

PART 4

General Technical Specifications

4. General Technical Specifications

4.1 DISTRIBUTION BOARDS

All distribution boards shall be of adequate size, to accommodate equipment and space for future equipment, according to the Schedules of Technical Requirements.

Recessed and Semi-Recessed Distribution Boards

Distribution boards shall consist of the following parts:

Bonding Tray: constructed of 1.6mm corrosion resistant mild sheet steel. Bracing gussets with cam-shaped slots shall be welded in the four corners. Knockouts shall be provided in the upper and lower sides of the distribution boards. Expanded metal shall be spot-welded to the back of all bonding trays for 102.5mm thick walls.

Architrave Frame: constructed of 1.20mm sheet with square edges. The architrave frame shall form a 50mm border around bonding tray and shall be fixed to the tray in such a manner as to allow for adjustment for inequalities in wall finish.

A minimum of 75mm shall be allowed between the inside of the architrave frame and the equipment.

Distribution board numbers consisting of black engraved lettering on a white background shall be fixed to the top of the architrave frame.

Doors: constructed of 1.20mm sheet steel, reinforced to ensure rigidity. Doors shall be mounted flush in architrave frames. Door catches shall be constructed of chromium-plated brass and shall be mounted flush in the door. Built-in locks shall be provided when specified in the distribution board schedule.

Chassis: shall be fixed to the architrave frame. The chassis shall be reinforced, with necessary provision for fixing of the switchgear. A distance of 75mm must be allowed between rows of equipment.

Panels: shall be rigidly constructed from 1.6mm sheet steel with machine cut openings for flush mounted equipment. Panels shall be fixed to the architrave frame on studs with chromium plated hexagon dome headed nuts, hank nuts or captive fasteners such as “DZUS” or “CAMLOC”, such that a clearance of 40mm is maintained between panels and doors. Chromium plated handles shall be supplied to facilitate removal of panels.

Bus bars: shall be of the tinned HDHC solid copper with adequate cross section. Bus bars are to be mounted on suitable insulators, and shall be drilled and tapped. An insulator shall be provided onto which the main incoming neutral shall terminate.

Each distribution board shall be supplied with neutral and earth bars from copper. Adequate terminals shall be provided. Each terminal shall have 2 proper brass terminal screws (cadmium plated).

Each bus bar must be supplied with bigger terminals for feeder cable.

Wiring: shall be by means of PVC insulated conductors with sizes to suit the relevant switchgear.

The ends of wires shall be provided with suitable lugs, firmly crimped for connection to bus bars.

Wiring shall, where possible, be carried out in front of the chassis and shall be neatly bound in horizontal and vertical rows, by means of approved plastic ties of suitable size. Wiring shall be kept free of any current carrying parts.

Ends of wires which, are connected to the clamps of miniature circuit breakers, shall be ferruled before insertion into terminals.

Finish: welding joints and steelwork shall be ground smooth and free from blemishes.

Paint treatment shall be as follows:

1. Degrease all metal parts and rinse.
2. Apply acid bath treatment and rinse.
3. Apply phosphate treatment and neutralise.

4. Dry properly.
5. Apply one coat, powder type paint.

Surface Mounted Distribution Boards

Surface mounted distribution boards, shall comply with SABS1180 and shall be similar to the specification for flush mounted boards, except that the architrave frames and bonding trays are not required. In this case, a box shall be supplied, manufactured from 1.60mm corrosion resistant sheet steel, with knockouts at the top and bottom for conduit entry. The board shall have a 25mm wide frame around the flush mounted door, if required.

4.2 CONSTRUCTION OF MAIN LOW TENSION AND OTHER FREE STANDING SWITCHBOARDS

CONSTRUCTION

Framework

A metal framework for freestanding switchboards, shall be manufactured from angle iron, channel iron or 2mm minimum folded metal. A solid 75mm deep U-channel base frame, sufficiently braced to support all equipment and span floor trenches and access holes, shall be provided. All joints shall be non-continuously butt-welded. Welds shall be ground smooth and the joint wiped with plumber's metal in order to provide a smooth finish. Switchboards wider than 2000mm shall be fitted with screwed eyebolts, attached to the framework to facilitate loading and transportation of the board. Large switchboards shall be manufactured in sections for ease of transportation and installation. The maximum allowable height of freestanding switchboards shall be 2200mm, unless otherwise specified.

Panels

The rear panels shall be removable and shall be manufactured from 2mm minimum sheet steel. The panels shall have returned edges,

which are recessed in the frame, or which fit over lips on the switchboard frame. The panels shall be secured to the frame by means of studs and chromium plated hexagonal domed brass nuts, hank nuts or captive fasteners such as "DZUS" or "CAMLOC".

All boards shall be so constructed that they are flush along the front and rear and no panels shall protrude. A minimum clearance of 50mm shall be maintained between the rear (taking into account any projections) of equipment mounted on the front panels and the frame and chassis of the switchboard. A minimum clearance of 75mm shall be provided between horizontal rows of equipment, the maximum outside dimensions of equipment shall be considered.

All removable rear panels shall be provided with neoprene or rubber dustproof seals.

Front Panels

The front panel of floor-standing boards shall be either hinged (except where flush mounted equipment prevent this) or the panel may be secured to the architrave frame, by means of two or more pins at the bottom and a latch or lock at the top of the panel.

Hinged panels shall be secured by means of non-ferrous fasteners, designed to draw panels closed and which are operated by means of a removable key, acting on fasteners with spigots of square cross section. All non-hinged removable panels shall be provided with chromium plated brass handles at the top and bottom.

Chassis

A suitably braced chassis for the mounting of switchgear and equipment shall be firmly secured to the frame of the switchboard.

Doors

Doors need only provided when specified in the Detail Technical Specification, or the Schedules of Technical Requirements of this document. When specified, doors shall be of 2mm minimum sheet steel and shall be suitably braced and stiffened, to carry electrical equipment where required. Doors containing electrical equipment

shall be bonded to the switchboard frame with a braided copper earth wire of equivalent cross-sectional area of at least 4 sq mm.

Doors shall be provided with handles and catches. Locking facilities shall only be provided when specified in the Detail Technical Specification of this document.

Neoprene or rubber dustproof seals shall be provided on all doors.

Bus Bars

General

Bus bars shall be manufactured of solid drawn high conductivity copper of rectangular cross-section, in accordance with SABS784 and 1195, and BS159 and 1433, where applicable. All bus bars and connections shall be air insulated, and shall be mounted on resin insulators.

All ac bus bars, circuit connections and droppers, shall be indelibly marked with coloured heat-shrinkable material or coloured PVC tape, along their entire length, to indicate to which phase of the supply they are connected, and shall have the phases coloured, red, white, blue and the neutral black. All connections shall be covered with non-hardening compound and then taped with coloured PVC tape.

Unless otherwise specified in the Detail Technical Specification of this document, all freestanding switchboards shall be bottom entry switchboards with the bus bars situated in the top section of the board.

All joints and tees in bus bar connections shall preferably be made with bolts, nuts and washers of not less than 12mm diameter. As an alternative, cadmium plated high tensile steel bolts with hexagonal bolts and washers shall be used. All conductor ends shall be fitted with crimped lugs, which are bolted to the bus bars.

Rating of bus bars

All bus bars shall be capable of carrying the full incoming current along their entire length and the neutral bus bar in three phase, four

wire supplies shall have a cross-section equal to that of the phase bus bars.

The maximum allowable temperature of bus bars carrying full load current in an assumed ambient temperature of 35 degrees Celsius, shall not exceed 80 degrees Celsius.

The size and rating of the bus bars shall be as specified in Detail Technical Specification of this document. Where no value is given, table 1 below shall be used as a guide in determining bus bar ratings.

**TABLE 1 : CURRENT RATING FOR SINGLE COPPER BUS BARS
(A)**

WIDTH (mm)	THICKNESS (mm)							
	3.5	4.0	5.0	6.3	8.0	10.0	12.5	16.0
12.5	146							
16	178	205						
20	215	246	280					
25	259	296	335	383				
31.5	316	360	406	459	522			
40	388	441	492	556	635			
50	471	534	592	668	755	842		
63	570	642	719	805	902	1005	1120	
80	700	786	877	976	1090	1207	1338	
100		950	1050	1170	1301	1440	1582	
125			1262	1396	1555	1706	1885	2090
160				1703	1887	2074	2270	2560
206					2307	2550	2795	3100
250						3010	3210	3630
315							4000	4300

Earthing

An earth bus bar shall be provided in a convenient position along the entire length of the switchboard, bolted directly to the framework. The

cross sectional area of earth bus bars, shall be calculated according to IEC439, with a minimum cross section of 6.33mm x 20mm.

All metal parts other than those forming part of an electrical circuit, shall be bonded to the earth bus bar.

Wiring & Cabling

The switchboard shall be such that all cables can either enter the switchboard through a continuous slot in the floor. Cables connected to incoming and outgoing circuits, shall be terminated on a gland plate with the gland types as specified in Detail Technical Specification of this document.

Special attention shall be given to the vermin proofing of freestanding switchboards, especially from below.

Internal Wiring

Standard 600/1000V grade PV insulated stranded annealed copper conductors of cross-sectional area adequate for the maximum continuous current rating required. A minimum conductor size of 2.5 sq mm, shall be used for power wiring.

Wiring shall be arranged neatly in horizontal and vertical rows and shall be bound with suitable plastic straps or installed in PVC wiring channels.

Power and control circuit wiring shall not be installed in common wiring channels.

Where conductors pass through holes in the metal work, they shall be protected by means of neoprene or rubber grommets.

Paint Finish

Metal components of the framework, panels and chassis, shall be painted in accordance with the procedure detailed below. Baked enamel or electrostatically applied powder coating, may be used.

Surface Preparation

Prior to painting, all metal parts shall be thoroughly cleaned of rust, mill-scale, grease and foreign matter to a continuous metallic finish. Sand or shot blasting or acid pickling and washing, may be employed for this purpose.

Baked Enamel Finish

Immediately after cleaning all surfaces shall be covered by a rust inhibiting, tough, unbroken metal phosphate film and then thoroughly dried to SABS064. Within forty-eight (48) hours after phosphating, a passivating layer consisting of a high quality zinc-chromate primer shall be applied, followed by two (2) coats of high quality baked enamel to SABS783 type 1.

The minimum paint thickness after baking shall be 0.6mm. The paint shall have a shock resistance of 25kg-cm on 0.9mm soft steel plate and a scratch resistance of 2kg.

Labelling

Care shall be taken to ensure that all equipment is fully labelled and accurate descriptions appear in English.

Engraved plastic or ivory sandwiches strips shall be used throughout. The strips shall bear black lettering on a white background.

Main switchboards shall have a main designation label prominently displayed on the outside of the switchboard. The lettering shall be 10mm high. Distribution boards shall be identified by means of a label fixed to the architrave frame or doors the lettering shall be 10mm high.

Flush mounted equipment within doors or front panels shall be identified with labels fixed to the doors or front panels respectively. The labels for equipment installed behind panels, shall be fixed to the chassis close to the equipment. Where the positioning of the equipment is such that descriptive labels cannot be accommodated, or where the equipment is identified by means of labels containing circuit numbers, the abbreviations and/or circuit numbers shall be identified on a legend card. Where blanked off slots are provided for

future equipment, these spaces shall be labelled in accordance with the circuit numbers and/or the code used for existing circuits on the switchboard, and shall not bear the inscription "SPARE". The codes for spare circuits shall be identified as "SPARE", on the legend card. The legend card shall be of A5 size, covered by 1.5mm acrylic plastic panels and shall be installed on the inside of the switchboard door, or in any other prominent position. All information contained on the legend card, shall be typed in black, handwritten descriptions shall not be accepted.

All labels identifying equipment shall have 5mm high lettering.

Fixing of Labels

Labels shall be fixed by means of slotted label holders, self-tapping screws, "pop-rivets" or brass nuts and bolts. The labels shall not be glued to the switchboard.

Drawings

Drawings for Approval

A set of three prints of the shop drawings for the switchboards, shall be submitted to the Engineer for approval, before the boards are manufactured. The following information shall be presented:

- a) A complete wiring diagram of the equipment on the boards.
- b) A complete layout of the arrangement of the switchboards, indicating all equipment dimensions and the construction of the boards. The position and method of fixing of bus bars shall be shown.
- c) All labelling information in English on a separate sheet.
- d) The make, catalogue number and capacity of all equipment, such as
isolators, circuit breakers, fuses, contactors, etc.

The approval of drawings shall not relieve the Electrical Contractor of his responsibility to the Engineer, to supply the switchboards according to the requirements of this specification.

Final Drawings

A complete set of sepia and in electronic form (DXF) “as built” drawings of all switchboards, shall be submitted to the Engineer within two weeks after delivery of the boards. The following information shall be presented:

- a) (a) to (d) of the previous paragraph.
- b) Terminal strip numbers, numbers and colours of conductors, connected to the terminal strips, and numbers and colours of the conductors utilised for the internal wiring.
- c) A separate ***schedule*** of all equipment.

Manuals

Manuals shall only be supplied when specified in the Detail Technical Specification of this document.

4.3 CABLES AND CONDUCTORS

Underground PVC Cables – 600/1000V Grade

Multi core underground cables shall consist of high conductivity annealed or hard drawn stranded copper conductors, with polyvinyl chloride insulation and one layer of galvanised steel wire armouring. The cores may be shaped or circular, but the cross-sectional area of each conductor, shall not be less than that specified. The cores shall have the following colours:

- 2-core cable : 1 red and 1 black
- 3-core cable : 1 red, 1 white and 1 blue
- 4-core cable : 1 red, 1 white, 1 blue and 1 black

The cables shall be suitable for system voltage of up to 660-volt ac, and shall comply with SABS150:1957 with special reference to table xxix.

Where specified, an earth continuity conductor shall be provided in the armouring in accordance with SABS150.

Cables shall be of new stock and shall be carried out on production runs of the cable, in accordance with SABS150.

Underground Paper Insulated Cable

All underground PLSTS, PLSTC, PESTS, PESTC, cables, shall be 11000-volt grade and shall have a lead sheath and double steel tape armouring, fully complying with SABS97:1970.

The conductors shall be of high conductivity annealed stranded copper that may be shaded or circular, but the cross-sectional area of each conductor shall, not be less than that specified.

Unless cables are made to order, only cables from new stock shall be delivered to site.

At the request of the Engineer, tests shall, if required, be carried out on production runs of the cable in accordance with SABS97.

Conductors

Single core PVC cable shall consist of high conductivity stranded copper conductors, insulated with red or black polyvinyl chloride. Cable shall be of 250-volt grade to SABS150:1957, with special reference to table i and xx. Cables shall be from new stock delivered to site with unbroken seals.

PVC insulated conductors, shall not be used for direct connection to equipment, where the temperature exceeds 75 degrees Celsius, such as stoves, geysers, electric heaters and high wattage incandescent lamps.

Metal Sheathed Cables

Aluminium sheathed cables shall be similar and equal to ABERDARE manufacture. Mineral insulated copper sheathed cables shall be similar and equal to “Pyrotenax”.

4.4 CABLE END BOXES AND GLANDS

Cable end boxes for copper insulated high tension cable, shall be equal and similar to “AEI-Henley” or “Scotchcast” manufacture, of the shallow type, filled with grade 621 bitumen compound.

Cable End Boxes

Cable end boxes shall be suitable to accept PLSTS, PLSTC, PESTS and PESTC cables.

The cable end boxes shall be of the metal clad type, suitable for indoor or outdoor use, as required for the specific application. Only inverted type boxes shall be supplied for outdoor use. The insulators of the inverted type boxes are angled downwards.

The boxes shall be equipped with armour clamps and brass or gunmetal conical wiping glands.

All cable end boxes shall comply with BS542.

The cable boxes shall be suitable for filling with bituminous, cold filling compound or resin oil semi-fluid compound.

Bituminous Compound

Compound shall be suitable for filling metal clad cable end boxes.

Compound shall comply with BS1858, shall be non-hygroscopic and shall have a high dielectric strength and insulation resistance.

The compound shall have good adhesive properties and shall not be suspect of cracking.

The compound shall be suitable for use in high ambient temperatures and system voltages of up to 11kV nominal.

Catalysed Cold Filling Compound

The compound shall be suitable for filling metal clad cable end boxes. The compound shall consist of two components, a base compound shall be suitable for use at atmospheric pressure.

The compound shall be non-hygroscopic and shall have a high dielectric strength and insulation resistance.

Shrinkage shall be limited so that topping up of the boxes is not necessary.

Resin Oil Semi-fluid Compound

The compound shall be suitable for filling metal clad cable end boxes with level indicators.

This compound shall have a pouring temperature above 100 degrees Celsius.

The compound shall be non-hygroscopic and shall have a high dielectric strength and insulation resistance.

The compound shall have a minimal contraction when cooling.

The compound shall be of the HENLEY COMPOUND NO 57018, INSULOL DG, or equivalent.

Cable Terminations and Joints with Heat Shrinkable Materials

All materials used shall comply with VDE0278, and shall be packed in kit form marked for the type of cable insulation, construction and voltage range for which the materials are suitable.

All materials used for this type of joint or termination, shall comply with the following:

- a) The electrical and mechanical properties shall be retained without deterioration.
- b) They shall provide protection against ultraviolet radiation and be weather resistant.
- c) Outdoor terminations shall be designed to prevent flashover under wet and contaminated conditions.
- d) A shrunk-on protective layer against surface tracking, shall be provided on all terminations on cables rated at 3.3kV and above.
- e) The electrical continuity of all the conductors, screens and armouring, shall not be impaired by the joints.
- f) The earth continuity shall be accomplished within the joints.
- g) Minimum use shall be made of stress relieving or insulating tapes, insulating and stress relieving tubing that is heat-shrunk onto the termination or joint is preferred.

Glands for PVC Insulated Cables

Glands to be used for terminating PVC/SWA/PVC cables, shall be of the adjustable type, similar or equal to PRATLEY.

Glands shall be suitable for general purpose 600/1000V grade cable with steel armouring.

The glands shall be made of heavily nickel-plated bronze or brass.

The glands shall consist of a barrel carrying a cone bush screwed into one end and a nickel-plated brass nipple carrying a nickel-plated brass of a heavy galvanised steel lock nut, screwed into the other end. The galvanising shall comply with SABS763.

The shrouds shall be made of non-deteriorating neoprene or other synthetic rubber, and shall be resistant to water, oil and sunlight. The shrouds shall fit tightly around the glands and cable.

Glands shall be provided with ISO threads and shall be suitable for the specified cable sizes.

Flameproof glands shall comply with SABS808, Groups 1, 2a and 2b.

Suitable accessories shall be provided with glands to be used on EEC armoured cables to facilitate a bolted lug connection of the earth continuity conductors. Grooves cut into the barrel or cone bush to accommodate the earth continuity conductors are not acceptable.

For armoured cables, the cone and compression ring of the glands, shall be replaced with a synthetic rubber compression bush and ring to provide the required grip on the outer sheath of the cable.

4.5 WIRING

General

Wiring shall consist of PVC insulated 600/1000V grade stranded copper conductors and bare stranded or green PVC insulated copper earth conductors, except where expressly stated otherwise.

Wiring may only be carried out after the complete conduit installation for a sub distribution board has been completed. The wiring shall, however, be completed before paintwork commences.

Wiring shall be carried out by means of the loop-in system, except when stated otherwise. Only circuits of the same type may be wired in one tube, with a maximum of two circuits per tube. No more than 4 conduit ends shall appear at any one light outlet. No joining of conductors in tubing shall be allowed.

Where aluminium sheathed or mineral insulated copper sheathed cables are to be employed, they shall be used strictly to the manufacturer's instruction.

The following conductor sizes shall be used, except when stated otherwise:

Lighting circuits	:	1.5 sq mm
Socket outlet circuits	:	2.5 sq mm

Stove circuits : 6.0 sq mm with 4 sq mm earth conductor
Earth of fluorescent fittings and socket outlets: 2.5 sq mm.

The colour of conductor insulation shall comply with SABS0142 para. 5.2.1(d). The colour of conductors for two-way and intermediate switches, shall preferably differ from the colour of the phase conductors.

Where cable ends connect onto switches, fittings etc, the end strand must be neatly and tightly twisted together and firmly secured. Cutting away of wire strands of any cable, will not be allowed.

4.6 MOUNTING HEIGHT OF DISTRIBUTION BOARDS, SWITCHES AND SOCKET OUTLETS

Except where stated otherwise, mounting heights shall be as follows:

Distribution boards : top frame 2000mm above finished floor level
Switches : underside 1400mm above finished floor level
Socket outlets : underside 300mm above finished floor level
Telephone outlets : underside 300mm above finished floor level
Power skirting : 10mm above finished floor level.

All distribution boards, switches and socket outlets, shall be of the flush mounted type, except when stated otherwise.

4.7 EARTHING ELECTRODES

General

This section covers uncoated, coated and metal-clad circular rod electrodes or extensible rod electrodes, intended to provide an earth in soil for electrical and lightning arrester systems.

Category and Type

Only the following type of earth rods shall be used:

- 1
 - solid draw copper
 - solid stainless steel
- 2
 - solid steel with bonded copper protection
 - solid steel with plated copper protection
 - solid steel with shrunk-on copper jacket

A molecular bond shall exist between the two materials to prevent separation between them.

- 3
 - solid steel with shrunk-on stainless steel jacket

Aluminium or aluminium alloy rods are not acceptable.

All rods shall be of the solid round sectional type with lengths as specified in the Detail Technical Specification.

The nominal diameters of the earthing rods shall not be less than 16mm, unless the rods are specified for placing in pre-drilled holes in which event the minimum nominal diameters shall be not less than 12mm.

Plated or jacketed rods shall show no signs of cracking or separation of the jacket from the rod, if the rod is subjected to bending, shearing or compression.

Couplings and Conductor Clamps

Rods designed for coupling by means of external sleeves, shall be provided with an adequate quantity of hydrocarbon or silicon grease to be applied to the coupling, before the joint is made. Sufficient numbers of couplings shall be provided to assemble rods of the lengths specified.

Rods designed for coupling by means of internal pins or splines, shall be provided with thin-walled tubes and hydrocarbon or silicon grease to seal the joint. Sufficient numbers of couplings shall be provided to assemble rods of the lengths specified.

Conductor clamps shall be provided to suit the type and size of rods provided and the type and size of conductor specified in the Detail Technical Specification.

The material of the clamps shall be compatible with the rod and conductor materials to prevent any electrolytic corrosion.

Where brazed or welded connections are specified, the supplier of the rods shall stipulate at least two types of metals, which are compatible with the rod and conductor materials.

An adequate number of driving caps or bolts shall be supplied with the rods, to protect the ends of the earthing rods, whilst being driven into hard soil.

The threads on couplings, driving bolts and rods, shall be rolled and not machined.

Installation

The minimum length of rod shall be 1.8m. If longer lengths are required, this will be specified in the Detail Technical Specification. The tops of rods connected to buried earth conductors shall be at least 600mm below ground level.

The maximum earth resistance of the rod electrode, measured before bonding it to any other conductors or electrodes, shall not exceed 200ohms.

Underground joints between the electrode rod and any conductor, and between conductors, shall either be brazed or welded. Above ground, joints may be made by means of hexagonal, compression crimped lugs, clamping or double bolting. The "CADWELD" welding process may be used.

Rods shall be driven into soft ground. In very hard ground or rock, the rods shall be inserted in pre-drilled holes. The holes shall then be refilled with a fine mud slurry. Cognisance shall be taken of the corrosive effect of the mud slurry on the earth electrode rod.

4.8 SWITCHES

Flush mounted switches shall be similar and equal to CRABTREE with ivory bakelite rocker type operating toggles. All switches shall be suitable for mounting in 100 x 50 x 50 mm galvanised steel or stove enamelled boxes.

Switches shall be of the tumbler operated micro-gap type and of silent operation.

Cover plates shall be finished in ivory coloured, baked enamel and shall all bear the identical manufacturing batch number. Cover plates shall have bevelled edges, which overlap the box, and shall conform to SABS1084.

Surface mounted switches shall consist of single or multiple switches (not more than 4), with brown, bakelite dolly-type toggles, mounted in a pressed steel box of heavy construction. Surface mounted switches, shall be similar and equal to CRABTREE. All switches shall be suitable for 250V, 50Hz ac system and shall fully comply with SABS1085.

4.9 SOCKET OUTLETS WITH SWITCHES

All socket outlets with switches, shall be of the standard 16A 3-pin pattern. Units for flush mounting shall be suitable for 100 x 100 x 50 mm deep, flush wall box. Surface mounted patterns shall be housed in heavy pressed steel boxes. Shutters shall be provided. Units for power skirting shall be rigidly mounted.

All socket outlets with switches, shall be continuously rated at 16A and shall be suitable for operation on 1 250V, 50Hz ac system. Socket outlets with switches for flush mounting, surface mounted patterns, shall be similar and equal to CRABTREE. All socket outlets with switches, shall fully comply with SABS164, as amended and SABS163, as amended.

Cover plates shall be in accordance with SABS1084 and shall have bevelled edges, which overlap the box.

4.10 MOULDED CASE AIR CIRCUIT BREAKERS (MCB)

This section covers single or multi-pole moulded case circuit breakers for use in power distribution systems, suitable for panel mounting, for ratings up to 2000A, 600V, 60Hz, AC.

The overload protection and time lag settings for large frame multi-pole MCB's, shall be either adjustable or non-adjustable, as specified in the Detail Technical Specification.

All miniature or small frame circuit breakers shall be of the free-handle type for panel mounting with frame lag, and non-adjustable overload protection. The silver alloy contacts, quick acting mechanism, heavy brass terminals and magnetic trip unit shall be housed in a black phenolic moulded case. Circuit breakers shall be continuously rated at 1.5 x trip current with a fault capacity as specified in the Detail specification.

All MCB's shall comply with SABS156: 1977 and shall be similar and equal to ABB manufacture.

4.11 METAL CLAD AIR CIRCUIT BREAKERS, WITHDRAWABLE TYPE

This section covers withdrawable air circuit breakers for use in power distribution system up to 1kV, 50Hz.

The circuit breakers shall be metal-clad, and shall comply with BS4752 and IEC157.

The circuit breaker shall be withdrawable and shall be a self-contained unit, with the necessary mechanical interlocks to prevent:

- i) Access to "LIVE" terminals when the circuit breakers are withdrawn.
- ii) The withdrawal or insertion of the unit, when the circuit breaker is in the closed position.

- iii) Closing of the circuit breaker, following an automatic trip condition without resetting the mechanism.

Adjustable thermal overload releases shall be provided to suit the required current range. In addition, instantaneous magnetic short circuit trips, which are adjustable, shall be fitted. This delay adjustment shall be bypassed with an instantaneous making current release when the circuit breaker is closed to prevent the delay timer from operating when the circuit breaker is closed on a fault.

The air circuit breakers shall be of the quick-make and quick-break type, with a stored energy spring assisted operating mechanism provided with:

- i) A trip free mechanical hand operated closing mechanism;
- ii) A manually operated mechanical trip mechanism, suitably protected to prevent inadvertent tripping;
- iii) A positively driven mechanical device to provide ON/Off/TRIP indication. This indication shall be clearly visible with the circuit breaker in position.

Provision must exist for the addition, if required, of a supply side under voltage release.

Air circuit breakers shall have electrically separate auxiliary contacts as specified. Where none is specified, two N/O and two N/C auxiliary contacts shall be provided.

Shunt trips and electrical stored energy circuit breakers shall be interlinked, to prevent repeated operation of the trips or winding mechanism when the circuit breaker is in the tripped or closed position.

All non-current carrying metal parts of air circuit breakers, shall be solidly interconnected and connected to an earth contact on the truck, which shall engage with a mating contact or copper plate on the cradle, which is connected to the earth bus bar of the switchboard. The arrangement shall be such that the air circuit breaker frame is

earthed in the test position and before the circuit breaker contacts engage the live fixed contacts.

The fixed cradle shall be of high mechanical strength.

The circuit breaker shall have RACKED-OUT, TEST, and ENGAGED positions, which shall be clearly marked.

The air circuit breaker shall bear a clearly legible rating plate indicating the current rating, breaking capacity and voltage rating.

Extension type operating handles shall be fixed to the air circuit breaker on completion of the installation.

A description and illustration of the circuit breaker, as well as trip curves, operating manuals and rupturing test certificates, shall be provided.

Circuit breakers shall be de-rated if necessary, to compensate for the following environmental factors:

- a) Maximum ambient air temperature in excess of 40 degrees Celsius, or the daily average ambient air temperature in excess of 30 degrees Celsius. This is especially important with regard to the type of Enclosure in which the circuit breaker is to be installed.
- b) Height above sea level.
- c) Operational duty cycle and estimated loading.

Metal-clad air circuit breakers, withdrawable type, shall be similar and equal to "ABB" manufacture.

4.12 FUSE-SWITCHES

Fuse switches shall be of the heavy and rigid construction, suitable for flush mounting behind a panel. Contacts shall be brass with adequate cross section and positive contact pressure. The fuses must be carried on a rigid frame and shall be fixed by means of bolts

and nuts. The switch mechanism shall be of the quick-acting spring assisted type. Fuse switches shall be similar and equal to English Electric "FRONTIER" Stanley Electrical "QUADBREAK" or ATW "STORMBERG".

The fuse switch shall have a hand-operated lever with clearly marked "ON" AND "OFF" positions. The nominal rating, voltage and allowable fuse ratings, shall be clearly and indelibly marked on the cover. Interlocks shall be provided to prevent the cover from being opened when the switch is on the "ON" position, and to prevent the switch from being operated when the cover is open.

Light duty fuse-switches (up to 200A), shall comply with BS2510 and heavy-duty fuse switches (up to 1200A), shall comply with BS3185.

4.13 FUSELINKS

All fuses shall be of the standard cartridge type, non-ageing, with a high rupturing capacity (HRC) and shall be similar and equal to English Electric Type "T".

All fuses used for distribution systems shall conform to the following standards:

Fuses: BS88, Parts 1 and 2 and SABS172.

Holders: SABS173 as revised.

Fuses of the types described above and conforming to the relevant DIN (49510, 49511, 49515, 49522, 49360, 49367) and VD (0635, 0660) standards are also acceptable.

Types

The following fuse and fuse holder types are acceptable for use in distribution and power systems:

A cartridge type fuse-link, fitting into a fuse carrier, together with a fuse base with fixed terminals. The fuse can be removed by taking out the fuse carrier and then removing the fuse from the carrier.

Re-wireable fuses are not acceptable and shall not be used.

Fuses shall be equipped with moulded plastic covers or rigid isolating barriers, shall be installed between the fuses. Sufficient spacing to prevent accidental contact when inserting or withdrawing fuses, shall be maintained. The covers or barriers shall be manufactured for the specific fuses to be used.

Fuses and holders shall not contain any parts that can wear unduly or distort.

Ratings

Fuse ratings shall be accurate to with plus minus 5% of the published value of unused fuses and shall not vary significantly after long periods of service.

Fuses shall be de-rated for ambient temperatures above 25 degrees Celsius, in accordance with the Supplier's recommendation.

If no such recommendation exists, a de-rating factor of 1%/ degrees Celsius above 25 degrees Celsius, shall be applied.

Fuses shall be de-rated for elevations of more than 1000m above sea level in accordance with the Supplier's recommendation. If no such recommendation exists, a de-rating factor of 1%/300m above 1000m above sea level, shall be applied.

4.14 LIGHTNING ARRESTERS

Lightning arresters shall be similar and equal to CBI complying with SABS171:1960. Lightning arresters are to be installed close to the earth electrode and connected to it by means of copper tape following the shortest possible route.

4.15 EARTH LEAKAGE RELAYS

This section covers single and three phase earth leakage relays with a sensitivity of 30mA, with associated circuit breaker. If overload tripping is required, it will be specified in the Schedules of Technical Requirements.

The earth leakage relay shall conform to SABS767 and shall be similar and equal to ABB manufacture.

On load switches used integrally with earth leakage, units shall comply with BS5419.

4.16 SWITCHBOARD INSTRUMENTS

General

Where indicating instruments are called for on switchboards or control panels, they shall comply with BS89, BS3693 and IEC51.

All instruments shall be of the flush mounting industrial switchboard type, and shall be contained in dustproof cases with non-reflecting, anti-static, impact-resistant glass faces.

Instruments shall be suitable rated for the supply voltage and frequency to be applied, which shall be 415/240V, 50Hz, unless otherwise specified.

Instruments shall be insulated to achieve a 2kV insulation resistance to earth.

Instruments shall be sufficiently resistant to vibration that may be encountered in the specific application.

All instruments shall be capable of withstanding overloads of continuous or short duration in accordance with section 8.3 of IEC51. Instruments shall be provided with studs for rear connection. Shrouds shall be provided to prevent accidental contact where instruments are to be installed in hinged panels of switchboards.

Unless stated otherwise in the Detail Technical Specification, all indicating instruments shall be equal or similar to the “ELIMA” manufacture.

Voltmeters and Voltmeter Selector Switches

Unless specified to the contrary, voltmeters shall be scaled from 00-250V in the case of LV applications.

Voltmeters shall be of the moving iron type with class 1.5 accuracy, as specified in IEC51.

Zero adjustment screws shall be provided.

Unless specified to the contrary, a single voltmeter and selector switch, shall be provided. The voltmeter switch shall have an “OFF” and three metering positions to indicate readings between neutral and each of the three phases.

The markings shall be indicated clearly on the faceplate of the selector switch, and the handle position shall be accurate in relation to the markings on the faceplate.

The selector switch shall be of the cam-actuated or wiping air break type with two breaks per pole.

Where voltmeters are connected to the bus bars of the switchboard, they shall be protected by means of 2A fuses in an easily accessible position.

Ammeters

Ammeters shall have a moving iron element to indicate instantaneous values.

Direct reading ammeters up to a maximum rating of 60A, may be used. Current transformer operated ammeters shall be 5A full scale, calibrated to read actual primary circuit currents. The current transformer ratio shall be indicated on the faceplate.

A zero-adjustment screw shall be provided.

Where combined maximum demand and indicating ammeters are specified, a bimetallic spiral element shall be provided in the same housing to indicate mean value over a 15 minute period.

The bimetal element shall drive a residual pointer to indicate maximum mean current between re-settings. This pointer shall operate on the main scale and shall be of a distinctive colour. The pointer shall be re-settable from the face of the meter.

The bimetal element shall be designed to compensate for limits of ambient temperature between –20 and 70 degrees Celsius.

Full load or rated current shall be clearly indicated, preferably with a red line. Unless specified to the contrary, a 100% condensed over scale shall be provided for instantaneous reading instruments, and no over scale for combined maximum demand ammeters.

The intrinsic error, expressed in terms of the fiducially value in accordance with IEC51, shall be class 1.5 for the instantaneous readings and class 2.5 for the mean maxima.

Where saturation current transformers are required, these shall be an integral part of the meter. Separate saturation current transformers are unacceptable.

4.17 CONTACTORS

Contactors shall be of the open or totally enclosed, triple- or double pole, electromechanically operated air-break type, suitable for 380-420V or 220-240V supplies. Open type contactors shall comply with SABS1092, where applicable.

The current rating of the contactor shall be as specified for the circuit with a switching duty in accordance with the IEC Publication 158 – 1, utilisation category AC1 for lighting and power circuits and utilisation category AC3 for motor starting.

The mechanical duty of the contactor shall comply with the specified requirements for class IV of clause 5.6 of BS775.

Non-current carrying metallic parts shall be solidly interconnected and a common screwed earth terminal shall be provided. The contactor shall be earthed to the switchboard earth bar.

Latched contactors shall be provided with a trip coil and a closing coil. The contactor shall remain closed after de-energising the closing coil and shall only trip on energising the trip coil.

Contactor operating coils shall have a voltage rating as required by the control circuitry and shall have the limits of operating and temperature rise as specified in Table IV of the IEC Publication 158-1. Latched contactors shall be capable of being tripped at 50% of the rated coil voltage.

Contactors with provision to add auxiliary contacts and convert auxiliary contacts on site are preferred. Contactors with permanently fixed auxiliary contacts shall have at least 1 x N/O and 1 x N/C spare auxiliary contacts in addition to the contacts specified for control purposes, and in addition to contacts required for self-holding operations or economy resistances.

Auxiliary contacts shall be capable of making carrying continuously and breaking 6A at 240V AC, unity power factor for contactors used on 380-430/240/220V systems.

Contactors shall be similar or equal to “TELEMECHANIQUE” manufacture.

4.18 INDICATOR LIGHTS

Indicator lights may be of the neon, or LED types and shall conform to BS1050.

Lamps shall suit the supply or control voltage and where LED's are used as indicators on main supply voltages, a suitable current limiting capacitor and reverse voltage protection diode must be used.

All indicating lamps shall consist of interchangeable lenses, lamp base, and a chromed screw or retaining ring. The lamps shall, where

applicable, be replaceable from the front without the use of special tools.

4.19 PRE-FABRICATED BUS BAR TRUNKING

General

Power transfer bus bar trunking shall be fully enclosed in a metal duct, which shall form part of the bus bar support. The metal enclosure shall form an integral part of the bus section and shall be of the same length as the conducting sections of the bus bar. The covers of the bus bar trunking, shall be secured to the framework by at least four points per section. Bus bar covers shall be so designed that they can be easily removed after installation of the trunking. Sections of the bus bar, which pass through walls and floors, shall have separate covers.

Two fire barriers of non-flammable, non-conducting material in the bus bar trunking, shall form an integral part of each section of rising bus bars.

The fire barriers shall be so placed, as to prevent the spreading of fire from one floor to another, but shall not restrict the ventilation of the bus bar.

Overhead bus bars shall be equipped with fire barriers, where the bus bars pass through walls or partitions.

Bus bar trunking shall be equal or similar to "TELEMECANIQUE" manufacture.

Rating

Bus bars shall be either manufactured from aluminium or solid drawn high conductivity copper, with a rectangular cross-section, as specified in the Detail Technical Specification of this document. Bus bars shall be in accordance with SABS 784, 1195 and BS1433, 159, where applicable.

The rating shall be as specified in the Detail Technical Specification, with the maximum allowable temperature of the bus bars (including joints), carrying full load current, not to exceed 60 deg C, in ambient temperature of maximum 45 deg C

Bus bars shall not be tapered and the neutral bus bar in three-phase, four wire supplies shall have a cross-section equal to 100% of the cross-section of the phase bus bars.

An earth bus bar shall be installed along the entire length of the bus bar trunking and shall be calculated according to IEC439 with a minimum cross-section of 6.3 x 20mm.

Construction

The bus bars shall be supported at a minimum of two points in each section and shall be supported by a suitable resin bound synthetic material. The surface of these supports shall be treated to prevent surface tracking. The fixing of the bus bars shall be designed to withstand the mechanical and thermal stresses during fault conditions at the specified fault level.

All non-current carrying metal parts of the trunking shall be bonded to the earth bus bar.

Expansion joints shall be provided at intervals not exceeding 10m. These expansion joints shall have the same current rating as the rest of the bus bar trunking.

All accessories shall be purpose made and shall conform to the same specification as the bus bars.

All ratings and the name and address of the manufacturer, shall be indicated on a metal label fixed to each section of the bus bar trunking.

4.20 PHOTO-ELECTRIC DAYLIGHT SENSITIVE SWITCH FOR OUTSIDE LIGHTING

The unit shall comprise a photo-cell thermal actuator and change-over switch. The cover of the unit shall be manufactured from a

tough, durable material providing protection against tampering. The cover shall have good weathering properties. It shall be ultra violet resistant and shall not deteriorate when exposed to sunlight for prolonged periods.

The operational level shall be factory preset for “ON” at a light level of approximately 54 lux and “OFF” at approximately 108 lux. Voltage variations shall not materially affect the operational levels.

A time delay of not less than 15 seconds shall be provided to prevent the unit from functioning due to lightning or other short period changes in illumination.

The unit shall be effectively safeguarded against voltage surges by means of a suitable surge protector, which shall preferably form an integral part of the unit.

The unit shall be of the wall mounting type and shall be supplied, complete with a suitable bracket.

4.21 EARTHING PROTECTION

General

All electrical installations shall be earthed in accordance with the provisions of the current issue of the SABS Code of Practice for the Wiring of Premises: SABS 0142, as well as the relevant provisions of the Factories, Machinery and Building Work Act, 1941, as amended. The requirements of the local supply authority shall also be complied with.

Earthing of Substations

Main Earth Bar

A main earth bar, at least 500mm long, shall be provided and fixed to the substation wall or the cable trench wall in the vicinity of the transformer LV terminals. The earth bar shall be fixed at least 30mm away from the structure, at 500mm intervals, by means of spacer bar or resin type insulators. The

bar shall be long enough to accommodate the fixing of all earth conductors to the bar, with a minimum spacing between fixings of 50mm.

The minimum cross-sectional area of the main earth bar, shall be determined according to the installed capacity of the transformers as follows:

0 - 400 kVA	50mm x 4mm
500 - 800 kVA	63mm x 5mm
1000 - 1600 kVA	80mm x 8mm
2000 - 3000 kVA	100mm x 10mm

The main earth bar shall be made of copper.

Earth Electrode System

Earth conductivity tests shall be taken by a qualified contractor, where after an earth mat design will be done to ensure earthing compliance.

Unless otherwise specified, the earth electrode and ground earth conductors shall be installed according to the conductivity test and earthing design.

Earthing and Bonding Conductors

Earthing and bonding conductors shall be hard drawn stranded copper conductors, or rectangular solid copper strands. All earth conductors shall be bolted to the main earth bar or to earth and neutral bus bars, by means of 10mm dia brass bolts, nuts and locknuts. Each earth conductor shall be clearly labelled, for identification purposes, with durable labels or tags.

The ends of stranded copper conductors shall be fitted with Lugs. The lugs shall be fixed by means of a hexagonal Compression crimping tool, brazing or silver soldering. The

ends of rectangular solid copper strands shall be tinned before being connected to bus bars or earthing points.

Earthing of Substation Equipment

Each end of the HV switchboard, the transformer earthing terminal and the cable support, shall be bonded to the main earthing bar by means of 70 sq mm earth conductors. The neutral bus bar and earth bar in the main LV switchboard, and the transformer neutral terminal, shall each be bonded to the main earth bar with an earth conductor (or conductors in parallel), having a cross-sectional area of not less than half the size of the LV phase conductor (or conductors in parallel), having a cross-sectional area of not less than half the size of the LV phase conductor (or conductors in parallel), between the transformer and the main LV switchboard.

Earth Resistance Measurements

The Electrical Contractor, shall carry out earth resistance measurements on completion of the installation of the earth system and the results shall be submitted to the Engineer, for approval. Should the earth resistance be too high, the Electrical Contractor may be requested to install additional earth rods or trench earths.

Arrangements shall be made for the Engineer, or his representative, to witness the above tests.

The maximum earth resistance allowable, shall be as follows, dependent on installed transformer capacity:

0 - 500 kVA	5 ohm
500 - 800 kVA	3 ohm
800 – 1000 kVA	2 ohm
above - 1000 kVA	1 ohm

Earthing of Miniature Substations

The earthing of miniature substations is similar to the earthing requirements of substations described above, except that a main earth bar is not required. The earthing bar in the LV compartment shall become the main earth bar. The HV switch transformer earth terminal and neutral bus bar, shall be bonded to the earthing bar in the LV compartment as described for the Earthing of Substations, above.

Earthing of Outdoor Substations

In the case of outdoor substations, the earthing of equipment shall comply with the earthing of substations, as above, with the following additional requirements:

a) Earthing of Perimeter Fence

A 50 sq mm earth conductor shall be installed 600mm below ground level and 1000mm from the fence, on the outside of the substation, along the entire length of the fence. This earth wire shall be earthed at each corner by means of a 1.8m earth electrode rod. The perimeter earth wire shall be bonded to the fence at 5m intervals. The earth wire shall also be bonded at, at least two points, to the main earthing system.

b) Earthing of Equipment

A 70 sq mm earth conductor shall be buried at a depth of 600mm around each transformer, switch or distribution board and shall be bonded to the main earthing system, as well as to the earth terminal of the related transformer, switch or distribution board.

Earthing of Distribution Boards and Equipment

The earth bar or earth terminal of distribution boards, sub-distribution boards and equipment, shall be connected to the earth bar of the supplying distribution board in accordance with the provisions of

SABS0142, in particular, Table 2 and 3. These connections shall consist of bare, stranded, copper conductors, supplied along the same routes as the supply cables. If the supply connections consist of conductors in conduit, the earth conductors shall be installed in the same conduit.

In addition to the above, the following minimum requirements shall be met:

- a) Size of earth continuity conductor:
 - (i) The minimum size of an earth continuity conductor shall be 2.5 sq mm.
 - (ii) The minimum cross-sectional area of an earth continuity conductor, shall not be less than half the cross-sectional area of the current carrying phase conductors.
- b) Connections:
 - (i) The ends of the stranded copper conductors, shall be fitted with lugs fixed by means of a hexagonal compression crimping tool, brazing or silver soldering.
 - (ii) All earth continuity conductors between distribution boards, shall be fixed to the earth bar, by means of nuts and bolts. Self-tapping screws will not be accepted.
 - (iii) Under no circumstances, shall any connection points, bolts, etc, used for earthing, be utilised for any other purpose.
- c) Ring mains:

Common earth conductors may be used where various circuits are installed in the same wiring channel in accordance with SABS0142. Earth conductors for individual circuits, branching from the ring main, shall be connected to the common earth conductors with T-ferrules or soldered. ***The common earth shall not be broken.***

Earthing of the Installation

The earthing of metallic parts in the installation, shall be done in accordance with SABS0142. The following minimum requirements, shall also be met:

a) Water pipes:

Cold water mains shall be connected with solid 12 x 1.6mm copper strapping to the earth bus bar in the main switchboard. All other hot and cold water pipes shall be connected with 12 x 0.8mm perforated or solid copper strapping (not conductors) to the nearest switchboard. the strapping shall be fixed to the pipe work with brass nuts and bolts and against walls with brass screws at 150m centres. In **all cases** where water pipes are positioned within 1.6m of switchboards, an earth connection consisting of copper strapping, shall be installed between the pipe work and the board. In vertical building ducts accommodating both water pipes and electrical cables, all the pipes shall be earthed at each distribution board.

All hot water pipes are to be earthed, at the geyser outlet point, to the nearest distribution board.

At wash basins, metal hot water, cold water and drainage pipes, are to be bonded to each other by means of 12 x 0.8mm perforated or solid copper strapping.

b) Roofs:

Corrugated iron roofs and gutters, shall be earthed by means of 12 x 0.8mm copper strapping (not conductors), fixed with galvanized bolts and nuts. Self-tapping screws will not be accepted. One bare 10 sq mm copper conductor shall be installed over the full length of the ceiling void, fixed to the top purlin and connected to the main earth conductor of **each** switchboard. The roof and gutters shall be connected at 15mm intervals to this conductor.

c) Cable ladders and trays:

- (i) Where there are breaks in the cable ladder or cable tray installation

- (e.g. at bends or at wall penetrations), the two sections of cable ladder or tray, shall be bonded to each other by means of a 35 sq mm bare stranded copper conductor.
- (ii) Cable ladders or trays shall be bonded to the earth bus bar of the distribution board, by means of a 35 sq mm bare stranded copper conductor.
- d) PVC conduit

Where PVC conduit is installed, stranded copper earth conductors shall be installed in the conduits, and fixed securely to all metal appliances and equipment, including switch boxes, plug boxes, draw boxes, switchboards, light fittings, etc.

4.23 LIGHTNING PROTECTION

The lightning protection installation shall comply with the requirements of the SABS Code of Practice for the Protection of Structures Against Lightning: SABS03.

Appointment of Specialist

Unless otherwise specified, immediately after the award of the contract, the successful tenderer shall appoint a reputable organisation, approved by the Engineer, to conduct soil resistivity tests on site and obtain proposals for suitable lightning protection of the building.

These proposals by the specialist, shall be submitted to the Engineer timeously. The proposal shall be accompanied by a quotation for the complete lightning protection installation as proposed.

The tenderers shall include the provisional amount, as indicated in the tender form, in their tender price, for the appointment of a specialist and the installation of the lightning protection.

Approval of Design

After the lightning protection design has been submitted to the Engineer for comments and recommendations, the Electrical Contractor shall submit the design to the SABS, for approval.

A transparent drawing of the SABS approved design shall be submitted to the Engineer.

Tests and Test Certificates

The Electrical Contractor shall make arrangements for testing the earth resistance of the lightning protection electrodes, in the presence of the Engineer. Two copies of the test certificate, containing these tests, shall be submitted to the Engineer.

The maximum earth resistance of the electrodes shall be as follows:

Trench earth	50 ohms
Earth electrode rod (before bonding to other electrodes)	100 ohms

4.24 STANDBY GENERATOR PLANT AND EQUIPMENT

ENGINE REQUIREMENTS

TYPE

Except where otherwise specified, the prime mover shall be a diesel engine.

All engines offered shall be naturally aspirated and shall take **full load without switching load out (full load in one step)**, accept if otherwise specified in the Detailed Specification (Part 5).

The load acceptance time must be as short as possible and must not exceed 10 seconds from the time of initiating the starter motor, to the time of switching the unit on to the load.

The engine shall be a multi cylinder, two or four stroke cycle, cold starting, water- or air-cooled, compression ignition, direct injection, industrial type as complying with BS5514 Part 1-5 as amended or similar international specification. The fuel injection equipment must be suitable for operation with the commercial brands of fuel normally available in South Africa.

The engine must be amply rated for the site electrical output, load characteristics and power factor as specified in the Detailed Specification (Part 5). The de-rating of the engine due to site conditions must be guaranteed and strictly in accordance with BS5514 Part 1-5 as amended to date.

The engine must be suitable for continuous running, at rated output at the altitude and ambient temperature, as specified in the Detailed Specification (Part 5).

The output of the engine under the specified site conditions, must be the net available output after allowance for all auxiliary equipment, including air filter, radiator fan, oil pump, water pump, battery-charging alternator, governor, etc has been made.

Engine to be capable of developing sufficient power for a load, 10% in excess of the rated load for the duration of one hour, after the set has been running at full load for a period of twelve hours, without overheating, mechanical strain, incomplete combustion of the fuel or other ill effects. If required, these characteristics must be demonstrated to the Engineer during the acceptance test.

A flywheel (statically and dynamically balanced) of sufficient inertia, shall be fitted to keep the cyclic irregularity within the limits laid down in the relevant BS Specification (although BS649 was replaced by BS5514, BS649 must still be used). No flicker shall be noticeable.

The engine shall be provided with removable cylinder liners.

TURBO CHARGED ENGINES

Turbo-charged engines will only be accepted if the engine supplier can give a written guarantee that the engine will be able to take full load from stand still within a maximum time of 10 seconds (if required in the Detailed Specification), and provide details of load acceptance characteristics.

Turbo-charged engines must have a run down time of at least 5 minutes at no-load speed before shut down.

COMPLIANCE TO EMISSION REGULATIONS

The emission of combustion gasses of the engine shall comply with The Air Quality Act of South Africa (Act 39 of 2004, as amended). The EU Stage 2, emission level is also acceptable.

STARTING AND BATTERIES

General

Engine starting shall be entirely automatic, by means of a battery-operated electric starter motor operating on the ring gear of the flywheel.

The electric starting motor shall be of a type, which is readily available in the Republic of South Africa.

The starter motor is to be of the non-hold-on type, which automatically disengages from the flywheel starter ring when the engine has successfully started.

It must not be possible for the starter motor to be re-energised whilst the engine is running or during the engine stopping cycle (to prevent damage).

The starter batteries shall have a nominal voltage of 12 or 24 volts, and shall be of the lead acid type. The batteries shall have sufficient capacity for six starting attempts each lasting not less than 10 seconds and maximum of 30 seconds, with 10 second intervals between attempts, which sequence shall be fully automatic, with lock-out and alarm failure to start on the last attempt, but shall comprise at least 1 x 195 Ah lead acid type batteries.

The output voltage whilst the last attempt is in operation shall be not less than 75% of nominal voltage, to ensure acceptable control voltage for relays, etc.

Upon handing over the battery shall be in a fully charged condition.

Batteries shall be housed on a suitable stand (corrosion resisting) with protective cover attached to the base frame.

In the case of mobile generators PVC coated angle iron frame of adequate size, shall be provided and be so placed as to allow easy access to the battery at all times. Suitable PVC coated battery clamps must be provided to hold the battery firmly in position.

All battery terminals shall be equipped with anti-corrosive terminals and washers. The cell polarity shall be clearly marked.

After failure of the main supply, the cranking of the engine with the starting equipment shall commence immediately. The change over contactor shall switch over from normal position to stand-by position as soon as the engine has attained normal governed speed. This period shall not exceed 10 seconds. Normal supply voltage is said to have failed when the normal voltage has dropped below 10% of nominal voltage.

Quick easy starting from cold, in cold weather, under winter conditions, is of paramount importance.

Engine Start Failure

A repeat-start control is required so that in the event of the engine failing to start on the first start attempt, the starter motor shall be released and the start attempt repeated.

The repeat-start control shall be mounted in the control cubicle.

The duration of each starting attempt shall not exceed 10 seconds with a period of approximately 10 seconds between successive starting attempts. Should the engine fail to start after the sixth attempt, the repeat-start control shall transmit a signal for alarm purposes, and the start attempt sequence shall be abandoned.

The engine must not start if the alternator potential, the frequency and the oil pressure do not reach their pre-programmed values within a pre-programmed time.

Battery Charger

Provide a battery charger of the combined trickle and rapid charger type with automatic change over. The charger shall be specifically designed to match the charging characteristics of the cells. Documentary evidence to support this may be required from the battery supplier.

Chargers shall be complete with voltmeter, automatic rated ammeters (to indicate the charge or discharge current), and AC/DC protective gear.

The battery charger shall be capable of fully charging the batteries in 4 hours, and shall be fed from the standby power supply.

Provide a battery charger fail alarm.

When used as a mobile unit, it must be possible to power the battery charger from an external source. In the idle condition the battery shall be disconnected via an on/off switch. A label indicating

BATTERY SWITCHED OFF shall be provided.

All terminals must be clearly marked.

Provide over boost charge protection.

FUEL SYSTEM

Required Fuel System

The system consists of a bulk fuel storage plant, complete with pumping station and interconnecting piping, which are more fully described in Part 5 of this document.

The engine and fuel injection equipment shall be suitable for the usual commercial brands of diesel fuel obtainable locally.

The injection pump and valves shall be of a type not normally requiring adjustment in service.

The method of fuel injection and particulars of the injectors and fuel piping shall be clearly described in the tender.

The fuel system shall be equipped with replaceable fuel filter elements which may be easily removed without breaking any fuel line connections or disturbing fuel pumps or any other engine parts.

The fuel system must in all aspects comply with the Fire-regulations of the City of Johannesburg

Fuel Day Tank

The generators shall be supplied directly from the Bulk Fuel system, so no Day Tank will be required.

Fuel Lines

All pump manifolds and valves to be designed so that any individual section can be disassembled and removed without disturbing other sections.

All fuel lines shall be interconnected by means of high-pressure rubber hoses or un-galvanised steel pipes with screwed and socket type joints.

All indoor fuel piping shall be screwed steel tubing, and shall be laid in trenches or mounted on walls etc. in such a way to prevent it from possible damage.

Flexible couplings to allow for machine movement and vibration must be provided.

Fuel-cooling

Details regarding fuel-cooling arrangements, where required in the detail specification, must be submitted to the Engineer for approval. Kindly note that fuel-cooling arrangements must be of the closed loop type in order to minimize fire hazards. Under no circumstances will a system be permitted where the fuel is open to the atmosphere.

General

Alarm contacts shall be provided and arranged to operate when the diesel reserve drops to 30% of the tank capacity.

A suitably sized fuel filter/water separator similar or equally approved to Racor or GUD CF1000 must be fitted in the fuel line to the fuel filters.

Provide a hand pump and pipes to pump fuel from drums to tank if needed.

The interior and exterior of the fuel tank must be thoroughly de-rusted and cleaned. Paint exterior surface with enamel paint.

GENERATOR COOLING

Water-cooled Engines

In the case of water-cooled engines, the cooling system shall be thermostatically controlled, entirely self-contained and shall consist of a radiator, fan and circulating pump.

A corrosion inhibiting, non-slugging chemical must be added to the engine cooling circuit. Contractor to advise on the cooling water additive requirements.

Radiators must be of the heavy-duty air blast, tropical pressurized type, adequately sized for continuous full load operation of the set.

The capacity of the fan shall be sufficient to provide the required engine cooling and plant room/canopy ventilation.

The manufacturer shall indicate the method of driving the fan and pump (whether it is by mechanical coupling to the engine or by means of an electric motor).

Fit a 220V ac electrical immersion heater or heaters and thermostats to engine's water jackets, capable of maintaining jacket temperature to ensure easy starting. The heated water must be able to circulate through the whole system.

Fit the unit as such to permit withdrawal without draining the water.

The heater connection shall be brought out to a separate terminal strip.

The hoses connecting the engine to the radiator shall be of a robust and approved vibration resistant design.

If requested in the detailed specification, a cooling tower with its associated heat exchanger, pump, air release valves etc shall be provided. The manufacturer shall indicate the required pipe sizes, temperature gradients, water flow and air volume required for cooling the engine.

The following alarms shall be provided:

- (i) Water flow – after pump
- (ii) Air flow - fan failure

The direction of water flow shall be indicated on the pipes.

The radiator shall be fitted with a 100mm wide stub duct to allow for the mounting of the radiator cowl.

The engine must be fitted with blower fan and cowling between radiator and outlet louver and contractors must ensure that radiator exit air is expelled through the outlet louvers in an efficient manner and without the possibility of re-circulation of cooling air.

Air-cooled Engines

Air shall not be re-circulated through the plant enclosure (room or canopy).

A heater or heaters shall be fitted to the engine sump to maintain the engine at a suitable temperature for cold starting.

General

Contractors must pay particular attention to room/canopy cooling arrangements. Where no mechanical ventilation for the room/enclosure is provided, the engine driven fan must provide sufficient mass of cooling air under the most arduous conditions of ambient temperature and humidity and station load, to ensure stable engine temperature conditions.

Air volume through the intake and outlet louvers must be adequate to sufficiently scavenge the room/enclosure to maintain room temperature to an acceptable level. Fresh air for cooling and aspiration shall be drawn from the outside.

Suitably sized inlet and exhaust grille shall be louvered, and shall be of a robust, impact and corrosion resistant design.

All ducting or piping required, form part of this contract.

All cooling arrangements must be to the approval of the Engine Supplier and documentary evidence must be submitted.

The electrical circuit for the heater(s) must be taken from the control switchboard and must be protected by a suitably rated moulded case circuit breaker.

LUBRICATION

The engine shall have a forced fed lubrication system, adequately rated to supply circulating lubrication oil to all bearings, gear trains and important moving parts.

The lubricating oil filter shall be of the renewable element type and suitable for heavy detergent oils which satisfies SABS 400A. The oil filter must be suitable for at least 250 hours of continuous working.

The bearings of the engine shall be suitable for lubrication with the same oils.

A label indicating the grade of oil and frequency of oil changes, must be affixed to the engine.

Fit an oil pressure relay that will operate when the lubricating oil pressure fails below the engine manufacturer's stated safe value.

Mount an oil pressure gauge on the engine or control cubicle.

An automatic lubricating oil level control system shall not be supplied unless otherwise stated.

Incorporate a reputable type of automatic turbo lubricator for turbo charged engines.

Automotive type oil and temperature sensors are not acceptable and the engine must be fitted with suitably rated, normally closed, fail-safe snap action sensors compatible with solid state controls.

Flexible lubrication oil pipes (if provided), shall be of hydraulic quality metal braid reinforced oil resistant piping, with professionally manufactured screw-on or equally approved terminations. Flexible piping slipped over metal piping with hose type clamps, is not acceptable.

The removal of engine oil from the sump, shall be by acceptable means to prevent spillage of oil.

BEARINGS

All continuously rotating engine parts not submitted to pressure lubrication, shall operate in sealed ball or roller bearings.

AIR CLEANER

Fit an air cleaner of the oil bath type or dry element type (cyclone paper filter). The air intake shall be mounted so that air is taken in from the outside of canopy or enclosure sets.

On turbo charged engines the air intake shall be protected while travelling. Oil bath type filters shall not be used on turbo charged engines.

Submit full details with tender regarding efficiency and construction of filters.

EXHAUST SYSTEM

This contract must include for the supply and installation of a complete exhaust system. The exhaust system shall comprise of a silencer or silencers, piping and supports. The exhaust system may be constructed from mild steel with the exception of the flexible bellows mounted between the exhaust system and the engine intake flange. The bellows must be fabricated from suitable quality stainless steel of the type, length and diameter specified by the engine manufacturer.

Flanged joints shall be made with suitable gasket material.

Expansion pieces shall be suitable for the application and shall be selected to compensate for all expansion that may occur in the exhaust system.

All silencers, fittings, etc, shall be painted before lagging with heat resisting enamel.

The exhaust cowling shall be manufactured of galvanized sheet steel or as otherwise specified in the Detailed Technical Specifications.

Exhaust system design must be such that a maximum reading of 70 DB at 7m directly in line with the final silencer axis is obtained at full load. All efforts must be made to isolate the structure from mechanical or airborne vibrations and it is a requirement that no direct connection between any part of the engine alternator frame or exhaust system may be directly connected to any part of a structure, other than through springs, rubber, etc.

Suitable flexibility must be built into the system to firstly, isolate the system from the structure and secondly, to prevent any stresses whatever on the engine intake flanges, particularly where these are directly connected to the

turbo charger. In this regard, relative movement of the engine with the frame surrounding structure must be taken into consideration.

The exhaust pipe must be sized to stay within the manufacturer's recommended values for back pressure, when taking into consideration all elbows, bends, etc. Please note that the factory acceptance tests must be carried out with an exhaust system to simulate actual final site installation conditions.

Provision should be made to prevent rain from entering the exhaust outlet opening and counterbalanced flaps must be provided.

The exhaust system must be provided with an automatic condensate trap and drain valve to prevent excessive corrosion of the system.

The exhaust temperature should not exceed the manufacturer's stated limit.

All parts of the exhaust system must be readily available in the Republic of South Africa.

FINISH

The engine shall not be repainted.

Rubber hoses used on the water, lubricating oil or fuel oil systems and rubber belts, shall not be painted.

SPEED

The engine shall operate at a nominal speed as specified in the detailed specification.

The permanent speed variation shall not exceed 4.5% of the nominal engine speed. Suitable external facilities must be provided to adjust the nominal engine speed.

When full load is suddenly switched on or off, the temporary speed variation shall not exceed 10% of the nominal value.

GOVERNOR

A standard electronic/mechanical/hydraulic governor shall be fitted to comply with Class A1 governing in accordance with BS5514, and must give the required performance when used in conjunction with the specified governor control.

COUPLINGS

All flexible pipe couplings, between engine, fuel tank, filters, pumps and drain system, shall be with proper crimp on couplings.

DRAIN COCK

The Engine shall be supplied with an extended drain cock. Drain cock to be supplied with a padlock to lock in closed position.

Mount a No 2 Steward & Lloyds or similar, hand pump on the base frame and connect to oil drain plug of the engine sump with the necessary flexible pipe work for draining the engine oil into drums.

DRIP TRAY

Provide a suitable drip tray underneath the engine. The tray shall be of sufficient length and width to catch any drops of lubricating oil or fuel, and shall not be less than 75mm deep.

The drive belts must be overrated for the duty expected of them, and must not stretch in use, i.e., should require as little adjustment in use as possible.

CANOPY HOUSING

Generating Plant Enclosures/Canopies shall be manufactured to the highest quality and durability. Canopies shall be designed in such a way that air

supply for engine aspiration and engine cooling is sufficient and according to manufacturer's specifications.

Canopies shall provide full protection for the power plant but shall be fully accessible for maintenance purposes like oil/filter etc services and replacement of engine and alternator parts.

Canopy designs must further allow for exhaust extensions, crane lifting lugs and forklift pockets.

Canopies shall be weather proof and all doors, covers etc shall be properly sealed for this purpose. Door hinges, externally exposed bolts and nuts etc shall be stainless steel.

Soundproof Canopies shall fully comply with the specified sound damping requirements. Sound absorbing materials must comply with safety and flammable standards shall be durable under the high internal temperatures and shall be properly fixed to withstand wind and vibration disturbances.

For outdoor coastal use Canopies shall be manufactured from stainless steel material and powder coated (120 μ m coverage).

ALTERNATOR REQUIREMENTS

ELECTRICAL CHARACTERISTICS

Alternators shall generally be in accordance with BS4999/5000 as amended to date. Performance shall be in accordance with BS2613 as amended to date.

In the case of three phase machines, the alternator stator winding shall be star connected with neutral point brought out to provide a 3-phase 4 wire supply. The neutral point shall be earthed at the machine panel.

The nominal output voltage at normal engine speed and rated load must be 400/230 Volt.

The nominal voltage output for single phase machines is 230V.

The operating frequency must be 50Hz.

Power output must not be less than specified in the detailed specification, and internal power factor to be not less than 0.8 lagging.

The three-phase alternator shall be of the self-excited, self-regulating, brushless, revolving field, and direct drive type, employing an AC exciter with revolving armature and silicone diode rectifier supplying DC exciting current to the alternator field. Automatic output voltage regulation shall be achieved through a feedback circuit between the alternator output and the exciter field. The alternator shall be of the drip proof design, equipped with heavy-duty long-life roller or ball bearings of ample capacity, and shall be provided with a statically and dynamically balanced fan fitted on the shaft to provide adequate ventilation.

The excitation system must give voltage recovery to within 2.5% within 100 milliseconds after a 100% load swing. The transient dip shall not exceed 15%.

Three phase machines must have star point terminals.

The alternator shall be AVR controlled.

The following is applicable for three phase, balanced loads:

A constant output voltage shall be maintained to within 3% of nominal, regardless of load at unity and 0.8 power factor lag, inclusive of cold to hot drift, and inclusive of engine speed drop up to 4.5%.

If the above percentages are any higher, the voltage recovery time is to be indicated.

With any one phase carrying zero load and the remaining two phases carrying 100% load each, the voltage of these two phases shall not deviate by more than 5% of the nominal value.

With any two phases carrying zero load, the voltage of the remaining phase, shall not deviate by more than 7% of the nominal value.

With two phases carrying no load and the remaining phase loaded to 100%, the kVA rating of the single-phase mode shall not be less than 33.33% of the three-phase kVA rating.

The following is applicable for unbalanced loads:

Alternators rated above 35 kVA shall be capable of withstanding a 110% unbalanced load, providing the rated current is not exceeded in any phase. Under this condition the voltage shall be maintained to within 2.5% of nominal.

The alternator shall be capable of sustaining, without harm a load of 110% for one hour as specified. The alternator shall be suitable for supplying both linear and non-linear loads. The linear loads will comprise mainly of air

conditioning compressor motors or lighting, the non-linear loads will comprise of saturable reactor-controlled rectifiers and/or 6 pulse, 12 pulse controlled thyristors. The alternator shall be rated for a non-linear load of 70%, unless otherwise specified.

A good sinusoidal waveform free of slot ripple is essential. At no load, the waveform distortion shall be less than 2%. At full load unity and 0.8 pf lag linear loads the total waveform distortion shall be less than 5% with no individual harmonic exceeding 3%.

The distortion level of the output of the alternator should be limited to the extent that the direct access sub-transient reactance (unsaturated) is 0.15 per unit or better for machines greater than 35 kVA and 0.1 per unit or less for machines rated up to 35kVA.

The maximum wave form distortion of the alternator voltage when supplying 70% non-linear load, shall not exceed 15%, where the rms

value of the harmonic current for any individual harmonic will not exceed the value given by the following equation:

$$I_n \leq I_1/n$$

I_n = rms value of the nth harmonic current

I_1 = rms value of the 50Hz current

N – Nth harmonic

The efficiency of single-phase alternators shall be better than 70%. The efficiency of 3-phase alternators shall be better than 80% for machines with a capacity equal to or less than 16kW and better than 85% for machines with a capacity greater than 16kW. The above conditions shall apply at full load, nominal voltage and 50Hz at a load power factor of 0.8 lagging.

The alternator shall comply with BS4999 section 40.5 in respect of sudden short circuits.

The design of the alternator and regulator system shall be such that it will maintain machine excitation for a period to clear protection circuits, under the following conditions:

- a) any phase-to-phase short circuit
- b) any phase-to-neutral short circuit
- c) any phase-to-phase to neutral short circuit (double earth fault)
- d) three phase-to-neutral short circuit

The alternator and voltage regulator components shall be protected against voltage transients induced by switching or lightning surges. The requirements laid down in IEC publication 60.1 shall be adhered to.

Radio and TV interference suppression shall comply with the latest local legislation.

The insulation resistance between any component and wiring forming part of a circuit and the earthed frame, between any two separate circuits shall not be less than 50 Mega-ohm when tested with 500V dc after steady electrification for 2 minutes. The insulation test shall not be applied to components such as semiconductors, which may be damaged by the high-test potential. Alternatively, the isolation between components and wiring and the earthed frame, shall withstand a test voltage of 2 kV (rms) for all mains circuits and 1 kV (rms) for all dc circuits with the exception of electronic control modules, applied for not less than 3 seconds.

The above tests shall be carried out at a relative humidity of 85%.

Temperature rise under the specified site conditions shall be within the limits laid down in BSS2613 and BSS5000.

AUTOMATIC VOLTAGE REGULATOR (AVR)

In the case of three phase alternators, contractors should offer only three phase sensing regulator systems which take their input supply from either an auxiliary winding contained within the alternator, or from a directly coupled permanent magnet pilot exciter. Shunt connected AVR's will not be considered.

The voltage regulating system shall monitor average values and not peak.

The AVR must be mounted inside the control cubicle if it is not a sealed or encapsulated unit. If the AVR is not sealed and mounted inside the terminal box, the contractor must take the necessary precautions to protect the AVR from being damaged by vibrations.

A suitable terminal strip to terminate the wires to and from the AVR, shall be provided on the alternator, preferably of the plug-in socket type.

All components must be accessible and replaceable. Sealed or encapsulated units are not acceptable.

The automatic voltage control unit shall maintain the terminal voltage within the limits of approximately 1.5V under steady state conditions at any load between no load and full load.

The automatic voltage control unit shall permit the adjustment of the terminal voltage from 385 to 415 volts between phases. This adjustment shall be by means of a screwdriver or similar simple tool in a position, which is normally inaccessible to the operator.

The automatic voltage regulator shall maintain the voltage with a 100V step load test when cold within the limits of approximately 2.5% of the selected voltage for a load variation of no load to full load, a power factor variation between 0.8 and unity and allowing a speed variation of 4.5% over the entire load range.

The AVR shall be protected against failure due to low-speed operation.

All components must be approved to BS9000, or MIL standards. Alternatives will be considered on submission to the Administration.

The AVR shall be of the electronic type.

GENERAL

The alternator shall be equipped with sealed ball or roller bearings capable of operating for at least 720h without attention.

One or more lifting eyes shall be provided.

The complete assembly shall be dynamically balanced up to at least a 25% over speed condition.

PROTECTION

The alternator shall be protected to “IP21 S” or better as defined in BS4999 Part 20.

The alternator cooling shall be in accordance with “IC01” as defined in BS4999 Part 21.

Class H insulation shall be used, but to Class F temperature rise characteristics, as specified in BS4999 Part 32.

The alternator shall comply with the vibration test requirements specified in BS4999 Part 50.

All windings must be protected from adverse operating conditions i.e. high humidity, diesel mist, dirt, abrasive dust etc. (e g VPI or trickle impregnation).

FINISH

Main output terminals, auxiliary terminals, static semi-conductors, resistors etc, to be mounted in a clean area metal terminal box on the alternator frame.

All metal components must be subjected to a pre-cleaning operation to remove grease, dirt, rust, etc, prior to the application of good red oxide primer paint.

The alternator shall not be repainted.

THE CONTROL CUBICLE

GENERAL

The protective gear, control equipment, engine monitoring equipment, generating set circuit breaker, circuit breakers for heaters and battery charger, alternator circuit breaker, AVR, isolators, sensing circuit for starter motor removal and other components shall be housed in a sturdy, rigid cubicle manufactured from sheet steel, not more than 600mm deep, with a minimum thickness of 2mm.

The layout shall be kept neat and orderly, grouping together instruments which serve similar or related functions.

The control cubicle must be totally enclosed, vermin and dust proof with adequate ventilation provided. Suitable dust proofing rubbers shall be fitted (minimum thickness of 6mm).

Access to the cubicle shall be such that all components and wiring can be conveniently reached for testing and maintenance purposes. Doors must have a minimum opening angle of 180 degrees, and must latch when in open position.

The cubicle must be equipped with an emergency 24V or 12V/14W fluorescent light and switch powered from the engine battery.

Circuit panel shall be fitted with adequate vibration pads on the vertical and horizontal level.

The necessary bushings and screens over the terminals shall be provided where the power feeds enter and leave the cubicle.

The cubicle shall be so constructed that the AC and DC components are screened from one another.

All holes, slots etc. shall be pre drilled and pre cut before any spray painting is done. Touch-up work due to negligence shall be rejected.

The control panel must be designed so that the plant shall operate in base load as well as standby application mode.

Provide suitably rated three pole alternator air circuit breaker. The circuit breaker shall be flush mounted, provided with time lag and instantaneous tripping on short circuit.

Overload protection to be adjusted to capacity of alternator and shall be accurate to 10% of its indicated setting. Rupturing capacity shall suit short circuit characteristics of alternator.

Pushbuttons for manual starting and stopping and testing of set, is to be included in cubicle.

All instruments shall be mounted flush on the control panel of the cubicle.

All components required for control purposes such as fuses, contactors, relays etc, shall be mounted inside the control cubicle, but in such a way that they are easily accessible and removable when the front panel has been opened or withdrawn.

A 4-position control selector shall be provided to facilitate the following modes of operation:

OFF – plant entirely inoperative for maintenance purposes.

TEST – in this position the starting sequence and alarm circuits, can be tested without the unit switching onto the standby busbars.

AUTOMATIC – in this position, the plant operates entirely automatically.

MANUAL – in this position, the set must take the load when started with the pushbutton, but not be possible to switch the set onto mains or the mains onto the running set.

Unless otherwise specified, all protection equipment must be mounted in the control cubicle.

An emergency stop button shall be positioned on the front panel of the control cubicle. When depressed, the diesel/alternator shall immediately stop and the load shall be disconnected from the set. The stop button shall be of the self-latching, twist release type.

The stop button shall be red with a minimum diameter of 25mm. A label indicating its function shall be positioned directly above the stop button.

A key switch shall be provided on the engine for emergency situations. No protection shall be provided.

A control circuit shall be provided to operate the engine/alternator set(s) as a station power supply by means of remote signals. The circuit shall override the incoming supply failure timer when the start signal is received. In receiving the remote stop signal, the control circuit shall override the incoming supply restore timer. Both signals will be generated by a remote earth signal.

The supply of the following per plant:

- a) 1 x schematic diagram pasted inside door of control cubicle, behind plastic frame.
- b) 1 x hydrometer.
- c) 1 x set of tools (ring and flat 10mm to 22mm spanners) and engine Supplier's standard toolkit.
- d) 1 x 0-200 A meter – battery tester.
- e) 1 x 85g CO-PA Slip Paste.
- e) Plastic distil water fill can with sprout pipe.

The machine panel must be fitted with a reverse power relay to ensure isolation from the system in the event of reverse power flow.

All equipment/components shall have ample current carrying capacity.

CONTROL CIRCUIT AND PANEL

The control circuit shall be designed with solid-state devices only. The definition of solid state includes discrete elements such as, transistors, diodes, and integrated circuitry. The interface shall be implemented with relays, contactors, etc. The control circuit shall be designed by using fully approved electronic programmable logic controllers. Preference will be given to locally manufactured and programmed control circuits. It shall furthermore be possible to interchange control circuits between different capacity sets, supplied by the same manufacturer without any changes.

Clearly marked labels must be provided.

Test points shall be provided for fault finding purposes.

ENGINE CONTROLS, DETECTORS AND SENSORS

Engine controls shall include the following:

- a) Oil pressure gauge.

Provide an audible alarm on low oil pressure, and automatic shutdown.

- b) Temperature gauge.

An engine temperature gauge and overheating alarm (audible) with engine temperature, measured in cylinder head.

Contractors are to state at what temperature their engines are to shut down, and devices shall be set according to this statement.

The set must automatically shut down on over heating.

- c) Engine fine speed control.
- d) Refuel pushbuttons.

- e) Manual/automatic changeover switch and pushbuttons for manual starting, stopping and testing of set.
 - f) Low level water detectors.
This detector must not shut down plant, but only activate alarm.
 - g) Temperature detector (water cooled engines only).
The engine shall be equipped with a coolant temperature detector, complete with engine mounted gauge.
 - h) Pushbuttons for main contactor operation.
 - i) The alternator shall be protected against failure due to under speed and over speed operation.
 - j) Fuel pressure meter.
 - k) Indicator to indicate whether air filter is blocked.
-
- l) Gear to test the low oil pressure, engine overheating and 10% over-and under speed must be provided and installed on the control cubicle.
 - m) Mechanical means to simulate low oil pressure and engine overheating are to be provided and shall be present under test conditions.
 - n) All the sensors on the machine shall be marked in Red Paint, with symbols in White Lettering.

INSTRUMENTS

All instruments shall be either of the digital or the analogue type and shall be mounted on the control panel.

Digital instruments shall be of the seven-segment light emitting diode type. The digits shall have a height of not less than 10mm, and must be easily readable. The digital instruments shall have an accuracy of 0.5% of the maximum range and shall have at least one decimal digit.

Analogue instruments shall be of the square dial type with a 90 degrees deflection, and must comply with the requirements of BS89 for panel-mounted industrial instruments. The scale shall be linear and read from zero to as near as practically possible to 150% of the engine set's normal rating, with the scale length not less than 96mm. Analogue instruments shall have an accuracy of not less than 1.5% of the full scale deflection. The dc volt and ammeters shall have a scale length of not less than 40mm.

The following instruments are required:

- a) Three (one for each phase) ac instantaneous indicating, maximum demand 15-minute integrating type ammeters, with full-scale reading equal to approximately 120% of the alternator rated output (colour coded), are required. In the case of digital ammeters, additional maximum demand type ammeters shall be fitted.
- b) Implement one ac voltmeter (scaled 0-450V) and a selector switch to monitor line voltage between two of the three phases and to monitor phase voltage between the third phase and neutral.
- c) Dc meters for batteries as specified.
- d) An electric hour meter, capable of registering a minimum of 9999 hours, is required. The hour meter shall indicate engine running hours whether the set is loaded or not.
- e) A frequency meter.
- f) Engine protection gear indicators (if applicable), suitably scaled.
- g) A Wattmeter.
- h) A power factor meter.

ALARM/STATUS INDICATIONS

A control module will indicate the following alarms and statuses by means of high intensity LEDS and an audible alarm up to 80dB, and will at accordingly in order to protect the alternator from any damages:

- Mains Fail Alarm
- Alternator Output Voltage Alarm

- Over speed and Under speed Alarm
- Engine Start Failure Alarm
- Battery Charger Fail
- Low Oil Pressure Alarm
- Coolant Temperature High Alarm
- Coolant Level Low Alarm
- Fuel Level Low Alarm
- Emergency Stop Alarm
- Overload Alarm
- Earth Fault
- Reverse Power
- Alternator Working Indication
- Fault On Alternator Indication
- No Mains Indication
- Electric Fan Failure
- Dummy Load in Operation

The alarm must be cleared by a reset-button.

All present/pre-programmed values must be adjustable. The values must be shown on a digital readout. Secondary protection must be provided. The alarm indicator shall be of the pushbutton-rest type. All alarm/status indications shall be extended to a terminal strip to allow for remote control and monitoring.

The following information in connection with the control module, must be provided:

- General information
- Control instructions
- Circuit diagrams
- Handbook

MAINS FAIL ALARM

When the voltage of the incoming mains varies by more than 10% (adjustable to 20%) from the normal voltage on any phase, the monitor shall signal that the incoming mains must be disconnected and the engine starting sequence initiated.

Should normal supply be restored during the changeover period, the contactor shall remain “normal” whilst plant shall be kept in operation for 3 minutes.

Should main failure occur while plant is still in operation, contactor is to change over immediately.

It is essential that incoming supply failures occurring at short intervals, do not cause a series of starts and stops. A timer adjustable from 1 to 10 seconds is required, and will usually be set to 3 seconds. The signal generated by the mains voltage monitor shall start the timer (incoming supply failure timer). If the duration of the signal is less than the setting

on the timer, the signal is suppressed so that the switching and starting sequence is not initiated. However, if the duration of the signal is more than the setting on the timer, the signal shall be transmitted to initiate the switching and starting sequence.

Upon restoration of the incoming mains to within the voltage limits of 10% of the normal voltage on all phases, the monitor shall signal that the load must be disconnected from the alternator and reconnected to the incoming mains.

It is essential that incoming supply restorations occurring at short intervals do not cause a series of stops and starts. A timer (incoming supply restoration timer) adjustable from not less than 5s to not more than 150s, is required. The timer will usually be set to 150s. The signal generated by the mains-voltage monitor, shall start the timer. If the duration of the signal is less than the present value, the signal is suppressed and the timer resets. However, if the duration of the signal is more than preset value, the signal shall be transmitted to initiate the switching sequence.

It is essential that the alternator be disconnected from the load before the incoming supply is reconnected to the load. A minimum time of 5 seconds is required with a maximum setting of 15 seconds. On receipt of the switching signal, the alternator supply shall be disconnected from the load and the

timer started. After the pre-set time, the incoming supply shall be reconnected to the load.

After the load has been transferred to the incoming supply (mains), the engine shall run without load for a period to cool off and then stop. A timer (the cooling-off timer), adjustable up to 5 minutes, is required.

Should the incoming mains fail while the engine is running under control of the cooling-off timer, the control of the cooling-off timer and the starting sequence shall be cancelled after confirmation of the mains failure.

Test-gear must be provided and installed to test the said operations without interrupting main supply.

ALTERNATOR OUTPUT VOLTAGE ALARM

When the output voltage of the alternator varies by more than approximately 10% on a selected phase, the monitor shall signal that the circuit breaker must trip within a certain pre-programmed time.

If the alternator has been disconnected from the load as a result of this, then upon restoration of the incoming mains to within the voltage limits of approximately 10% on all phases, the monitor shall signal that the load must be reconnected to the incoming mains.

OVER SPEED AND UNDER SPEED ALARM

A frequency monitor shall be provided, which shall shut down the set after an adjustable pre-programmed time, if the frequency exceeds 52.2Hz (over speed), or drops below 47.5Hz (under speed). It shall meet the requirements of class A1 governing. The monitor shall not detect harmonics. The over speed and under speed frequency values must be adjustable.

BATTERY CHARGER FAIL

A loss-of-battery-charge current, alarm shall indicate the failure of the charger. A delay period of 1 minute must be allowed before the alarm is triggered.

LOW OIL PRESSURE

This alarm will indicate a low oil pressure, and will stop the alternator within a certain pre-programmed time.

COOLANT TEMPERATURE HIGH

This alarm will indicate a high coolant temperature, and will stop the alternator within a certain pre-programmed time.

COOLANT LEVEL LOW

This alarm will indicate a low coolant level, and will stop the alternator within a certain pre-programmed time.

FUEL LEVEL LOW

This alarm will indicate a low fuel level.

EMERGENCY STOP

This alarm shall be activated by an active emergency stop input, or in cases where the air inlet is blocked.

OVERLOAD

This alarm is caused by an active overload, and the circuit breaker must trip in a certain pre-programmed time.

This alarm is caused by an earth fault, and must trip the circuit breaker in a certain pre-programmed time.

REVERSE POWER

The reverse power alarm must trip the main circuit breaker.

CABLE AND WIRING OF GENERATORS

CABLES

Cables connected to incoming or outgoing circuits, shall be terminated on the gland type plate, supplied for this purpose. Power cables up to and including 70 sq mm, may terminate on clamp type terminals where the clamping screws are not in direct contact with the conductor. Connection to the equipment can then be made with cables that are similarly connected to the clamp terminal. All power cables larger than 70 sq mm, shall terminate on bus bars that are connected to the associated equipment. Parallel incoming or outgoing cables, shall be connected to a collector bus bar without crossing the conductors.

Contractors must use the existing cable route, and must allow for all excavations (including tar road, cement sidewalk, kerbs etc), additional cable racking, clamps etc that may be required. Contractors must accurately measure the cable run before ordering. All surfaces must be repaired to original finish (tar road, cement sidewalk, kerbs etc).

The contractor must allow for any PVC conduits under the tar road and sidewalk.

TERMINAL STRIPS

External wiring for low voltage, control, interlocking, alarm, measuring and dc circuits, shall terminate on numbered wiring terminals.

The correct terminal size as recommended by the manufacturer for each conductor to be connected, shall be used throughout. The terminal numbers shall appear on the wiring diagrams of the switchboard. Terminals for internal wiring shall not be interposed with terminals for external circuits. Where switchboards consist of separate sections, the control wiring passing between sections, shall be terminated on strips in each section, so that control wiring can be readily reinstated when reassembling the board. Terminals for power wiring shall be separated from other terminals.

CURRENT RATING

The current rating of conductors for the internal wiring, shall be sufficient for the maximum continuous current that can occur in the circuit. This value shall be determined from the circuit breaker or fuse protection of the circuit.

INTERNAL WIRING

Standard 600/1000 PVC insulated stranded annealed copper conductors to SABS 150, shall be employed for the internal power wiring of switchboards. The smallest conductor size to be used for power wiring in switchboards, shall be 2.5 sq mm.

Flexible cord of minimum size 1.0 sq mm, may be used for control wiring.

Where heat generating equipment is present and the internal temperature of the board is likely to exceed 50 degrees Celsius, silicon-rubber insulated stranded conductors shall be used.

Wiring shall be arranged in horizontal and vertical rows and shall be bound with suitable plastic straps or installed in PVC wiring channels. Under no circumstances may PVC adhesive tape be used for the bunching of conductors, or for the colour identification of conductors.

Bunched conductors shall be neatly formed to present a uniform appearance, without twisting or crossing the conductors. Conductors leaving the harnesses, shall be arranged that they are adjacent to the chassis.

Conductors to hinged panels and doors, shall be secured on both the door and the frame and shall be looped between the two points. The loop shall be arranged to produce a twisting motion when the door is opened or closed. A flexible protection sleeve, shall be installed over the conductors.

LOAD END CONNECTIONS

The supply end connections to all equipment, shall under all circumstances, be at the top, and the load end connections at the bottom.

WIRING TO CIRCUIT BREAKERS

Equipment with a rating exceeding the current rating of 70 sq mm conductors, shall be connected by means of bus bars to the main bus bars.

Looped connections may only be installed for a maximum of two outgoing circuits. Where there are more than two outgoing circuits, bus bars shall be used and equipment connected individually to the bus bars. Where miniature circuit breakers are mounted in continuous rows and supplied by bus bars connected to each MCB, each bus bar shall be supplied by a separate conductor. This conductor shall be connected to the bus bar by means of a separate lug and not via an MCB terminal.

CONDUCTOR TERMINATIONS

Connections to circuit breakers, insulators, contactors, etc, shall be made by one of the following methods:

- a) A ferrule of the correct size, shall be used as far as possible where cable conductors are connected directly to equipment with screws against the conductor strands.
- b) Soldering the end of the conductor.
- c) Winding a conductor strand tightly around the end to totally cover the end.

All conductors terminating on meters, fuse holders and other equipment with screwed terminals, shall be fitted with lugs. The lugs shall be soldered or crimped to the end of the conductor. The correct amount of isolation shall be stripped from the end to fit into the terminal. Strands may not be cut from the end of the conductor.

IDENTIFICATION

The colour of the conductors for all 220/250V circuits, shall correspond to the colour of the supply phase for that circuit. Neutral conductors shall be black.

Earth conductors shall be green or green/yellow, except for cases where bare copper earth straps are used.

All control conductors shall be grey.

All conductors that terminate at wiring terminals and all conductors used for the internal wiring of the switchboard, shall further be identified at both ends by means of durable cable marking ferrules. PVC or other tape is not acceptable.

The numbers on the markers shall be shown on the wiring diagrams. Where wiring channels are used, they shall be installed horizontally and vertically. Under no circumstances may power and control circuit wiring be installed in the same wiring channel. Channels shall not be more than 80% full.

All wiring between different panels within the same switchboard shall be installed in wiring channels.

Grommets shall be installed in each hole in the metalwork through which conductors pass.

All wiring shall be installed away from terminals, clamps or other current carrying parts. Wiring shall also be kept away from exposed metal edges or shall be protected where they cross metal edges.

Conductors may be jointed at equipment terminals or numbered terminal strips only. No other connections are allowed.

Where conductors change direction, smooth bends shall be formed with a radius of at least 5 times the outside diameter of the conductor or harness.

Where screened cables are specified, the screening shall be earthed in the switchboard or control board only, unless clearly specified to the contrary. Screened cabled entering control boxes through pressed knockouts, shall terminate in compression glands. Conductors shall as far as possible, remain inside the screening at terminations. Where conductors have to separate from the screen, the braiding shall be separated and the conductors drawn through the braid without damaging the braiding. The conductors shall then be connected to their respective terminals and the screening smoothed and connected to the earth terminal.

Where neutral connections are looped between the terminals of instruments, it is essential that the two conductor ends be inserted into a common lug or

ferrule and are crimped or soldered together in order that the neutral connection is not broken when the conductors are removed from one of the instruments.

Wiring should as far as possible be confined to the front portions of switchboards for ease of access.

A maximum of two conductors will be allowed per equipment terminal. Where more conductors must be connected to the same equipment terminal (e.g. a main circuit breaker feeding other circuit breakers), stud bus bars shall be provided for the various conductors.

CABLE ENTRIES

The cable entries for all sets shall be standard and so positioned that the output cable and sensing leads are in the middle of the side of the set, unless otherwise stated.

For a soundproof canopy and mobile/trailer set, the terminal connections shall be brought out to a lockable terminal box mounted at the rear.

OUTPUT TERMINALS

The terminals shall be clearly marked as follows:

- Red phase
- Blue phase
- Yellow phase
- Neutral
- Earth

A transparent cover plate shall be provided to protect the terminals against accidental contact.

SENSING TERMINALS AND CONTROL CABLE

Two groups of terminals, mounted close to the main output terminals are required for mains sensing, changeover contactor control and for feeding the battery charger, jacket-heater and diesel fuel pump mounted on the diesel alternator set.

BUS BARS AND OUTPUT CABLES

All bus bars used, shall be of the electrolytic tough-pitch high conductivity copper bars only and shall comply with SABS1195-1978 with condition of temper H2 and have a rectangular section and edges rounded off as per table 15 (of SABS1195-1978).

GENERATOR MOUNTING BASE REQUIREMENTS

The engine and alternator shall be mounted on a common rigid base frame, reinforced to ensure permanent alignment of the machines.

Simplex frames will only be considered for skid-mounted sets with a capacity of greater than 600 kVA, unless otherwise stated.

Base frames shall be of the double frame, freestanding type, supported on anti-vibrating frame mountings.

Anti-vibration mounting shall comprise oil hardened and tempered silica-manganese steel springs of robust construction, with conservative spring stresses to assure long life. The maximum static deflection shall not exceed 25mm and the vertical and horizontal movement of the isolated machines, due to dynamic forces, shall be controllable by adjusting screws provided for this purpose.

Base frame construction and sizes, and thickness of the channels, are to be submitted.

The inner frame must be provided with adequate and suitable raised machined set mounting pads, to which the set is to be solidly bolted.

The base of canopy sets must be completely sealed. Provide a drain plug at its lowest point. A label indicating the drain-plug, shall be fitted.

All the metal work shall receive a finishing process, consisting of degreasing, rust proofing and zinc phosphate immersion dip, followed by a double wash dip and forced air drying.

Alternatively, shot blasting and an epoxy powder coating process may be used.

The paint thickness must not be less than 0.075mm.

SET REQUIREMENTS

Each set shall comprise a diesel engine and an alternator mounted on a base. The machines shall be coupled by means of a flexible coupling, and the coupling distance must be as short as possible. This distance and the shaft diameters must be submitted.

Double or single bearing close coupled with adaptor flange construction, may be selected. If single bearing is offered, then the contractor shall confirm that the combination of engine and alternator offered, has been torsional analysed and approved. A test certificate shall be available at the time of factory inspection.

In the case of double bearing, a flexible coupling between the alternator and the diesel engine shall be designed to transmit torque smoothly and to take up any angular or axial misalignment running clearances. There should be no free movement in the coupling.

All moving and rotating parts, such as belts, couplings and fans, shall be protected with suitable guards to prevent accidental injury to personnel. Guards shall be fitted to all engines with side mounted exhaust manifolds.

The engine/alternator combination shall be arranged to run free from excessive vibration and noise under all conditions of load and speed.

The vibration amplitude shall not exceed the limits laid down in BS4999, part 50.

A metal jacket shall be provided on the inside of the door of canopy sets, to hold the various manuals and drawings associated with each set.

PROTECTION

Adequate provision shall be made to protect the control circuits against voltage transients induced by switching or lightning surges. The requirements laid down in IEC publication 60.1, shall be adhered to.

All metal work, including the cabinet, shall be electrically bonded to the earthing terminal. Earth continuity conductors shall not be less than half the cross sectional area of mains cables to the cubicle, with a minimum of 4 sq mm.

The neutral point of the system shall be connected to this bar. Suitable terminals shall be provided on the earth bar for connection of the main earth conductor.

All relays or other components carrying mains voltage, shall be labelled:

“DANGER-MAINS VOLTAGE”

All coils of contactors and relays used in the apparatus, shall be rated at twice, or more, the operating current. All solenoids must have their switching surges suppressed by diodes or RC combinations.

Mains terminals shall be separated by at least 20mm from each other, or from other terminals, and shall be protected from accidental contact. The rod test shall be applied as laid down in the NEMA Standard.

All circuits shall be protected via suitably rated moulded case circuit breakers with a minimum fault level of 5kA. Install suitably rated fuses for all the instruments.

No component in the system is to be adversely affected by spikes and surges in the mains supply.

DUMMY LOADS

Dummy loads, if called for in the Detailed Specification, shall be provided as follows:

The dummy loads shall be rated at 50% of the total kVA output rating of the diesel alternator supplied.

Automatic sensing shall be incorporated to switch the dummy loads in after a 5-to-10-minute period, once the actual load is less than 45% of the rated output of the alternator and shall be switched out when the actual load, excluding the dummy loads, is 50% or more.

The dummy loads shall be parallel to the output circuit after the ACB. (Alternator Circuit Breaker).

The dummy loads shall be positioned in the radiator cowling.

FIXING OF AUXILIARY EQUIPMENT

Self-tapping screws will under no circumstances be allowed for supporting auxiliary equipment, such as the battery charges, regulators etc.

Cadmium coated nuts and bolts shall be used with spring washers. The nut shall be welded to the support structure.

HANDBOOKS AND DRAWINGS

Operating and Maintenance Manuals

The contractor shall prepare and supply manuals for the successful operation and maintenance of the installation. A draft manual shall be submitted to the Engineer after commissioning, for approval. The draft shall then be corrected, if required, and three sets of the manual shall be submitted before first acceptance of the plant will be considered.

These manuals shall contain the following information in the sections indicated, in respect of all sections of the installation.

Section 1 : System Description

A comprehensive description of the system including schematic diagrams, shall be included in this section.

Section 2 : Commissioning Data

The results of all checks and measurements as recorded during the commissioning period, shall be included and shall be compiled in such a manner that every measurement is clearly defined.

Section 3 : Operating Instructions

1. Plant running check list and frequency of service.
2. Safety precautions to be taken.

3. Manual operation.
4. Operator's duties.
5. Lubrication oils and servicing.
6. Pre start checklist for each individual plant.
7. Starting and stopping instructions.

Section 4 : Mechanical Equipment

1. Descriptions of all major items of equipment with the make, model number, names, addresses and phone numbers of the suppliers, manufacturers and their agents.
2. Design capacities of all equipment including selection parameters, selection curves, capacities.
3. Manufacturer's brochures and pamphlets.
4. Schedule of spares with part numbers recommended to be held in stock by the department.

Section 5 : Maintenance Instructions

1. Schedule maintenance particulars, frequency of service and replacements.
2. Troubleshooting guide.
3. Part number of all replacement items and spares.
4. Capacity curves of pumps, fans and compressors.
5. Belt sizes, types and lengths.
6. Serial numbers of principal pieces of equipment.

Section 6 : Electrical Equipment

The following information shall be provided for electrical equipment:

1. Electrical equipment schedule with make, model number, rating, Commissioning setting and name, address and telephone number of supplier.
2. Maintenance instructions.
3. Manufacturer's brochures and pamphlets.

Section 7 : Instrumentation and Controls

1. Description of each individual control system.
2. Control equipment schedule with make, model number, rating, commissioning setting and name, address and telephone number of supplier.
3. Maintenance instructions.
4. Manufacturer's brochures and pamphlets.

Section 8 : Drawings

Paper prints or reduced size print of all contractor's drawings updated to "As Built" drawings.

- a) Wiring and schematic drawings showing detailed circuitry of the following:
 - Engine
 - Alternator
 - AVR
 - Control cubicle
 - The engine, exhaust and piping system
 - The changeover system
 - Interfacing between assemblies, sub-assemblies, components, etc.
- b) 1 x schematic diagram mounted behind a glass in a wooden or metal frame on the wall (if applicable).

- c) 1 x schematic diagram pasted inside door of the control cubicle.
- d) 1 x log-book.
- e) 1 x wood or steel shelf with hinged top for log-book and drawings.
- f) A drawing with clearly defined symbols. Sequence of all operations from start up to shutdown, indicating whether it is drawn with power on or off. All interlocking to be shown clearly.
- g) All wiring diagrams to correspond with panel and machine wiring.
- h) Each wire, component, terminal, etc, shall be clearly annotated on the drawing for identification and maintenance purposes. No drawing shall exceed A1 size. Each drawing shall be properly numbered.

Handbooks and drawings shall be provided on the following basis:

- a) Two copies of every handbook and of every drawing per plant (for Region use).
- b) One copy of every handbook and of every drawing per type of plant (for Head Office use).
- c) Unless handbooks and drawings are available at the time of final inspection, a certificate will not be issued.

The contract will be considered incomplete until all tests have been conducted to the satisfaction of the Engineer and all drawings and manuals have been handed over to the Employer.

TEST OF SET

COMMISSIONING ENGINEER

Contractors must allow in their tender price for the service of an expert commissioning engineer for the installation, testing and final commissioning of the installation.

Should undue problems be encountered at the commissioning stage, the contractor may be requested by the Engineer to obtain the services of a representative or representatives of the manufacturer of specific items of equipment, at no cost to the client.

FACTORY TESTING

Contractors must provide in their tender price for the following:

- a) Testing at the works of the manufacturer or supplier, the completed and assembled installation, working into a dummy load of sufficient capacity to test the combined output of the installation. The exhaust system must be calculated to present at least an equivalent total back pressure to that calculated for the final installation.
- b) The complete installation will be checked for correct functioning of all controls and apparatus. The test shall cover a period of at least two hours. For the first hour the alternator shall be loaded to its full capacity at unity power factor. At the commencement of the second hour of the test, the alternator shall be subjected to an overload of 10%, which shall be maintained for 1 hour. The set shall be capable of carrying this load without overheating the engine or alternator. All costs associated with such tests, will be for the cost of the contractor, as well as the provision of all instruments and ancillary equipment such as dummy loads, cables etc, as well as the diesel fuel and oil.
- c) The contractor must supply all fuel for test purposes.

The following shall be recorded every 30 minutes throughout the tests:

- Voltage across load
- Current through load

- Engine head temperature

Any adjustment made to the set during the test run, shall be recorded on the test sheet.

The supplier shall specifically certify that every set is capable of producing its full output without overheating of the alternator or the engine, when operating under the conditions specified in the detailed specification.

No inspection certificate will be issued if the contractor fails to submit the above test results at the time of final inspection.

SIGNWRITING, MARKINGS AND LABELLING

All meters, switches, indicators, lamps, etc on the face of the cubicle, shall be clearly sign written in English as to purpose or function.

An engraved riveted plate with the following inscription in letters not less than 10mm high, shall be mounted in a readily visible position on the front of the unit:

***“DANGER – MAINS VOLTAGE.
THIS ENGINE WILL START
WITHOUT NOTICE”***

The manufacturer’s rating plate and the identification plate shall be mounted on the front of the unit, and shall include the following in letters not less than 5mm high:

***NAME OF MANUFACTURER
ADDRESS OF MANUFACTURER
SPECIFICATION NUMBER
DATE OF MANUFACTURE
TOTAL MASS OF SET (not including oil, water or fuel)***

All assemblies, sub-assemblies and components, shall be clearly labelled for easy identification on the schematic circuit drawings and wiring diagrams.

TECHNICAL ASSISTANCE

The supplier shall undertake to furnish such technical assistance and information as may be required to overcome any difficulties that may be encountered in the operation of sets.

The contractor shall train two members of the staff of the client in the operation of the equipment, demonstrating all facilities and action to be taken in the event of failure of the equipment, and simulating these conditions, to ensure that the staff is fully conversant with the operation of the equipment. This shall take place before final delivery of the plant.

GUARANTEE

The plant shall be guaranteed against faulty material, faulty design and poor workmanship, fair wear and tear.

The successful contractor will be required to guarantee the complete plant (equipment and workmanship) for a period of 12 months, from the date it has been taken over.

If, during this period, the plant is not working satisfactorily owing to faulty material, design or workmanship, the contractor will be notified, and immediate steps shall be taken by him to rectify the defects and/or replace the affected parts on site at his own expense.

However, should the contractor fail to hand over the plant in good working order on expiring of the specified 12 months, the contractor will be responsible for further monthly maintenance until final delivery is taken.

During this time the contractor will undertake to arrange once per month for a visit to the plant by a qualified member of his staff who shall:

- a) Report to the Office-in-Charge, keeping the maintenance records, and either enter into a log book, the date of the visit, the tests carried out, the adjustments made, and any further details that may be required.
- b) When necessary, clean the plant and its components.
- c) Grease and oil moving parts where necessary.

- d) Check the air filter and, when necessary, clean the filter and replace filter oil.
- e) Check the lubricating oil, and top up when necessary.
- f) After the plant has run on one oil change for the number of hours stipulated by the manufacturers, drain the sump and refill with fresh lubricating oil. The reading of the hour meter on the switchboard will be taken to establish the number of hours run by

the plant. Under this heading, only the cost of the actual oil used, shall be charged as an extra on the monthly account.
- g) Clean the lubricating oil filter, and/or replace the filter element at intervals recommended by the engine manufacturer. The cost of a new filter element to be charged as an extra on the monthly account.
- h) Check, and when necessary, adjust the valve settings and the fuel injection equipment.
- i) Check the battery and top up the electrolyte when necessary.
- j) Test-run the plant for half an hour, check the automatic starting with simulated faults on each mains phase and check the proper working of all parts, including the electrical gear, the protective devices with fault indicators, the changeover equipment and the battery charger. Make the necessary adjustments.
- k) Report on any parts that become unserviceable through fair wear and tear, or damaged beyond control of the contractor. The contractor, on receiving the report, shall immediately submit a detailed quotation for the repair or replacement of such parts.
- l) Advise the client when it has become necessary to decarbonise the engine, and submit a quotation for this service.
- m) Top up the water of the radiator, if applicable.

After the lapse of the 12 month period, the contractor may be required to enter into a maintenance agreement as described.

This agreement will initially be for one calendar year and monthly visits or at intervals as required by the local authority. The agreement may subsequently be renewed for yearly periods.

The availability of all spares/components, shall be guaranteed for a minimum period of **10 years**.

DEVIATION FROM THE SPECIFICATION

The tenderer must note that any deviations from the specification must be specifically pointed out on an item-by-item basis at the time of tender, whether in the information schedule or elsewhere, or both. Reference to appended literature, catalogues etc, can be used to signify deviations from the specification. In the absence of any such information, it will be assumed that the contractor is offering equipment which conforms strictly with the specification and the successful tenderer will therefore not be permitted to supply and install any items of plant and equipment not strictly conforming with the specification, without the prior written approval of the Engineer. Any costs associated with such alternate supplies, will be entirely for the cost of the successful tenderer.

SPARE PARTS AND AGENCIES

Where tenderers offer plant embodying units of manufacture, other than those of the principals, and for which they are not the accredited South African Agents, and for which they do not stock parts, they should state in the tender the name of the accredited South African Agents who will be able and licensed to services the engine etc. and from whom spare parts for such units are obtainable.

In all cases, tenderers should furnish an undertaking from the agents to the effect that they are prepared to carry the necessary stock of spare parts for their particular units and that they will be able and are licensed to service the particular units.

Tenderers are also required to furnish the same undertakings with regards the spares of units manufactured by their own principals.

Lubricating oil filter elements, air filter elements and diesel fuel filter elements, sufficient for 1000h of continuous running, shall be supplied with each engine.

TOOLS

All special tools required, i.e., tools specially designed for the particular equipment offered, must be supplied and listed in the tender offer, and included in the unit price. In the case of a number of identical items of plant being supplied, it will only be necessary to supply two sets of tools covering all units and not one set for each unit.

Contractors must state what general-purpose tools and equipment are considered necessary, and whether these tools are supplied.

It is the responsibility of the contractor to ensure that all tools are handed over to the Engineer on completion of the contract, in brand new condition. Damaged tools will not be accepted and the contract will not be considered complete until such tools are satisfactorily received. Tools handed over should be suitably mounted on a wall board, or supplied in a high-quality metal tool box or other container as may be agreed to by the Engineer.