system, tested and commissioned to International Standards. Provide accommodation for telecommunications cabling infrastructure complying with relevant clearance requirements from power cable distribution systems.

Include the following and to the Telecommunication equipment schedule:

- Building distributor.
- Backbone cabling.
- Floor distributors.
- Consolidation points.
- Equipment racks and patch cords.
- Horizontal cabling.
- Telecommunications outlets.
- Fly leads.

Equipment racks

Type: 19-inch rack.

Free standing racks: Provide adjustable feet.

Modular connector patch panels

Terminations: Terminate directly to the modular connector.

Patch cords: Terminate cord ends with appropriate registered jacks.

Optical fibre termination panels

Break out trays: Provide fibre optic cable break out trays at each group of fibre optic cable terminations.

Loom cables: Neatly loom cables and lay stripped cables into the break out tray.

Secure cables: Ensure that cables are secured by the sheath and that there is no stress on the fibre optic cores.

Patch cords

Provide terminated patch cords for 60% of the total incoming and outgoing ports used.

Records

Record book: Provide a record book at each cross connect.

Records in pencil: Complete the records in pencil for each termination and jumper, providing origin and destination and type of service.

Location: Secure log books in each distribution frame records holder.

Cable separation

Low voltage cables: Separate telecommunications cables not enclosed in conduits or ducts from low voltage services by at least 150 mm.

Electromagnetic interference (EMI): Provide clearance to minimise the effect of EMI where communications cables are installed parallel and adjacent to power cables carrying loads in excess of 200 A.

Installation

Crossover: Install cables neatly and without crossovers between cables.

Loom size: Loom cables into groups not exceeding 50 cables, and hold looms in place using reusable cable ties at least 20 mm wide. Do not exert compressive force on the cables when installing cable straps.

Telecommunications outlets

Outlets: Provide RJ45 8 way modular jacks except where documented otherwise.

Pinouts: The pinouts vary with the application. Determine required pinouts before making cable terminations.

Fly leads

Provide minimum 2000mm long fly leads to 50% of the outlets installed.

Earthing system

Communication earth system (CES): Provide a communications earth terminal (CET) associated with the local protective earth (PE) system adjacent to each electrical distribution board.

9.1.2.9 AUTOMATIC FIRE DETECTION**General**

Provide a fully operational system, tested and commissioned in accordance with International Standards.

Base station monitoring system connection

Connection: Connect the installation to the fire alarm monitoring base station via telecommunication carrier lines where identified in the **Fire detection equipment schedule**.

Installation wiring

Conductor size: > 1.5 mm² TPI 220 V rated, with red and white insulation.

Sheathing: Red.

Fire indicator panels

Provide metal cubicle-type enclosures to locations identified on drawings.

Detectors

Provide the following detector types as indicated on the drawings:

- Point type heat detectors.
- Duct sampling units.
- Integral heat detector/alarm units.
- Point type smoke detectors.
- Integral smoke detector/alarm units.

Self-indicating detectors

Provide a light emitting diode mounted in a clearly visible position, which illuminates whenever detector operation causes an alarm condition to register on the fire indicator panel. Provide self-indicating devices which, if faulty, will not render the detector inoperative under fire conditions.

Mounting positions of light emitting diodes:

- Visible detectors: On the outside of the detector or its base.
- Detectors concealed above ceilings: On the underside of the ceiling immediately below the detector.
- Detectors in other concealed spaces: On a visible panel close to the entry to the concealed space housing the detector.

Installation

Install detectors so they can be easily inspected and tested in situ, and readily withdrawn for service.

Control facilities

Provide ancillary control device circuits and connections for automatically controlling and releasing magnetic door holders to operate the relevant fire doors under fire alarm conditions.

Fire fan control and indication panels

Provide fire detection and alarm signals for the fire fan control panel to be incorporated by mechanical services.

9.1.2.10 ACCESS CONTROL

General

Provide a complete operational access control system, tested and commissioned in accordance with International Standards as applicable. Refer to the **Access control equipment schedule**.

Processors or panels

Capacity: Provide separate entry/exit control modules for each designated door.

Users: Program the system to match the number of authorised users with unique access codes.

Time zones: At least 3 per day, with provision for weekends and public holidays.

Door control devices

Provide electric strikes, electric locks, drop bolts, or similar devices to suit door construction and hardware.

Fail-safe: Connect door control devices in a fail-safe mode to permit exit in the event of power failure.

Authorised products: Provide equipment approved for use by the Engineer.

Double leaf doors (solid frame): Provide an electric strike or lock on the fixed leaf, connected to the door frame by concealed flexible wiring.

Activation

Provide keypads, card readers or other activation devices, and locate next to entry points.

External: Provide weatherproof (IP56) hoods or housings for external units.

Mounting height: 1200 mm from floor level.

Vehicle control

Vehicle access control: Provide a vehicle access control system combining connection to vehicular doors and boom gates, and interconnection to the main access control system.

Exit Loop detection: Provide a buried loop detection system adjacent to the exit point to activate boom gates or vehicular doors on approach by a vehicle. Connect so that doors or gates close after a pre-set time.

Interlock: Provide a photo electric beam safety interlock.

Interlock function: To prevent door or gate from closing until the vehicle has cleared the exit point.

Push-buttons and readers: Where practicable, provide direct wall mounting for push-buttons or readers; otherwise provide a mounting bollard and extension arm.

Mounting height: 1000 mm from floor level.

Reed switches: Provide heavy duty reed switches on both sides of vehicle doors, which generate a door closed indication at the control panel.

Intercom

Base station: Provide an intercom base station at each external entry point, interconnected with the individual local stations. Include speakers and microphones.

Construction: Wall mounted flush stainless-steel panel.

Weatherproofing: IP56.

Dial: Digital push-button type.

Schedule: Provide a weatherproof (IP56) schedule holder and card identifying individual local stations. Locate next to the intercom panel.

Local station: Provide wall mounted intercom local stations, interconnected with the base stations and external entry points.

Type: Surface mounted, removable handset type.

Operation: Provide an audible tone device to indicate that the individual station is being called, and a press-to-talk switch so that the local station can communicate with the base station only when the switch is held down.

Door control: Provide integral momentary action door release switches to operate the door release or opening mechanisms at each external entry point.

9.1.2.11 LABELLING

General

Provide labels including control and circuit equipment ratings, functional units, notices for operational and maintenance personnel, incoming and outgoing circuit rating, sizes and origin of supply and kW ratings of motor starters.

Identifying labels

Provide labels fixed to access panels, doors, covers and escutcheon panels and internal equipment, indicating the relevant information and componentry.

Single-line diagrams

Custom-built assemblies: Provide single-line diagrams.

Format: Non-fading print, at least A3 size, showing the situation as installed.

Mounting: Enclose in a folder and fix close to assembly.

Marking cables

Identify the origin of all wiring by means of legible indelible marking.

Identification labels: Provide durable labels fitted to each core and sheath, permanently marked with numbers, letters or both to suit the connection diagrams.

Telecommunications Cabling

Label telecommunications cables, cross connects and outlets.

Labels: Label cables to indicate the origin and destination of the cable. Label outlets to show the origin of the cross connect, the workstation or outlet number, and the port designation.

Location marking

Accurately mark the location of underground cables with route markers consisting of a marker plate set flush in a concrete base.

Location: Place markers at each joint, route junction, change of direction, termination and building entry point and in straight runs at intervals of not more than 100 m.

Concrete bases: 200 mm diameter x 200 mm deep, minimum.

Direction marking: Show the direction of the cable run by means of direction arrows on the marker plate. Indicate distance to the next marker.

Plates: Brass, minimum size 75 x 75 x 1 mm thick.

Plate fixing: Waterproof adhesive and 4 brass or stainless steel countersunk screws.

Marker height: Set the marker plate flush with paved surfaces, and 25 mm above other surfaces.

Labelling – Minimum Lettering Heights

Main assembly designation: 25 mm.

Distribution assembly designations: 15 mm.

Small proprietary distribution boards: 10 mm.

Main switches: 10 mm.

Outgoing functional units: 8 mm.

Identifying labels (on outside of cabinet rear covers): 4 mm.

Danger, warning and caution notices: 10 mm for main heading, 5 mm for remainder.

Other labels including equipment labels within cabinets: 3 mm.

Label colours

Generally black lettering on white background except as follows:

- Main switch and caution labels: Red lettering on white background.
- Danger, warning labels: White lettering on red background.

Fixing

General: Fix labels securely.

Fixing methods: Use screws and double-sided adhesive. Fixed in extruded aluminium sections attached to panels with rivets or countersunk screws.

Permanent fixing: Fix labels permanently in place.

Refer to drawings, BOQ and Electrical **Schedules** for details and locations of all fixtures, fittings and cabling.

9.2 Generating sets

9.2.1 General

9.2.1.1 Aims

General

Provide proprietary packaged stand-by generating set(s) incorporating the following:

- Engine cooling system.
- Combustion air system.
- Exhaust system.
- Liquid fuel system.
- Acoustic enclosure.
- Control system.
- Connection to low voltage power system.

9.2.1.2 Interpretations

Definitions

Net continuous rated output (or prime rating): Net continuous electrical output available at alternator terminals, not including the electrical power consumed by the generating set's dependent and essential auxiliaries.

Net short-time rated output (or stand-by rating): Net electrical output available from the generating set for 1 hour in every 12 hours at net continuous rated output, not including electrical power consumed by the generating set's dependent and essential auxiliaries.

Start response time: Total elapsed time from receipt of start signal to final connection to load.

9.2.1.3 Inspection

Notice

Give sufficient notice so that inspection may be made of each completed generating set and associated systems before connection to electrical services.

9.2.1.4 Submissions

Refer to the **Generator Set Performance Schedule** for details before providing technical data and drawings for any generator.

Technical Data

Submit technical data including the following:

- Technical description and specifications of each generating set, including output curves for base load and stand-by conditions, alternator and engine data, automatic voltage regulator, synchronising and load sharing modules and auxiliaries.
- Net continuous rated output.
- Net short-time rated output.
- Voltage regulation grade.
- Generating set efficiency at 50%, 75% and 100% load.
- Evidence that the engine type has previously passed cold starting tests at the minimum ambient site temperature.

Shop Drawings

Submit shop drawings indicating the following:

- Location and size of fuel tanks.
- Physical size of generating set base and clearances for maintenance.
- Location and estimated size of control and distribution boards.
- Maximum mass and overall dimensions of each separable assembly.

- Access clearances for operational maintenance and dismantling.
- Control diagrams.
- Details of control panels
- Details of foundations and anti-vibration mountings.

9.2.2 Products

9.2.2.1 General

Multiple Generating Sets

For multiple generating sets operating in parallel, provide generating sets of the same make and type.

Mounting

Mount the engine and alternator units on a common structural steel frame to support the generating set assembly and the engine local control board.

Coupling

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

9.2.2.2 Alternators

General

Voltage waveform: Sinusoidal, with total wave form deviation not exceeding 10%.

Excitation: Provide self-regulated brushless type exciters.

Over speed: Withstand a speed of 1.2 times unit rated speed for both alternator and engine.

Alternator underspeed withstand: Normal operation at net continuous rated output at a speed of 0.95 times unit rated speed, without overheating.

Number of poles: 4.

Enclosure classification: IP21, with screened ventilation openings.

Anti-condensation Heaters

Provide at least 2 anti-condensation heaters within the winding enclosure.

Rating: Rate heaters to maintain the windings and insulation at least 6°C above ambient temperature when the alternator is at rest and one heater is in service.

Location: Locate a 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.

Winding Thermistors

Provide thermistors to alternator stator windings.

Thermistor type: Positive temperature coefficient.

Thermistor temperatures:

- Engine shutdown: 160°C.
- Winding temperature high pre-alarm: 140°C.

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 and side covers.

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.

9.2.2.3 Engines

General

Sizing: When sizing the engine, take into account the nature of connected loads including auxiliaries, harmonics and transient operation.

Bearings: Provide front and rear main bearings, so that crankshaft alignment is not affected by dismantling of the alternator.

Governing

Provide electronic or mechanically controlled governors which enable engines to operate continuously at 1480 r/min from no-load to the maximum rated electrical load connected to the alternator. Provide filters which ensure that harmonics or switching spikes generated by the load do not interfere with the operation of the governor, over speed or under speed cut out devices.

9.2.2.4 Fuel Storage

General

Provide daily fuel tank capacity and bulk storage capacity to the capacities identified in the **Generator Set Fuel Tanks Schedule**.

9.2.2.5 Controls

General

Provide automatic and manual modes, or manual modes only, depending on generator set capacity 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 capacities.

Manual Sequence Control

Provide controls to manually synchronise and shut-down each generating set. Include emergency stop, meters, selector switches, check synchroniser and status indicating lights.

Automatic Start Control

Provide for the following:

- When a “start” signal is received, generating sets start automatically, come on-line and, when synchronised, connect to the load.
- Connection of alternators for sequential control of load sharing/shedding.
- Shutdown of alternate machines.

Automatic Engine Shutdown

Provide for generating sets to run to suit the load demand until receipt of the mains “restored” signal is received. At this point the automatic sequenced engine shutdown signal must be activated after an adjustable time delay of 0 – 30 min.

Emergency and Fault Shutdown

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

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 each generating set to immediately shutdown:

- Emergency stop push-button: Pressed.
- Generating set: Over voltage.
- Generating set: Over current.

- Engine: Over speed.
- Engine oil pressure: Low.
- Daily fuel tank: Low.
- Jacket water temperature: High.

Automatic Synchronising

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

Emergency Stop Push-buttons

Generating sets < 2 m 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: 40 mm diameter red, palm operated type mounted in a metal wall box. Wire to disconnect the generator and immediately shut down the engine when the controls are in the automatic or manual mode.

9.2.2.6 Control Panels

General

Provide control panels, switchgear and control gear assemblies required to enable the safe operation of the generating set and the interconnections with the low voltage supply service.

Engine Local Control Board

For each generating set, provide the following minimum level of information and equipment:

- Key operated local engine start/stop control.
- Controls for auto/off/manual/load test.
- Emergency manual shutdown.
- Speed indicator, kW meter, frequency meter, ammeter, and hours run meter.
- Indicator showing generating set under local control.
- Oil pressure indicator.
- Coolant temperature indicator.
- Automatic voltage regulator consisting of the following:

Switch to select manual or automatic voltage control.

Solid-state type automatic voltage regulator.

- Under and overvoltage sensing.
- Over and under speed sensors.

9.2.2.7 Batteries and Chargers

General

Provide separate batteries and charger systems for the following:

- Engine start.
- Control and alarm functions.

Chargers – Control and Alarm Batteries

Select the charger to suit the batteries supplied.

9.2.2.8 Starting

Electric Starting

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-energised. Provide an interlock, connected directly to the engine, to prevent the starter motor operating when the engine is running.

Starting Batteries

Locate in proprietary battery holders attached to the generating set, or on purpose-built stands next to the set and constructed of timber or other corrosion resistant material. Isolate batteries from vibration.

Capacity: Sufficient to crank the engine for 3 successive attempted starts, repeated at 5 min intervals.

Isolator: Provide a lockable isolator to prevent accidental starting.

Starting Batteries Chargers

Mains power: Connect chargers to the mains power to ensure that power is maintained to the charger under all supply conditions.

9.2.2.9 Acoustic Enclosures

General

Provide weatherproof acoustic enclosures to surround generating sets, including inlet and outlet sound attenuators.

Sound Pressure Level Limit

85 dB (A) at 12 locations 1 m from the enclosure exterior surface, at 1.5 m above floor level, measured with the generating set operating at constant maximum rated full load output, with doors closed and service penetrations sealed.

Doors

Provide doors of same material as the enclosure. Provide door stays to each door.

Ventilation

Provide ventilation to the enclosure so that:

- With generating sets running at full rated output the enclosure temperature rise does not exceed 10°C.
- Hazardous concentrations of toxic or explosive fumes and gases are prevented.

9.2.3 Execution

9.2.3.1 General

Plinths

Provide reinforced concrete plinths for floor mounted equipment, sized to suit equipment footprints.

Resilient Mounts

Provide at least 6 resilient mounting blocks between the frame and the plinth.

Drip Trays

Provide removable drip trays under those parts of the assembly where fuel or lubricant leakage may occur. Provide overflow outlet pipes taken to a point where a receptacle can be fitted under the pipe outlet.

Capacity: At least 1.5 times the oil capacity of the engine sump.

Material: 1.6 mm galvanized steel with brazed joints and rolled edges.

9.2.3.2 Engine Cooling

General

Provide a cooling system consisting of radiators, fans and pumps.

Cooling air ductwork: Connect the cooling air outlet to generator room cooling air outlet.

9.2.3.3 Engine Air Intake

General

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

Fans: Provide a fan selected for the installed system air pressure drop. Include power absorbed by the fan under site operating conditions when calculating generator output.

9.2.3.4 Exhaust System

General

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

Weatherproofing

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

9.2.3.5 Fuel System

Stop valves

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

9.2.3.6 Completion

Completion Tests

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.
- Cold start with the engine having been at rest for the previous 24 hours.
- Continuous operational trial consisting of:

4 hours at 100% rated power.

1 hour at 110% rated power.

30 min at 75% rated power.

30 min at 50% rated power.

- Record fuel consumption for each step of the continuous trial.
- 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.

Oil pressure and water temperature.

Synchronisation and load sharing tests: For generating sets running in parallel perform tests to verify automatic synchronisation and load sharing including the following:

- Sequence start and shutdown of each generating set.
- Parallel operation of generating sets.
- Synchronising of generating sets.
- Operation of controls, switchgear and auxiliaries.

Temporary Test Loads

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