

C1037-002-EE-004

BACKUP GENERATOR SET SPECIFICATION

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GENERAL TECHNICAL SPECIFICATION

1. GENERAL

This is a typical standard specification that covers the supply, delivery, complete installation and testing on site in full working order and the guarantee of new diesel generator plant as detailed below.

Brochures with full technical particulars, performance curves and illustrations of the equipment offered must be submitted with the tender. Contractors may quote their standard equipment, complying as close as possible with the specification, but any deviations from the specifications must be fully detailed.

The schedules following this specification must be completed by the Contractor in all respects.

The Employer reserves the right to accept any portion of any tender and does not bind itself to accept the lowest or any offer.

2. REQUIREMENTS

The diesel engine alternator set shall be robust in construction, of the heavy duty, industrial engine type with speed not exceeding 1500 RPM and shall comply with SANS 8528. The set shall be fully automatic, i.e. it shall start when any one phase of the main supply fails, and shall shut down when the normal supply is re-established. The set shall be capable of delivering the specific output continuously under the site conditions, without overheating. Maximum ambient temperature can be assumed to be 40° C and the maximum ambient humidity at lowest temperature to be 80 %. The altitude is between below 1 m above sea level. The engine shall be capable of delivering 110% of the specified output for one hour in any period of 12 hours consecutive running, in accordance with BS 5514.

Full particulars, including detailed descriptions, illustrations and curves, with engine performance (output of engine against speed for both intermittent and continuous operation) and fuel consumption curves shall be submitted with the tender.

This shall be an open set frame, the engine and alternator shall be mounted as a complete set on a common steel base which shall incorporate anti-vibration dampers. The set must be placed on a level concrete floor. A drip tray, large enough to catch a drip from any part of the engine and water discharged from the fuel / water separator filter, must be fitted under the engine. All diesel engines must be fitted with a charging alternator for charging the battery.

3. VOLTAGE AND OUTPUT

The output shall be rated to suit the specified, kVA, power factor and voltage ratings as shown on the specification schedule. The engine size shall not exceed the specified ratings by more than 25%. Contractor to complete the attached schedule and return it with the BOQ for evaluation.

4. CONCRETE BASE

The generator plant shall be installed on a reinforced concrete plinth, which must be raised above ground line to prevent water ingress and corrosion. A concrete base shall be cast in situ for each generator plant. The base shall be made of reinforced concrete at least 350mm thick and overlap the plant by 500mm all round. The plinth must protrude 150mm above ground line. The concrete shall have strength of 30MPA after 28 days. It is essential that the base is level. The edges of the base shall be tapered for neatness. Concrete bases shall be cast in position at least 28 days prior to installation of the plant. The base frame of the plant must be bolted / bracketed to the concrete base. Provision must be made in the base for the cable entry and the main earth wire connection. A molthoid strip shall be placed between the concrete base and the generator plant. The generator floor shall withstand a maximum weight of 15 tons. Any designs required for this plinth shall be made by the Contractor and must be approved by a Professional Registered Engineer / Professional Registered Technologist where applicable.

5. DIESEL ENGINE

Diesel engines shall be manufactured in accordance with BS 5514. The engine must be of the solid injection, compression ignition type, running at a speed not exceeding 1500 r.p.m. The engine must be amply rated for the required electrical output of the set, when running under the specified site conditions. **The engine shall be de-rated for the site conditions.** Unless otherwise indicated, the starting period from either automatic or manual switching-on until the taking over by the generating set, in one step, of a load equal to the specified site electrical output shall not exceed **15 seconds**. This must be guaranteed by the Tenderer. The engine shall be easily started from cold, without the use of any special ignition devices, under summer as well as winter conditions, against full load. Water cooled engines shall be fitted with immersion heaters. Turbo charged engines will only be accepted if the Tenderer submits a written guarantee that the engine can deliver full load within the specified period. Emissions from the exhaust shall be kept to a minimum and shall be given at the time of tender.

A remote drain for draining the sump oil and water from the radiator must be extended to the outside of the base frame.

7.1. Battery

The set must be supplied with a fully charged **heavy duty, industrial**, maintenance free lead-acid/calcium type battery, complete with the necessary electrolyte. Batteries shall be of the DELTEC or as approved by the Engineer and shall not be less than 120 Ah rating. The battery will be of sufficient capacity to provide ample starting torque for the engine, which could require up to six consecutive starts. However the battery capacity shall not be less than that recommended by the diesel plant manufacturer.

The battery shall be mounted on a painted non corrodible, battery shelf secured to the base frame. Rubber insertion shall be installed at the bottom of the shelf. The terminals of the battery shall be sprayed red and green with a terminal spray protector.

Where plant is installed indoors within a plant room, a complete set of distilled water bottles, funnel, hydrometer, etc. will be provided in a glass case fixed on to the plant room wall to maintain and test the battery.

7.2. Cooling

Air cooled or water cooled engines shall be acceptable. To prevent excessive running temperatures on water cooled engines, an engine-mounted, tropicalised, pressurised radiator with blower-type fan shall be provided to maintain safe operation at 43°C ambient temperature. The radiator shall be designed for an ambient air temperature of 50° C. Total air flow restriction to and from the radiator shall not exceed 0,12

kPa. The Contractor shall provide duct work with flexible connecting section between radiator and discharge louvre frame. Radiators must be dosed with anti-freeze and a suitable corrosion inhibitor. A low level probe shall be mounted near the top of the radiator to alarm with visual indicator and shut-down the plant. Should the radiator be too narrow to accommodate the probe, then the probe shall be installed in an enclosed cylinder with extension pipe fixed to the radiator. The probe shall be of the Electromech AC DC Dynamics LS 103-3 or similar make.

An audible alarm and visual trip system shall be provided on the control panel to indicate that excessive temperatures have been reached.

7.3. Lubrication

The main bearings and other important moving parts in the engine shall be lubricated by a forced feed system. An audible alarm and visual trip system shall be provided on the A.M.F. panel to operate the stop solenoid in the event of low oil pressure.

7.4. Fuel Pump

An automatic fuel pump must be permanently connected to the fuel tank to enable refuelling from 1000 litre fuel tank. The fuel injection equipment must be suitable for operation with all commercial brands of diesel fuel.

7.5. Fuel Tank

The generator shall have its own diesel tank that shall run for 10 hours at full load. There will be an additional external 1000 litre tank nearby the site.

All fuel pipes shall be steel (but not galvanised) with appropriate bends to provide an expansion facility and flexible connections with armoured covering for vibration isolation at the engine. Copper shall only be used from the primary filter to the engine pump.

7.6. Fuel / Water Separator

A fuel / water separator unit with automatic water dump feature shall be installed in the fuel line from the tank to the diesel engine and shall be mounted above the engine drip tray. The unit shall be of the Duvalco Mk3 DSF type with 10 micron filter cartridge and have a flow rate of +/- 4 litres/min. supplied by *Duvalco Africa*.

7.7. Governor

The speed of the engine shall be controlled accurately by a mechanical governor complying with class A1 to BS 5514 such that when full load is suddenly switched off the temporary increase in speed will not exceed 10% above 1500 rpm. The permanent speed variation shall not exceed 2½% of the nominal engine speed. Manual adjustment must be provided on the engine to adjust the normal speed setting. Engines delivering an output 80 KVA shall be provided with an electronic governor where the engine is electronic.

7.8 Flywheel

A suitable flywheel must be fitted that is large enough to prevent any visible flicker in the lights. The cyclic irregularity of the set must be within the limits specified in BS 5514. The fly wheel must be covered/enclosed.

7.9 Silencer and Exhaust System

The complete exhaust system shall be made of stainless steel.

A residential exhaust silencer (to 65 dB (A)), muffler companion flanges, and flexible stainless steel (suitable for coastal conditions) bellows-type exhaust fitting properly sized shall be furnished and installed according to the manufacturer's recommendation. The generator set should be sound attenuated to achieve an ambient sound level 79dB(A) at 7 metres from the plant. The exhaust pipe shall be secured by flanges both sides of the wall of the plant room at the point of exit and shall extend 0,5m above the room gutters and must be fitted with a weather flap. Exhaust pipes through canopy walls must be flanged where it penetrates the canopy wall to permit ease of removal of the canopy. The exhaust pipe must be flexibly connected to the engine to take up vibrations transmitted from the engine. The exhaust pipe and silencer must be lagged inside the generator room to reduce heat and noise transmission.

The silencer shall be mounted so that its weight is not supported by the engine nor will exhaust system growth, due to thermal expansion, be imposed on the engine penetration. Exhaust pipe size shall be sufficient to ensure that exhaust back pressure does not exceed the maximum limitations specified by the engine manufacturer.

The muffler and all indoor exhaust piping shall be lagged by the installing Contractor to maintain a surface temperature not to exceed 150°F (65.5°C). The insulation shall be installed so that it does not interfere with the functioning of the flexible exhaust fitting. Insulation between the manifold and silencer shall be double 25mm layers of FIBREFAX and the silencer and piping to the outer wall insulated using 50mm thick wire backed INSULWOOL of at least 80kg density. The insulation shall be cladded under tension and riveted with 3mm stainless steel rivets. The cladding shall be 0,7 mm thick 430 stainless steel.

6. ALTERNATOR

Alternators shall be manufactured in accordance with BS 5000. Unless otherwise specified, the alternator shall be of the self excited brushless type enclosed in a ventilated drip-proof housing, and must be capable of supplying the specified kVA continuously with a temperature rise not exceeding the limits laid down in BS 5000 for rotor and stator windings having 'Class H' insulation.

The alternator shall be capable of delivering an output of 110% of the specified output, for 1 hour in any period of 12 hours consecutive running.

The alternator windings will be suitably impregnated and tropicalised to withstand the specified climatic conditions. Alternators shall be of the low harmonic type. An alternator heater will not be required. Contractors are to list the number of similar installations operating in similar climatic conditions.

8.1. Regulation

Since the alternator set could be installed in an area where maintenance staffs are not readily available it is essential to offer regulating equipment which is simple and robust in construction. Complicated equipment requiring specialised knowledge will not be considered.

The alternator shall be self regulated and the voltage regulation limits shall not exceed $\pm 1\%$ of the nominal specified voltage, under all load conditions and at the specified power factor, while the engine speed "droop" variations between no load and full load shall not exceed $4\frac{1}{2}\%$.

8.2. Performance

The excitation system shall be designed to promote rapid voltage recovery following the sudden application of full load. The voltage shall recover to within $2\frac{1}{2}\%$ of the steady state within 300 milliseconds following the application of full load and the transient voltage dip shall not exceed 15%.

8.3. Coupling

The engine and alternator must be directly coupled with a high class quality flexible coupling which is designed to cope with the most severe torque changes, due to instantaneous load changes in the alternator from no load to full load. The flexible coupling shall be of the HOLSET type or equal and similar.

8.4. Computer Power Supply

The Contractor shall ensure that the output has low harmonic distortion and voltage regulation of less than 4%.

7. AUTOMATIC MAINS FAILURE PANEL

The panel will incorporate all of the specified control and protection equipment required to operate and protect the alternator. The preferred AMF panel is a Reid & Associate-AMF control unit or the Generator Control cc. with LAVATO RGAM12/24 generator controller or equal and approved. Control units must be supported by GSM and have modem support with auto-call function for e-mail or SMS sending. It is important that the equipment used in the control panel has a history of use in RSA and that parts are readily available off the shelf.

The visual and audible alarms, battery-charging unit and mains failure sensing relays will also be incorporated in the panel. All instruments are to be flush mounted.

Where solid-state equipment is used for control circuits etc, these shall be of the printed circuit board design, which can be easily unplugged and replaced with standard replacement cards in the event of failure, testing etc. Spares of these PCB cards etc must be available at all times from the supplier of the emergency equipment.

The *Project Manager / Engineer* must approve the panel manufacturer's detailed working drawings of the assembly before any fabrication commences. Any other construction or type of assembly proposed as an alternative to that specified must have the approval of the *Project Manager / Engineer* in writing. The drawings will detail all dimensions of busbars, connections, electrical component make, type and rating. Positions and layout of busbars, earth bars and gland plates will be shown in front and side elevation drawings.

All panel and equipment shall to be designed in accordance with SABS IEC 60439-1 and SANS 1973-1-2 and shall be suitable for operation on supply voltages of 230/400 Volts, 50 Hz, AC.

Panels designed for plant within plant rooms shall generally be of a floor standing cubicle type assembly, suitable for top and bottom cable entries. Schematic drawings will show the specific requirements applicable to each assembly.

Panels designed for plant shall be mounted on the base frame of the plant and provided with vibration isolation from the generator set.

The entire assembly shall be of strong and rigid construction with suitable folded 3CR12 stainless steel frame work, totally enclosed by means of removable 3CR12 stainless steel covers and hinged 3CR12 stainless steel doors where required. The entire assembly shall be manufactured from 3CR12 sheeting of a minimum 2mm thick.

The overall outside dimensions of the assembly shall be suitable for easy handling of the switchgear as indicated on the drawings. The height of the assembly shall generally not exceed 2 100mm above floor level.

All removable covers shall be secured in position by means of patent screw locking devices approved by the *Project Manager / Engineer*. All panels shall be suitably braced to ensure rigidity.

Identification labels in accordance with the specification will be screwed to the front of each door on the panel. The label will describe the purpose of the equipment contained within each compartment.

All hinges and door handles shall be of the bolted-on type and shall be manufactured from non-ferrous materials or stainless steel, suitably finished and treated against corrosion by an electro-plating process. All hinges are to be of the lift-off type and samples shall be submitted to the Representative/Agent (Consultant) for approval.

Hinges and door locks shall be of Barker and Nelson, Zeuss, Yale or equivalent quality to ensure satisfactory operation and a pleasant appearance, and where possible the lock and door catch shall consist of one combination unit.

Door latching and de-latching operations shall be smooth and quick, whilst ensuring proper compression of the sealing gaskets.

The repeated opening and closing of the hinged doors and the operations of the door locks and catches shall not cause chipping or scratching of the painted surfaces or any other blemishes to the finished panels.

Each lock shall have two keys, and where more than one locked panel is specified the locks shall be in one master series. All keys, plus one master key, shall be handed to the Department for which a receipt shall be obtained. One master key shall, in addition, be handed to the Representative/Agent (Consultant).

All keys submitted by the Contractor shall be suitably tagged with the panel designation and location.

Bolts, nuts and washers used throughout the panel shall be of stainless steel with the exception of busbar bolts, nuts and lock-washers which shall be of stainless high tensile steel or high tensile phosphor bronze material.

All screws, bolts, door locks, etc must not be in direct contact with painted surfaces, to avoid sticking or damage to the paintwork.

The 3CR12 panel shall be epoxy powder coated Red (Colour VEP 2002).

This inside of the cabinet door shall be fitted with a suitable holder for the schematic control diagrams, schedules of equipment of the method of operation specification.

All busbars shall comply with the requirements laid down in SANS 1195. The completed busbar system shall be a standard modular system and shall have been tested to SABS approval and a certificate shall be made available confirming the full busbar technical description, current rating and fault rating together with full details of the test results. Busbars shall be rigidly supported by means of approved insulated busbar clamps to prevent damage resulting from the specified short circuit conditions,

Solid high conductivity copper busbars shall be rigidly mounted in the top section of the switchpanel. The busbars must be rated for the continuous full load current, as stated, at a current density not exceeding 1,60 Amps per mm².

If a relaxation of SANS 1973 is agreed to permit the drilling of holes, the cross-sectional area as measured is to be reduced by the area of the holes.

The busbars shall run along the entire length of the assembly up to 76mm from either end, and the incoming collector bars shall be fitted directly below the main circuit breaker or incoming HRC fuse unit.

Sufficient space must be allowed for the connection of all the incoming cables as specified. All busbars shall be identified in the phase colours red, white and blue.

The busbars shall be arranged horizontally with the longer side of the cross-sections in the vertical plane and one behind the other in the horizontal plane at 90mm centres.

All connections and extensions to busbars shall be effected by means of high tensile phosphor bronze nuts, bolts and washers or cadmium plated, high tensile steel bolts and nuts which shall also be provided for future extensions. The minimum diameter of any hole will be 10 mm.

A solid copper earth bar shall be provided inside each assembly at the back and along the entire length, at a height of approximately 500mm above floor level, or 200 mm above the gland plates. A bar is to be provided at the top of the assembly where top entries exist and this shall be solidly connected to the bottom earth bar.

The bar will be supported on robust spacers and will have a minimum clearance of 40mm to the sheet steel panel.

The earth bar shall have a cross-section of not less than 40mm X 6mm and shall be drilled with the requisite number of holes for the individual connection of all cable ECC and other earth conductors.

High tensile phosphor bronze or cadmium plated nuts, bolts and lock washers shall be provided through the earth bar at each earthing position and at least 5 additional holes will be provided for future connections, each being fitted with nuts and bolts as above.

The earthing positions shall be evenly spaced along the length of the earth bar and the bar must be clearly identified as the earth.

9.1. Alternator Protection

Small alternators shall be protected by a triple pole MCB or air circuit breaker with instantaneous short circuit trips and adjustable thermal overload protection of the correct characteristics which shall be provided on the front of the panel. The settings of this unit will ensure that the alternator is adequately protected against all short circuit conditions. Alternatively, on small alternators, fuse protection may be used in conjunction with a phase failure monitor.

Larger alternators shall be protected by an adjustable electronic circuit breaker.

9.2. Parallel Operation

Should parallel operation with other sets or any supply network be specified, it must be possible to synchronise such machines without creating any undue shock or fluctuating conditions.

9.3. Alarm and Protection Equipment

Alarm relays with re-set push buttons are required to give visible and audible alarm signals to protect the plant by shutting it down before any permanent damage results. The visual indication will remain uncanceled until the problem causing the trip has been returned to normal.

The protection required will be:

- OVERLOAD
- TEMPERATURE HIGH
- LOW OIL PRESSURE
- OVER SPEED
- UNDERSPEED

- START FAILURE
- LOW WATER LEVEL
- In addition, one DIESEL FUEL LOW level alarm and indication as well as one BATTERY/CHARGER FAILURE alarm and indication must be provided which does not trip the engine. Provision must be made for both these items to be remotely alarmed.
- FUEL TANK EMPTY – to trip the engine before the fuel runs out completely so as to avoid bleeding the engine on refuelling. The lights and associated push buttons will be engraved accordingly.

One common hooter (Klaxon type SY2/725) and red flashing light is required to be mounted on the outside wall of the plant room with the alarm cancel button mounted on the control panel. The alarm system must be supplied from the starting battery.

Provision is also to be made for remote alarm indication and remote cancellation in the charge office.

A remote alarm panel shall be supplied and installed in the charge office with a connecting 2,5mm² 4 core pvc/swa/pvc cable from the generator control panel. The remote alarm panel shall incorporate a mains on and generator on and not in auto indicators, a low fuel, low battery, start fail, and genset fault indicators and relays as well as an electronic sounder (with low sound level) and a silence button. The silence button shall not switch off the pilot lights – pilot lights can only be switched off when the fault has been cleared at the generator panel.

9.4. Start and Stop Delay Timers

Where connected to a rural supply system with auto-reclosing protection, an adjustable timer (0-180 sec) will be fitted to prevent starting as a result of transient faults. The engine control system is also to be fitted with an adjustable timer (0-3 minutes and set on 1 minute) which will keep the engine running on load for a pre-set time after the mains power has been restored to normal. An additional timer (0-10 minutes and set on 8 minutes) will keep the engine operating on no load for its 'run-down' period. It shall be possible for the set to take load again without adverse effects.

9.5. Operation Selector

A four-position selector switch is to be provided on the AMF panel to select the mode of operation, which could be – 'Auto', 'Manual', 'Test' and 'Off'.

With the selector in the 'Auto' position, the set is to automatically start and stop, according to the mains supply condition.

In the 'Test' position the engine shall be capable of being manually started and stopped without the alternator picking up any electrical load, to ensure that starting equipment, battery etc. are in operational condition. This routine will be repeated every week and a logbook recording this fact must be provided in the plant room.

With the selector in the 'Manual' position, the set must pick up the electrical load when started but it must not be possible for this supply to be paralleled with authorities supply. A change over relay/contactors is therefore to be provided in the main distribution board.

In the 'Off' position the set shall be completely isolated and cannot be started manually or automatically. This setting will be used for maintenance of the machine only.

9.6. Battery Charging

The AMF panel is to include a fully automatic battery-charging unit to keep the battery at its optimum condition at all times. The preferred charger unit is the LAVATO model BCE or equal and approved. The system shall ensure that the batteries are not overcharged by being permanently connected to the

charging system. The charging current must reduce to 30% when the battery voltage is above 50%. The charging circuit must be able to inhibit:

A short circuit at the battery charger terminals

Inverse battery polarity

Low battery charge ($< 0.2 U_c$)

The output current of the charger shall not be less than 3 amps at 12 volts.

An alarm relay output will be required.

Fuse protection must be provided on the input supply and on the battery output.

An ammeter and voltmeter suitably scaled to indicate the trickle charging supply will be flush mounted in the front panel. The voltmeter will operate by depressing a spring loaded push button and will not remain in the circuit continuously.

9.7. Panel Equipment

The following items of equipment will be fitted to the panel:

- One flush mounted 72mm x 72mm PCI voltmeter scaled to the specified voltage to read all phase-neutral voltages.
- One 7 way voltmeter selector switch to suit item 7.7.1 above.
- One 72mm x 72mm frequency meter showing alternator frequency.
- One run hour meter with cyclometer counter showing the actual running hours of the engine.
- 3 - 2 amp HRC fuses for the voltmeter circuit, including spare fuses.
- 3 - 72mm x 72mm maximum demand indicating ammeters scaled to the specified maximum load current, complete with current transformer, to indicate the current in each phase of the alternator.
- One phase rotation indicator.
- One suitable rated main isolating switch to isolate the complete board.
- One adjustable type triple pole MCB or air circuit breaker rated to protect the alternator.
- One four-position selector switch as specified.
- One emergency stop push button behind a hinged cover.
- Two push buttons (green and red) marked 'Start' and 'Stop' for test operation.
- One complete battery charger with instrumentation to be operated from the mains supply.
- One alternator charge indicator with 30-amp deflection.
- One start-delay timer.
- One stop-delay timer.
- Relays and reset push buttons for engine protection with spare lamps.
- One lube oil pressure gauge and relay with shutdown for low pressure.
- One low fuel level relay device and spare lamps.
- One fuel tank empty cutout relay and spare lamps.
- One low water level relay device and spare lamps.
- One battery/charger relay device and spare lamps
- One 12 Volt DC. Hooter/alarm with protection fuses, cancellation button, etc and terminals for the operation of a remote alarm.
- One push button for manual start operation.
- One set of terminals and all interconnecting wiring including earth connections.
- One on-load by-pass switch in separate cubicle as specified.
- One spring-reserve seasonal time switch or photocell.
- Surge arrestors for all 3 phases and the neutral.
- Any other equipment necessary for the correct and safe operation of the installation.

9.7. Marking

All instruments, lights, push buttons etc are to be provided and will be marked with Trafolyte engraved labels, screwed to the panel. The lettering shall be 6mm high. All labels will be in English and any other Official Language as directed by the Representative/Agent (Consultant).

All engine instruments shall have clear markings on the faceplates, indicating the normal operating zone(s). Maximum and minimum allowable values/limits and danger zone(s).

The base frame or other suitable location shall be marked with the recommended oil type to be used in the engine.

9.8. Change Over System

The main switchboard shall be divided into two sections for 'mains supply' and 'mains/emergency generator supply'. Two specified three pole contactors rated for AC3 operation or two motorised circuit breakers shall be incorporated in the switchboard to facilitate the automatic change over of supplies, but they shall be electrically and mechanically interlocked to prevent the generator from running in parallel with the mains supply.

An engraved plastic danger notice is to be prominently fixed on the switchboard stating that "This switchboard can be automatically energised from the emergency generating set."

9.9. By-pass Switch

The main switchboard must be equipped with a manually operated on-load by-pass switch, which shall connect the incoming mains to the automatic control gear or directly to the outgoing feeder. In the latter position, the automatic control gear, including the main contractors, shall be isolated for maintenance purposes. A triple pole on-load isolator is to be provided to isolate the mains. It shall not be possible to start the engine except with the selector switch in the "Test" position.

It is required that this by-pass switch and mains isolator be mounted away from the automatic control gear in a separate compartment either on one side or in the lower portion of the switchboard and that the switches are operated from the front of the cubicle.

8. EARTHING & LIGHTNING PROTECTION SYSTEM

The system shall comply with the relevant requirements of the following specifications.

- SANS 10313 : Protection of structures against lightning
- SANS 10199 : Design and installation of earth electrodes
- SANS 1063 : Earth Rods and Couplers

Only SABS approved earth rods and couplers bearing the SABS mark must be used.

10.1. Earthing

The neutral of the system and the alternator must be solidly earthed. The Contractor shall provide a 500 x 50 x 6mm thick copper bar fixed to the plant room wall on two insulators rated at 500V. The earth mat shall consist of 70mm² bare standard copper conductor and 4 or more 1500mm long x 16mm diameter earth spikes to achieve a maximum resistance of 10 OHMS. The earth mat shall be spaced 4 metres from the plant room. Two 70mm² insulated copper conductors shall connect the diagonal ends of the earth mat and earth bar within the plant room.

10.2. Lightning Protection

Aluminium roof conductor shall be installed on the roof and bonded to a down conductor and then connected to the 1500mm long earth spike via 70mm² insulated copper conductor. Bi-Metallic connectors are to be made at all aluminium and copper connections. The lightning protection and earthing system shall be bonded to ensure that they are at the same potential

Suitable surge arresters must be installed on each phase and the neutral in the AMF control panel and connected to the earth bar.

9. WARNING NOTICES

A non-corrodable and non deteriorating engraved warning notice will be wall mounted in a conspicuous position reading:

“Danger: This engine will start without notice. Turn selector switch to ‘Off’ position before working on plant. (Do not forget to reset)”.

In addition all statutory notices required by the Occupational Health and Safety Act No. 85 of 1993, for the handling and generation of electrical equipment.

10. INSPECTION AND TESTING

12.1 General

Because of the number of Contracts and the need for the project to function as a co-ordinated whole, particular emphasis will be paid to testing. No test will be recognised unless it is documented in a previously agreed format. The test procedure shall ensure that every combination of switches and events is tested for correct functioning and each such combination is recorded in a test sheet and checked off.

No plant or equipment may be energised until testing is complete and the results accepted by the Representative/Agent (Consultant).

The Contractor shall supply all test equipment and consumables.

The Contractor shall conduct tests at the following stages. The Representative/Agent (Consultant) shall be advised of the tests one week in advance of the test dates.

- a) At manufacturer’s work before equipment is released to site.
- b) During installation where testing is necessary
- c) Before final connections are made
- d) After installation is complete

After the tests are complete the Contractor shall compile and submit a report to the Representative/Agent (Consultant). After submission of the test report the Representative/Agent (Consultant) may call for all or some of the tests to be repeated in his presence. Should any test be unsatisfactory at this time the Representative/Agent (Consultant) reserves the right to have his reasonable abortive costs deducted from the contract sum.

12.2 Inspections during Manufacture

The Representative/Agent (Consultant) or his representative shall have access at all reasonable times to any works where materials are being manufactured for the purpose to the contract and shall be at liberty to inspect the manufacture at any stage and to witness the carrying out of the specified tests. Every

reasonable facility and assistance shall be provided by the Contractor and/or his supplier for the purpose of such inspection by the Representative/Agent (Consultant) or his representative. The Representative/Agent's (Consultant) may reject at any stage of manufacture any material which does not comply with the specification or such modifications thereof as have been agreed by the Representative/Agent (Consultant).

12.3 Factory Testing

It shall be the responsibility of the Contractor to carry out such factory tests as are practicable to ensure that all plant, equipment and components supplied under this Contract comply fully with the relevant specifications and can function as intended. Dummy load tests of the alternators full rated output shall be carried out in the suppliers workshops prior to the plant being despatched to site.

12.4 Inspection on Arrival at Site

On delivery direct to the erection position or to the storage area, the plant and equipment shall be inspected by the Representative/Agent (Consultant) and the Contractor or his agent. The Representative/Agent (Consultant) shall be at liberty to carry out any tests he may deem fit before acceptance.

Payment for delivery to site shall not be made until the relevant items of plant and equipment have been inspected and accepted by the Representative/Agent (Consultant).

12.5 Repairs to Damage

Damage or defects of any kind, which become apparent on inspection or delivery, shall be repaired by the supplier of such items to the satisfaction of the Representative/Agent (Consultant) immediately upon detection. Where damage is such that, in the opinion of the Representative/Agent (Consultant), satisfactory repairs are not practicable, the damaged articles shall be replaced at no cost to the Department which shall accept no responsibility for any loss or damage which may be suffered as a result of delays in obtaining the necessary replacements.

12.6 Testing After Installation

On completion of the installation of all plant and equipment the Contractor will be required to make appropriate arrangements and supply any instruments or apparatus etc. necessary for the testing of all plant and equipment supplied by the Contractor. Testing shall be in the presence of the Representative/Agent's (Consultant's) representative in order to demonstrate compliance with the requirements or the specification.

All load resistance equipment and instruments including fuel oil will be provided by the Contractor and test reports in duplicate for both series of tests will be submitted to the Representative/Agent (Consultant) within 7 days of such tests.

Site tests must include function tests of all operating systems and protection devices.

12.6.1 Insulation Testing

Before starting the generator set after installation, test the insulation resistance of the alternator windings. The automatic voltage regulator (AVR) must be disconnected and the rotating diodes either shorted out with temporary links or disconnected. Any control wiring must also be disconnected.

A 500 volt Megger or similar instrument should be used. Disconnect any earthing conductor connected between neutral and earth and megger an output terminal to earth. The insulation resistance should exceed 5 megger ohm to earth. Should the insulation resistance be less than 5 megger ohm, the winding must be dried out.

11. COMMISSIONING

Commissioning shall proceed in accordance with a previously agreed procedure which shall be documented and which shall form the basis of the commissioning report.

During commissioning the operating parameters of each piece of equipment and each device shall be established and recorded at no-load, average and full load conditions.

The final set of points of all adjustable devices shall be recorded.

The Contractor will be required to make appropriate arrangements, and supply the necessary instruments and apparatus, etc., for the testing of all plant and equipment, in the presence of the Representative/Agent's (Consultant's) representative in order to demonstrate compliance with the requirements of the specification.

The Representative/Agent (Consultant) may require valid calibration certificates to be submitted to cover any meters, gauges, or other instruments used in the tests and may, if considered necessary, arrange for the use of additional meters or other instruments in order to establish the degree of accuracy of the tests.

The Contractor shall be responsible for performing all tests on completion and shall provide the services of an approved Commissioning *Project Manager / Engineer* and all necessary skilled and unskilled labour, as well as the required tools and test equipment. The *Project Manager / Engineer* shall approve the procedure for carrying out the tests on completion and shall witness all tests and shall approve any adjustments or modifications necessary to achieve satisfactory operation.

The *Project Manager / Engineer* shall also witness and approve the tests for demonstrating the plants ability to meet the specified duty. Should the *Contractor* fail to provide the necessary staff to undertake the tests on completion timeously or efficiently, the *Project Manager / Engineer* may, in order to meet the programme for start-up, make arrangements to have the outstanding duties undertaken by others for the *Contractor's* account.

13.1 Load Balancing

It is important to ensure that a balanced load is presented to the generator set. If loading in one phase is substantially higher than the other phases, it will cause overheating in the alternator windings, imbalance in the phase to phase output voltage and possible damage to the sensitive 3 phase equipment connected to the system. Ensure that no individual phase current exceeds the current rating of the generator set. For connection to an existing distribution system, it may be necessary to reorganise the distribution system to ensure these loading factors are met.

12. SAFETY PRECAUTIONS

14.1 Protection of Persons and Plant

Due cognisance shall be taken of the need to provide adequate protection of persons and plant, from accidents arising or likely to arise from whatever source. To this end, all units of plant which may possibly be subject to damage or become a source of danger to human life either in itself or by virtue of its operation shall be adequately protected as laid down in the Occupational Health and Safety Act No. 85 of 1993.

14.2 Appointment of Responsible Person

- (a) The Contractor shall cause all work to be carried out under the general supervision of a responsible person appointed by the Contractor in writing in accordance with the provisions of the General

Safety Regulation R.11. Supervision of any work; made in terms of the Occupational Health and Safety Act No. 85 of 1993.

- (b) A copy of the letter of appointment and of the appointee's written acceptance thereof, shall be lodged with the Representative/Agent (Consultant).
- (c) Work on site shall not commence until the documents referred to in sub-clause (b) have been received by the Representative/Agent (Consultant).
- (d) Due cognisance shall be taken by the Contractor of Regulation 5 "Work in Confined Spaces", of the O.H.S.A. Regulations and further to this no clearance certificates shall be given by this Department.

Precautions shall be taken to avoid safety and health hazards to workmen. The Contractor shall be responsible for supplying protective clothing etc. for use of the workmen.

13. DEFECTS LIABILITY PERIOD

The Contractor shall be responsible for the initial routine maintenance and provision of all lubricants, etc., until such time as the plant and equipment is capable of fulfilling its specified operational duties.

Once the plant and equipment has been successfully commissioned and accepted, the Contractor's staff will undertake the routine maintenance of the plant and equipment for a period of 12 months in accordance with operating procedures and routine maintenance requirements to be furnished by the Contractor prior to acceptance.

The Defects Liability Period shall commence concurrent with the guarantee period.

All cost of servicing and maintenance during this period is to be included in the tender price.

Under the agreement the Contractor will arrange for qualified maintenance staff to visit the plant once every three months and shall, in the presence of the Officer –in-Charge:

- Enter into the log book the date of the visit, the tests carried out, adjustments made and any further notes concerning the condition of the plant and its operation. Also log the hour meter reading.
- Lubricate, grease all moving parts and check and clean all items of equipment as specified in the quarterly maintenance schedule addendum "A" and in accordance with the manufacturer's instructions. Replace all fuel filter cartridges.
- The plant to be tested for automatic starting by simulating a mains failure, and run on maximum possible load for at least half an hour. During this test all mechanical and electrical equipment will be checked for correct operation. All trip alarms and change over relays will be tested for correct operation. All necessary adjustments will be made and recorded in the log book.

Should the Contractor find **any** item which may require replacing due to fair wear and tear or any item which has become unserviceable for the same reason, he will immediately report this matter and submit a quotation in writing to the Representative/Agent (Consultant), detailing the cost of such repair.

The Contractor will advise when it becomes necessary to decarbonise the engine and will indicate the cost of this service.

After the expiry of the 12 month guarantee/defects liability period the Contractor will be required to maintain the generator sets and associated equipment for a further 2 year period.

14. GUARANTEE

The Contractor shall guarantee all plant, equipment and fittings supplied by him and installed under this contract for a period of **twelve months**. The guarantee shall include any latent defects in the plant, equipment, fittings and installation thereof and any labour or other costs inherent in repairing any defects and ensuring that the plant, equipment and fittings remain free of defects and in good working order to the satisfaction of the Representative/Agent (Consultant).

This guarantee shall not be applicable to existing plant and equipment previously installed by others.

Fair wear and tear shall not be considered as requiring any action by the Contractor under the requirements of the contractual guarantee.

Inspection of the plant shall be made by the Contractor in the presence of the Representative/Agent (Consultant), at suitable intervals, to confirm that the plant is operating in a satisfactory manner.

Provision, as required, shall be made in the contract rates, or elsewhere, for any additional costs incurred in providing this contractual guarantee.

15. TRAINING AND INSTRUCTION

On completion of the installation on site, the Contractor will be required to instruct the Staff member-in-Charge in the safe and satisfactory operation of the plant and will ensure that he/she is fully conversant with the equipment.

16. INSTRUCTION MANUALS

Three (3) copies of the operating and maintenance manuals shall be provided on delivery of the plant and equipment. These shall come in the form of plastic covered ring files with the following information indelibly printed on their covers.

OPERATING AND MAINTENANCE INSTRUCTIONS FOR THE
GENERATOR SET AT
Transnet

SUPPLIED BY

(Name, address, email, telephone and fax number of Contractor).

Each page, pamphlet, booklet, diagram, drawing etc. shall be separately bound into the manuals in a clear plastic pocket. Each pocket shall be numbered and indexed.

The first page of each set of manuals shall be an index which shall include a list of the numbers and descriptions of all drawings and pamphlets included in the set and also a list of the Representative/Agent (Consultant)'s drawings relating to the relevant sections of the Contract.

The instructions shall include the following:

- a. A list of spares, tools and testing equipment supplied under the Contract.
- b. A list of spare parts and testing equipment which are not supplied under the Contract but which may be required for future major overhaul and/or testing of electrical plant and equipment.
- c. For (a) and (b) above for spares, tools and testing equipment the Suppliers' names, addresses, telephone numbers, fax numbers and costs must be listed.
- d. List of "Name Plate Data" giving full particulars of serial numbers and other descriptive data pertaining to the plant and equipment installed.
- e. List of points requiring lubrication, stating for each point the type and grade of lubricant recommended and full details as to quantity, timing and renewing of lubrication. Before typing the manuals, the Contractor shall contact the Representative/Agent (Consultant) to obtain the name and brand of lubricants generally in use by the Representative/Agent (Consultant) and, wherever possible, suitable grades of lubricant of that particular brand shall be nominated by the Contractor in the manuals.
- f. Particulars of bearings, contacts and other moving parts with instructions relating to any special attention which may be required.
- g. Precautions to be taken in starting, running and stopping the plant or equipment by remote or manual control.
- h. Routine tests which the Contractor/Supplier(s) would suggest be carried out.

All information mentioned above shall be cross-referenced to the drawings.

Additionally the manuals shall provide the following information which shall also be cross-referenced to the drawings:

- All technical and other information, in English, concerning the equipment.
- Equipment layout drawings.
- Power single line diagrams.
- Control schematic diagrams.
- Narrative description of the control circuit operation.
- Fault finding routines.
- Routine maintenance instructions, procedures and frequencies.

- Equipment and component specification sheets.
- List of equipment and components including manufacturer, catalogue number and suppliers address, fax and telephone numbers.
- Instrument data sheets
- Cable block diagram
- Cable schedules
- Termination schedules
- Issue a certificate of compliance for electrical installations signed off by a currently registered Installation Electrician.

Copies of all computer generated drawings compatible with Autocad version 2002 shall be submitted to the Department on a Compact Disk.

Further one (1) set of drawings relevant to a particular generator and a hard covered A4 size log book shall be placed in a weatherproof glass fibre enclosure adjacent to the generator. This enclosure shall be electric orange in colour, be sized to accommodate drawings folded to A4 format, be labelled "Electrical Drawings" and shall have provision for fitting a standard padlock.