Technical Specification for GENSET

1.0 GENERAL

1.1 DESCRIPTION

.1 Manufacture, test at works, deliver to site, install, test and commission diesel engine driven 400V emergency generators and automatic transfer system.

1.2 WORK INCLUDED

Work included for the complete installation shall not be limited to the following items:

.1 400V emergency generator set inclusive of diesel engine and 400V alternator, all factory-assembled, aligned and tested for fully automatic transfer and retransfer and suitable for continuous operation for the duration of any utility power interruption.

.2 Auto Transfer Switch

.3 Auxiliary equipment.

.4 Daily service oil tank and piping.

.5 Exhaust system piping and insulation.

.6 Cooling water system and heat exchanger etc.

.7 Earthing.

.8 D.C. supply systems.

.9 400V cables, ladders and trays, etc.

.10 Acoustic system

1.3 SUBMITTALS

.1 Tender Stage

.1 Catalogue of complete generator set, engine and alternator, technical data including guaranteed sound power levels and/or

sound pressure levels of the equipment, and maximum transient voltage and frequency of the generator, fuel consumption, losses, efficiency etc. Data submitted shall be considered as guaranteed values.

.2 Type test certificates of alternators by internationally recognised independent testing laboratory.

.3 GA and dimensioned drawings of complete generator set and plinth dimensions and relevant technical details.

.4 The generator set manufacturer shall state the country of origin of the main parts of the generator set and all associated components.

.5 For maintenance and overhaul at site the manufacturer shall indicate the nearest service organisation for the location.

.6 List of equipment and tools recommended by manufacturer for on-site maintenance and commissioning.

.7 Full type test certificates of AMF switchboards from ASTA, UL and internationally recognised independent testing laboratory.

.8 Type test certificates for Moulded Case Circuit Breaker, Air Circuit Breaker from internationally recognised independent testing laboratories, such as ASTA,

.2 <u>Construction Stage</u>

.1 To repeat the above tender stage submission.

.2 A complete scaled drawing showing the exact generator system layout including all components and accessories being provided or required for operation as specified.

.3 Engine manufacturer's catalogue cut sheets, performance data, detailed drawings, power output curves, and fuel consumption curves which relate to the design criteria specified.

.4 Generator manufacturer's catalogue cut sheets, detailed drawings and performance data.

.5 Complete list of materials and catalogue cuts of all components being provided.

.6 Complete detailed control and wiring diagram of the system.

.7 Plinths size.

.8 Certified factory tests/routine tests are to be provided to demonstrate all performance requirements plus ½ hour at 25% load, ½ hour at 50% load, 1 hour at 75% load, 1 hour at 100% load and 1 hour at 110% load. Readings of the following to be taken every 15 minutes: -

.1 Oil pressure, engine lubricating

.2 Water temperature, oil temperature

.3 Ambient temperature

.4 RPM

.5 Power factor

.6 Frequency

.7 Amperes on all phases

.8 Voltage on all phases

.9 Hour run counter

.10 Strip chart recording of all transient response

.11 Relative humidity

.12 Load, percentage of load, KW, KVA

.13 Time

.9 Nameplate information

.10 Dimensions of foundations, structural loading data for coordination with foundation engineer etc.

.3 <u>Inspection and Acceptance Test</u>

.1 Type test and routine test reports prior to acceptance tests

.2 Acceptance test reports after tests

.3 Packaging, transportation and storage notes

.4 Site Installation

.1 Installation methods/Work method statements prior to installation work

.2 Pre-commissioning test procedures prior to pre-commissioning testing

.3 Pre-commissioning test records subsequent to testing

.5 Inspection and Commissioning Test

.1 Site test reports prior to commissioning test

.2 Commissioning test reports after testing

.3 O&M manuals

.4 As-built AutoCAD drawings

1.4 QUALITY ASSURANCE

.1 Except as modified by the Contract Documents, comply with the latest applicable provisions and latest recommendations of the following:-

.1	IEC 60034-1	Rotating Electrical Machines. Part 1 - Rating and Performance.
.2	IEC 60034-4	Rotating Electrical Machines. Part 4 - Methods for Determining Synchronous Machine Quantities from Tests
.3	IEC 60034-5	Rotating Electrical Machines. Part 5 - Classification of Degrees of Protection Provided by Enclosures for Rotating Machines.
.4	IEC 60034-6	Rotating Electrical Machines. Part 6 - Methods of Cooling (IC Code)
.5	IEC 60034-7	Rotating Electrical Machines. Part 7 - Classification Types of Construction, Mounting Arrangements and Terminal Box Position (IM Code)
.6	IEC 60034-8	Rotating Electrical Machines.

		Part 8 - Terminal Markings and Direction of Rotation of Rotating Machines.
.7	IEC 60034-9	Rotating Electrical Machines. Part 9 - Noise Limits.
.8	IEC 60034-14	Rotating Electrical Machines. Part 14 - Mechanical Vibration of Certain Machines with Shaft Heights 56mm and Higher – Measurement, Evaluation and Limits of the Vibration Severity.
.9	IEC 60085	Electrical Insulation – Thermal Classification
.10	IEC 60364-5-54 Buildings.	Electrical Installations of Part 5-54 – Selection and Erection of Electrical Equipment - Earthing Arrangements, Protective Conductors and Protective Bonding Conductors
.11	IEC 60947-3	Low-voltage Switchgear and Controlgear – Parts 3 : Switches – Disconnectors, Switch Disconnectors and Fuse-combination Units
.12	IEC 60529	Degrees of Protection Provided by Enclosures (IP Code).
.13	BS EN 210:2000	Steel Drums. Non-Removable Head (Tight Head) Drums with a Capacity of 216.5 Litres
.14	BS 1387	Specification for Screwed and Socketed Steel Tubes and Tubulars and for Plain End Steel Suitable for Welding or for Screwing to BS 21 pipe Threads.
.15	ISO 5011:2000	Inlet Air Cleaning Equipment for Internal Combustion Engines and Compressors –Performance Testing
.16	BS 2869	Specification for Fuel Oils for Agricultural, Domestic and Industrial

		Engines and Boilers
.17	BS 3900 Pt. E7	Methods of Test for Paints Part E7 - Resistance to Impact (Falling Ball Test)
.18	ASTM D3359-02	Standard Test Methods for Measuring Adhesion by Tape Test ASTM International
.19	BS 3900 Pt. F2	Methods of Test for Paints Part E2 - Determination of Resistance to Humidity (Cyclic Condensation)
.20	BS 5169	Specification for Fusion Welded Steel Air Receivers
.21	BS 6861-2:1997	Mechanical Vibration. Balance Quality Requirements of Rigid Rotors. Balance Errors.
.22	BS 5514 Pt. 1 Reciprocating Internal Combustion Engines- (ISO 30461-1) Performance-Part 1: Declaration of Power, Fuel and Lubricating Oil Consumptions and Test Methods – Additional Requirements for Engines for General Use.	
.23	BS 5514 Pt. 3 Reciprocating Internal Combustion Engines: (ISO 3046-3) Test Measurements.	
.24	BS 5514 Pt. 4 Reciprocating Internal Combustion Engines: (ISO 3046-4) Speed Governing.	
.25	BS 5514 Pt. 5 Reciprocating Internal Combustion Engines- (ISO 3046-5) Performance-Part 5: Torsional Vibrations.	
.26	BS 5514 Pt. 6 Reciprocating Internal Combustion Engines: (ISO 3046-6) Specification for Overspeed Protection.	
.27	BS 7079	Preparation of Steel Substrates Before Application of Paints and Related Products.
.28	ISO 8528 Pt. 1	Reciprocating internal combustion

		engine driven alternating current generating set - Application, ratings and performance
.29	ISO 8528 Pt. 2	Reciprocating internal combustion engine driven alternating current generating set - Engines
.30	ISO 8528 Pt. 3	Reciprocating internal combustion engine driven alternating current generating set - Alternating current generators for generating sets
.31	ISO 8528 Pt. 4	Reciprocating internal combustion engine driven alternating current generating set - Controlgear and switchgear
.32	ISO 8528 Pt. 5	Reciprocating internal combustion engine driven alternating current generating set - Generating sets
.33	ISO 8528 Pt. 6	Reciprocating internal combustion engine driven alternating current generating set - Test methods
.34	ISO 8528 Pt. 7	Reciprocating internal combustion engine driven alternating current generating set - Technical declarations for specification and design
.34	NFPA 110	Standard for Emergency and Standby Power Systems
.35	IEC 60623	Secondary Cells and Batteries containing alkaline or other non-acid electrolytes – Vented nickel-cadmium prismatic rechargeable single cells

.2 Manufacturer shall have a demonstrated performance record and at least 10 years experience in the manufacture of similar equipment. The Generator set shall be manufactured by a genset manufacturer

with manufacturing facility and management system certified to ISO 9001:2000

.3 Equipment suppliers shall have full parts backup and availability for this equipment.

.4 The warranty for the entire generator set and automatic mains failure or paralleling equipment shall be for two years parts and labour from the date of Certificate of Practical Completion. This warranty shall be offered by the manufacturer of the generating set.

2.0 PRODUCTS

2.1 DESCRIPTION OF OPERATION

.1 The function of the standby set is to extent electricity supply for essential services automatically via cabling to the Main L.V. Switchboard (Essential Services) during a TNB mains failure. Under normal mains available conditions, the load is fed via a 4-pole ATS and bypass switch to the Main Switchboard (Essential Services). When the TNB mains fail, the "normal supply" section of the ATS is released and by this action, the set starts automatically. Within the specified time the "generator supply" section of the ATS closes and thus feeds the load from the alternator of the generating set until such time as the TNB mains are restored to normal, thus reverting the ATS to "normal supply" condition and the engine shuts down. The general arrangement of connections is indicated on the relevant Main Schematic Diagrams.

.2 The mains sensing relays to be provided for the set shall be suitable to detect a total failure of the TNB supply or a drop of up to 15% or an increase of more than 10% of the normal rated voltage in any of the 3-phase of the supply. The set shall also be equipped with a device for time delay adjustment (0-30 minutes with 1 minute interval) to prevent the set from shutting down in the event of false mains restoration. A device shall also be provided to prevent the set from starting in the event of a false mains failure or momentary break in the supply. This device shall be adjustable from 0 to 10 seconds.

.3 The automatic start circuit shall be supplied from the "mains" side of the incoming Air Circuit Breakers of the Main L.V. Switchboard.

2.3 DESIGN AND CONSTRUCTION

.1 General

.1 Except as amended in this specification, the manufacturing performance, and testing of the engines and alternator sets shall be in accordance with the relevant parts of BS 5514, ISO 3046, ISO 8528 and IEC 60034 respectively.

.2 The complete generator set installation shall be capable of successfully providing standby power to start and carry load within 10 seconds and run continuously at full load under normal power supply failure or under fire emergency conditions.

.1 Ambient conditions - each set shall be capable of providing full-load under the following ambient conditions: -

Maximum temperature	:	40°C
Minimum temperature	:	20°C
Humidity	:	90%

All generator sets shall be installed indoor with proper ventilation.

.2 The Generator Sets offered shall be derated to comply to ISO 8528.

.3 Alternator rating shall be as indicated on the Contract Documents. Rated power factor shall be 0.8.

Number of phases/wire	:	Three (3)/four (4)
Winding connection	:	Star-connected with neutral earthed

.4 Steady-state nominal frequency at rated power is 50 hertz. Frequency shall be manually adjustable from 49 to 52 hertz. Alternator speed at nominal frequency shall be 1,500 revolutions per minute.

.5 Steady-state nominal line-to-line voltage at rated power shall be 400 volts. Voltage shall be manually adjustable from plus to minus 5 percent of nominal voltage.

.3 Voltage Regulation

.1 Voltage shall not exceed plus or minus 1 percent (difference in average voltage between no-load steady state and full-load steady state).

.2 Voltage steady-load bandwidth shall not exceed ± ½ percent.

.3 Generator must be able to accept a one step load of 70% at 0.8 power factor.

.4 Voltage Transient Performance

.1 Voltage dip with 75% step application at 0.8 power factor up to full load change shall not exceed 20 percent.

.2 Voltage rise with 75% step removal at 0.8 power factor up to full load change shall not exceed 18 percent.

.3 Recovery time shall not exceed 4 seconds.

.4 Frequency Regulation

.1 Frequency (difference in average frequency between no-load steady state and full-load steady state) shall be from 0 percent to 5 percent. It shall be adjusted at Works to 0 percent isochronously.

.2 Frequency steady-load bandwidth shall not exceed plus 1 percent.

.3 Generator must be able to accept a one step load of 70% at 0.8 power factor

.4 Frequency Transient Performance

.1 Frequency dip with 75% step application at 0.8 power factor up to full load change shall not exceed 10 percent.

.2 Frequency rise with 75% step removal at 0.8 power factor up to full load change shall not exceed 8 percent.

.3 Recovery time shall not exceed 4 seconds.

.5 Upon cold start-up, voltage and frequency must stabilize within their specified bandwidths at approximately the same time (difference shall not to exceed 2 seconds).

.6 The noise level shall be not more than 75dB at one metre distance outside the generators room or to the level complying to the requirements of the Department of Environmental, whichever is less. The noise level at the boundary shall not exceed 65dBA during the day time and shall not exceed 55dBA during the night time. The Contractor shall be required to coordinate with other Contractor(s) on the provision of noise abatement measures to ensure that the limit is not exceeded any where outside the generator room.

.1 Reverberation noise in the genset to be added into calculation for noise control.

.2 3 dBA needs to be added into calculation for 2 nos of genset.

.3 The following acoustic equipment shall be installed as minimum requirement: -

.1 Air Discharge duct type silencer
.2 Air Intake duct type silencer
.3 Primary Exhaust Silencer
.4 Secondary Exhaust Silencer
.5 Acoustic Door

2.4 ENGINE

.1 General

.1 The diesel engine shall be of the compression ignition, G3 performance class, four stroke, totally enclosed, water-cooled direct injection, vertical multi-cylinder, capable of cold starting, with two inlet and two exhaust valves per cylinder, toroidal cavity pistons and a common bore and stroke. The engine shall be turbo charged or turbo charged with after cooling of the charge air and shall be suitable for operation at a speed of 1,500 R.P.M.

.2 The brake horsepower of the engine, with all attached accessories as described below, shall not be less than that required by the full load-rating of the alternator taking into

consideration efficiency losses, plus a reserve factor at least nominal 10 percent under environmental conditions of altitude less than 925 metres or equivalent and maximum ambient temperature.

.3 Engine speed is not restricted except to the extend that the engine RPM shall not exceed the engine manufacturer's published curves and shall be suitable for direct connection to the alternator.

.4 The engine with individual cylinder head, shall be of multi-cylinder design, either in line or VEE arrangement. Removable cylinder liners shall be provided. Cylinder liners shall be wet type. The pistons shall be trunk or crosshead type, oil-cooled, of either cast-iron or aluminium alloy. Pistons shall be fitted with both compression and oil-control rings. The crankshaft shall be drop-forged, electrically hardened, and dynamically balanced. Connecting rods and main bearings shall be of the precision removable shell type.

.5 The flywheel shall be both statically and dynamically balanced. The flywheel shall be torsionally approved, compatible with the generator and ground to S.A.E. tolerances and free from harmful eccentricities.

.2 <u>Governor System</u>

.1 The governor system shall consist of electronic control unit, actuator and governor suitable for automatic starting and speed control. The electronic control unit shall have the following functions: -

.1 Idle and rated speed setting
.2 An adjustable ramp from idle to rated speed

.2 A electronic control unit with adjustable droop mechanism maintaining the engine speed within the limits of ISO 8528-2 and ISO 3046-1, and means for manual and automatic adjustment of the governed speed shall be incorporated with the engine. In addition, means of protection against overspeed shall be provided. The governor shall have sufficient sensitivity to control the automatic starting function and to maintain the engine speed within the limits specified in ISO 8528-2.

.3 The class of governing shall be Class G3 in accordance with the requirements of ISO 8528-2. The Contractor shall provide full details and characteristics of the governor that the

proposed to provide to meet this requirement.

.3 Cooling System

.1 Engine mounted radiator shall be provided. The radiator cooling system shall be complete with blower-type fan, water manifold and temperature control valve. In addition, gear-driven engine water-circulating pump shall be incorporated.

.1 Engine mounted radiator shall be provided. The radiator cooling system shall be complete with blower-type fan, water manifold and temperature control valve. In addition, gear driven engine water-circulating pump shall be incorporated.

.2 A heat exchanger of a type and capacity recommended by the engine manufacturer shall be provided. A solenoid valve shall be furnish and mounted on the cooling water inlet side of the heat exchanger. The solenoid valve shall open on the engine start and close on engine stop. A manually operated valve to ensure capacity shall be installed bypassing the solenoid valve to ensure cooling water supply in case of solenoid valve failure.

.3 An expansion / surge tank having capacity for expansion equal to no less than 10% of the jacket water system shall be supplied. The system shall have a pressure / vacuum relief control cap on the filler.

.4 The engine shall be equipped with a centrifugal type water circulating pump and thermostat valve to maintain the engine at recommended temperature level.

.5 The engine cooling system shall include one or more spin-on type engine water filter which will treat the coolant and prevent corrosion and scale deposits inside the cooling system.

.6 The engine cooling system shall be pre-treated by the engine supplier for the inhibition of internal corrosion.

.7 The radiator blower-type fan shall be rated to cater for the static pressure drops across the intake and exhaust air silencers without derating the generator capacity.

.4 Air Intake

.1 Each turbocharger shall incorporate an integral lubricating oil system. Suitable flexible pipe connections shall be used on all entry and discharge terminals selected such that no loads are transmitted from ducting/pipes to the turbocharger casings.

.2 A dry type air cleaner with replaceable elements and silencer shall be furnished as recommended by the engine manufacture. If a dry type air cleaner is used, the filter shall be equipped with moisture eliminator and restriction gauge.

2.5 EXHAUST SYSTEM

.1 The generator set shall be complete with exhaust manifold guard, exhaust silencer, flexible sections, exhaust piping from engine to silencer, adapters and connecting parts.

.2 The silencer shall be critical grade silencing, bottom inlet and outlet horizontal type, drain cock at lowest point and one (1) accessible cleanout port. It shall be finished in rust-preventive primer, heat-resistant paint and completely insulated.

.3 One (1) flexible exhaust pipe section shall be connected between the exhaust pipe and the engine exhaust manifold. It shall be smoke tight, of stainless steel construction and has the same inside diameter as the exhaust pipe. The section shall flex to permit relative motion of engine and exhaust pipe up to 25mm in any direction without strain on engine manifold or exhaust piping.

.4 The following adapters and connecting parts shall be provided as required: -

.1 To connect silencer inlet to exhaust pipe.

.2 To connect silencer outlet to exhaust pipe.

.3 To connect flexible section to engine exhaust manifold outlet flange.

.4 To connect flexible section to exhaust pipe.

.5 Bolts, nuts, lock-washers, and gaskets required for adapters.

.5 A metal manifold guard shall be provided to prevent personnel from contacting the engine exhaust manifold if manifolds are not water-cooled. It shall be rigid construction of open mesh or expanded metal.

.6 The exhaust piping and silencer shall be insulated with 980°C type insulation. They shall be lagged with 75 mm thick rock wool pipe insulation and protected by a1.2 mm (16 gauge) galvanised steel metal shield.

.7 The exhaust piping shall be adequately sized to ensure the backpressure requirement of the engine is not exceeded. The exhaust system shall incorporate sufficient expansion joints and an approved type silencer capable of reducing the noise to an acceptable level.

.8 Where the exhaust system rises above the engine, provision shall be made to prevent any condensate flow into the engine. The exhaust piping shall be connected by a suitable high temperature flexible connector and run overhead, well above head height, so that the exhaust gases will be clear of the working area, and finally through the wall to atmosphere.

.9 The minimum insertion loss required for the primary exhaust silencers are: -

Octave band Frequency							
In Hz	31.5	63	125	250	500	1K	2K
Insertion Loss							
In dB	6	18	28	30	25	22	22

.10 The Contractor shall submit insertion loss data of the silencers offered for evaluation.

2.6 FUEL CONSUMPTION

.1 The Contractor shall state in the appropriate Appendix or prepare a separate chart the fuel consumption at rated output, ¾ rated output and chart ½ rated output when the engine is operating under the prevailing site atmospheric conditions.

.2 The consumption shall be stated in both gallons/hour, litres/hour and pounds per BHP per hour and install be based on a fuel having a nett calorific value of 42.7 Megajoules/kilogram generally complying with B.S. 2869, Class A.

2.7 FUEL SYSTEM

.1 An integral engine driven fuel transfer pump shall be furnished to supply an adequate quantity of fuel under all operating conditions to the engine injection system. Replaceable fuel filter for primary and secondary filtration shall be provided. The design and construction of

the fuel system shall meet NFPA requirement.

.2 An enclosed, fuel injection pump with twin diaphragm type fuel lift pumps. In addition, twin parallel fuel filters with replaceable elements shall be fitted and a 24V shut-down solenoid shall also be provided. A primary fuel filter shall also be included as a feature of the fuel injection system of the engine. The shut-down solenoid should be de-energised to trip with provision for starting.

.3 The diesel engine set shall be provided with a Diesel Storage Tank having a storage capacity sufficient to allow the diesel engine to run on full load for at least eight (8) hours. The tank shall be situated in the same room and complete with the following: -

.1 Supporting stands of sufficient height to gravity feed fuel pump.

.2 Tank filling connection to exterior for vehicle delivery or electric motor pump from barrel. The electric motor pump shall be supplied.

.3 Fuel oil level dial gauge. Sight glass type shall also be incorporated.

.4 Open vent with flame/spark arrester.

.5 Drain connection and plug with sludge and sediment trap.

.6 Fuel supply piping between tank and diesel engine complete with manual isolating valve with facility for locking in the 'OPEN' position.

.7 Inspection and clearing hole.

.8 Drip tray with separate drain connection.

.4 The tank shall be subjected to a test pressure of 0.33 bar (5 psi) for a period of 1 hour on site to the approval of the Architect / M&E Engineer. Compressed air or dry nitrogen may be used for the pressure test. It is not permissible to use water for on-site testing.

.5 The daily service tank shall be manufactured in accordance with B.S. EN 210 for a welded mild steel drum and be complete with an initial fill of fuel oil to B.S. 2869 Class A. The tank, supporting stand and pipework shall be finished in a corrosion resistant finish to suit the environment with a cosmetic top coat (colour to be advised).

.6 For the fuel intake piping system of the generating set, a floor-mounted, motorised type pump is to be utilised to pump fuel from 44-gallon drums to the fuel day tank of the generating set. The pump shall be supplied and installed on the inside face of the wall of the generating plant's room which adjoins the access to the plantroom. One end of the pump's inlet pipe shall be connected to the pump whilst the other end of the inlet pipe shall terminate in a suitable valve, which shall be fitted with means of connection a flexible hose to the oil drum. At the outlet end of the pump, a fuel filter unit (provide with a built-in, removable-type, fine gauge brass gauge fuel filter element) shall be fitted, to which one end of the fuel outlet pipe to the fuel day tank shall be connected.

.7 All fuel piping and connections between the motorized pump and fuel storage tank, and between the fuel storage tank and the standby generator set fuel inlet shall be of black steel Schedule 40 to API with welded fittings. Flexible metallic connections shall be provided where fuel oil lines connect to the diesel engine. A guard or protection pipe shall be provided for all exposed fuel oil piping. A fuel-water separator shall also be incorporated between the tank and fuel pump. Means to enable the entire fuel system to be bled of air using a screwed plug shall be incorporated.

.8 In addition, the day tank shall be internally equipped with a float and sensor switch system (floats to be of copper and switches to be of the sparkless type) for remotely monitoring the fuel level in the day tank - "FULL", "HALF" & "ONE-QUARTER"

.9 The day tank shall be fully filled-up before Certificate of Completion, after all testing and commissioning are carried out.

.10 During the refuelling of the day tank, the electric fuel transfer pump shall be started manually. When the fuel level reaches the "FULL" level, the level switch shall trip the starter of the electric motor pump: Should this action failed to stop, the level switch "FULL FULL" shall be triggered an emergency stop the pump.

.11 A leak-proofed bund wall with a capacity equivalent to 50% of the diesel tank volume shall be constructed to contain any spillage or leaking. An appropriate drain cock shall be provided to drain off any excessive oil.

2.8 OVERFLOW DRIP TRAYS

.1 Drip trays, or other suitable portable receptacles, shall be provided for each plant, one each for fuel and lubricating oil overflow at the engine

and fuel overflow at the day fuel storage tank. These shall be manufactured from good quality sheet steel with welded edges to prevent leaking, and provided with suitable external lifting handles on all sides.

.2 Overflow pipes at the engine and daily service tank shall be extended, where necessary, to a level slightly above the height of these receptacles.

2.9 LUBRICATION SYSTEM

.1 The lubrication system shall include a submerged suction, positive displacement oil pump (integral with the engine) to provide a forced feed, constant pressure to all important points. A lubricating oil filter of the replacement element type, a lubricating oil cooler for oil temperature control, strainer and a relief valve shall be provided.

.2 Only the best quality oils and lubricants shall be used. All lubricants shall be filtered to 10 microns.

.3 Where accessibility to a particular lubricating point would be difficult, provision shall be made for remote lubrication.

.4 Lubrication shall be forced feed. All lubrication pumps shall be gear driven.

2.10 VIBRATION ISOLATION

.1 The diesel engine generator shall be mounted on a structural base provided by the diesel engine manufacturer. The equipment complete with isolation system shall be installed on a 150mm high concrete plinth over the complete floor area of the equipment. Although the concrete trade will complete all concrete work, all such work shall be shown in detail on shop drawings of the vibration base and concrete plinth.

.2 Generator shall be mounted on steel springs with a minimum static deflection of 25mm under the weight of the generator. Integral moulded rubber vibration isolators installed between the engine and skid base is acceptable

.3 Springs shall be selected to provide a ratio of horizontal stiffness to vertical stiffness within the range 80% - 100%. Springs shall allow 50% travel beyond rated load. Springs shall incorporate a ribbed neoprene noise stop pad of minimum 20mm thick (two layers of double ribbed rubber or neoprene of maximum 60 durometer separated by 1.6mm steel plates).

.4 The method of fixing the steel spring to the generator shall ensure that the neoprene noise stop pad is not short circuited by a rigid connection.

.5 Flexible connections between the generator set and exterior systems (such as fuel lines, electrical connections, and exhaust duct) shall be provided.

2.11 STARTING EQUIPMENT

.1 An electric starting motor with solenoid drive shall be furnished on the engine. Starting motor shall be of the required voltage as recommended by the engine manufacturer.

.2 Battery Charger and Batteries

.1 Each generator set shall be provided exclusively its own battery charger and battery bank. The charge and battery bank shall have sufficient capacity for cranking start the generator set using the electric starting motor. The duty and local requirements shall meet the starting requirements of the motor.

.2 In addition, an adjustable timing device shall be built-in with the starting system to prevent immediate consecutive operation of the starter motor, either by push-button or automatically remote starting device, in the event of the engine failing to fire. Such timing device shall allow a lapse of 6 sec. to 15 sec. between each successive restart of the starter motor so as to allow sufficient time for the starter motor to automatically disengage itself from the engine's cranking gear before an attempt to restart is made.

.3 All electrical equipment shall be suitable for operation on a 24 volt DC. Battery supply.

.4 A battery voltage testing meter and hydrometer, etc. shall be provided for routine maintenance.

.5 Battery Charger

.1 A completely automatic battery charger shall be furnished. The battery charger shall be capable of maintaining the starting battery at full charge and shall be of the solid state completely static type which will automatically control the charge rate.

.2 The charging rates shall be adjustable. An ammeter indicating the charge rate and an automatic reset thermal overload circuit breaker to protect the rectifier assembly and transformer shall be incorporated. The rectifier assembly shall be full wave and of the silicon type. The charger shall operate from 230 voltage normal power supply and may be mounted either in the generator control panel or provided for wall or shelf mounting. The high charge rate must be 3 amps for 12 volt systems and 4 amps for 24 volt systems.

.3 A battery charge failure protection alarm unit shall be fitted in each charger unit and arranged to sound in the event of the battery voltage falling below normal float level for a period of 10 minutes.

.6 Batteries

.1 The diesel generator set assembly shall be supplied with a set of Nickel-Cadmium Alkaline Batteries complete with storage stand and protective casing.

.2 Each battery set shall have a capacity at 40°C sufficient to maintain engine cranking speed recommended for the diesel engine through a 6 minute cycle (15 seconds cranking) and 15 seconds rest in 6 consecutive cycles and a certificate shall be provided to conform compliance with the Clause.

.3 The batteries shall be supported on substantial frame being on a concrete plinth, secured against displacement and located close to the diesel driver and in a position where they will not be subjected to excessive temperature, vibration, mechanical injury or flooding with water and shall be readily accessible for servicing. The location shall be chosen to minimise the lead length between the battery and the diesel engine starter.

2.12 INSTRUMENTS AND ALARM INDICATION

.1 The following engine gauges and controls are to be furnished on the generator set in an accessible and convenient location adjacent to the generator control panel: -

.1 Water temperature gauge (inlet and outlet)

.2 Coolant temperature gauge (inlet and outlet)

.3 Oil Pressure Gauge

.4 Oil Temperature Gauge

.5 Governor Control

.6 Turbo Charger Pressure Gauge

.7 Run-Stop Switch

.8 Electrical and fuel controls - for use under manual starting conditions.

.9 Battery start and stop push button to over-ride the complete control system excluding engine and alternator safety and interlocks.

.10 Emergency start and stop push button to over-ride the complete control system excluding engine and alternator safety and interlocks.

2.13 ENGINE PROTECTIVE DEVICES AND ALARM INDICATORS

.1 An alarm indicator panel shall be provided for generator set as part of the generator control panel. Provide 1 no. remote alarm indicator panels for the entire emergency power system as indicated on the Contract Documents, one to be located in the Master Fire Alarm Panel.

.2 Provide alarm indicators. When activated, these alarm shall sound audible alarms and indicate, by means of individual lights at alarm indicator panels, which particular malfunction is initiating the alarm. Provide 5mm high (minimum) labelling to identify the alarm.

.3 Provide a horn at each panel with silence (override) switch to silence the alarm. Override switch shall have flashing pilot lamp labelled "Override" to indicate that alarm is silenced. Provide power for alarm system from generator battery system.

.4 Indicators and controls shall be as follows: -

	Item	Lens Cap Colour
.1	High water temperature	Red
.2	Approach to high water	Yellow

	temperature		
.3	Low oil pressure		Red
.4	High oil temperature	Red	
.5	Overspeed (trip at 1750 rpm)	Red	
.6	Cranking failure (after 60 seconds)	Red	
.7	Generator output failure		Red
.8	Start/stop switch (fire control centre only)		--
.9	Test switch (fire control centre only)	--	
.10	Main circuit breaker tripped	Red	
.11	Running pilot lights for fuel oil pump		Red
.12	Low fuel oil (day tank)		Red
.13	Low fuel oil (main tank)		Red

.5 Engine protection and alarm wiring shall be brought to terminal strip or block that provides for interconnecting the engine protection system to the AMF panel and remote alarm indicator panel.

.1 Terminal strip enclosed in junction box.

.2 Accessible location on electric set.

.3 Terminals labelled to match corresponding terminal strips in AMF panel.

2.14 ALTERNATOR AND EXCITER

.1 General

.1 The alternator shall be engine-driven, synchronous type, AC brushless, single bearing (ball-type oil or grease lubricated) with bearing using the same grade of oil used in the engine crankcase, with intake and open guarded exhaust meeting or exceeding all relevant IEC Standards. The alternator shall be directly coupled to the engine prime mover by means of flexible driving discs.

.2 Alternator output shall be continuously rated (duty type S1 as per IEC 60034-1).

.3 Telephone Harmonic Factor (THF)

When tested on open circuit and at rated speed and voltage, the telephone harmonic factor (THF) of the line-to-line terminal voltage as measured according to the method spelled in IEC 60034-1 shall not exceed the following values for a rated output of the machine:

300kW (or kVA) to 1000kW (or kVA) – THF 5%
1000kW (or kVA) to 5000kW (or kVA) – THF 3%
More than 5000kW (or kVA) – THF 1.5%

.4 Sub-transient Reactance

The voltage dip shall not exceed 15% when applying the sub-transient reactance value.

.5 The alternator shaft shall be of rolled steel. The rotating field pole shall be bolted to the shaft with all other rotating electrical components. This means that the shaft will be free from electrical earth on the shaft.

.6 The alternator shaft with its rotating equipment shall be dynamically balanced up to 25% overspeed condition.

.7 The rotating bridge assembly shall be mechanically constructed with glass cloth impregnated with an epoxy resin binder and shall meet all requirements of IEC recommendation.

.8 The enclosure shall have a fabricated steel main frame with a minimum thickness of 6mm, which is treated in design as a structural member of the complete diesel generator set connecting the engine to the base for three point balanced suspension.

.9 The alternator feet shall have machined surfaces at the mounting rail positions for good axial parallelism.

.10 The alternator shall be equipped with anti-condensation heaters sized to prevent condensation during shutdown.

.11 Product that are persistent or toxic to the environment or that are considered potential carcinogens shall not be used. The use

of hygroscopic materials should be avoided. The materials used shall be selected to prevent contact corrosion.

.12 Alternators shall have jacking bolts or facilities to lift the generator with the aid of a mechanical jacking device to facilitate alignment of the alternator with the prime-mover.

.13 Alternator shall, during installation at site and subsequent maintenance work, allow for inspection of the air gap between stator and rotor.

.14 The degree of protection shall be at least: -

.1 IP 21 for alternator and auxiliaries

.2 IP 21 for the terminal boxes and bearing housing

.2 Method of Cooling

.1 Alternators shall be air-to-air, self-cooled machines with a method of cooling IC 01 - IP23.

.2 When cooling air inlets are protected by a screen, such a screen shall be of corrosion resistant material. Mesh wire of galvanised steel is not acceptable.

.3 Stator

.1 The insulation material used for the stator windings shall be of at least Class F in accordance with IEC 60085.

.2 Alternators shall have their stator windings star connected. The stator windings shall be preformed and be made of rectangular copper conductors adequately covered with glass silk material or other material of a comparable quality.

.3 All windings shall be adequately supported, braced and blocked to provide sufficient rigidity and to limit end-winding vibration and subsequent cracking of the winding insulation at the slot exits. Windings shall be capable of withstanding the dynamic forces which result from system fault conditions.

.4 Alternator frame, including bearing supports shall have sufficient strength and rigidity to avoid distortion or increased vibration as a result of external mechanical forces, e.g. tightening of fixing bolts.

.4 Rotor

.1 The insulation material used for the rotor windings shall be of at least Class F in accordance with IEC 60085.

.2 The shaft shall be made of one-piece, heat-treated forged steel.

.3 Balancing of rotors at nominal speed is recommended, however, balancing below rated speed followed by check balancing at rated speed may be acceptable. Rotors shall be equipped with provisions, such as balancing rings, which allow the addition of balancing weight. Balancing weight shall not be of lead or similar ductile material.

.4 Rotors shall be subjected to an overspeed test at 1.2 times rated speed for duration of 1 minute. The overspeed test shall be considered as satisfactory if no permanent abnormal deformation is apparent. This deformation can be detected if the phase angle of unbalance has changed after the overspeed test. Details are provided in IEC 60034-1.

.5 Terminal Box

.1 A terminal box of sturdy construction shall be provided with ample space for connecting the cable.

.2 The main terminal box and the star-point box shall be made of steel.

.3 The star-point box shall be located at the opposite side of the alternator from the main terminal box. The size of the terminal box shall be sufficient to accommodate the current transformers for the differential and negative phase sequence protection.

.4 Bushings and Terminals

.1 Terminal marking of the main cable connections and the direction of rotation shall be in accordance with IEC 60034-8.

.2 Terminal connections shall be constructed in such a way that direct contact between screws, bolts or nuts and the conductor is avoided.

.3 Clamping devices shall be provided inside the main terminal box of machine to separate and support the

cable conductors, thereby ensuring that the ability to withstand the short circuit current will be maintained after completion of the non-compound filled type of termination. Materials used for clamping devices shall be non-hygroscopic.

.6 Bearings

.1 The Contractor shall provide detailed data and drawings regarding the bearing arrangement. These data shall include but not be limited to: -

.1 Bearing data, e.g. type, size, clearance

.2 Installation instructions

.3 Bearing insulation details

.2 All bearings shall be fully insulated from the alternator frame and/or bed-plate to prevent the flow of shaft current. The method of insulation shall be permanent and non-deteriorating. Manufacturer shall submit detailed drawings showing the proposed insulation arrangement.

.3 The bearing design shall suppress hydrodynamic instabilities and provide sufficient damping to limit rotor vibration to less than the maximum specified amplitudes while at operating and critical speeds. The bearing house housing design shall not require removal of the lower half of end-bells or plate, the coupling lub or the exciter to permit replacement of the bearing liners.

.4 White metal liners and shells shall be protected against corrosion during transport and storage. Product used for protection, shall not require extensive cleaning of the bearings prior to commissioning of the machine.

.5 Rotors shall be secured during transport to avoid damage to the bearings.

.7 Vibration

.1 To permit evaluation of balance and vibration of rotating electrical machines, it is necessary to measure on the machine alone. The test conditions should be properly defined to enable

reproducible tests to be carried out and to provide comparable measurements.

.2 The test conditions shall be complied to IEC 60034-14.

.8 Noise Control

.1 General

.1 IEC 60034-9 shall be adhered to with regard to definitions, notations, measuring equipment/ procedures and calculation methods/procedures.

.2 Noise Limits

.1 Requirements for equipment noise limitations shall be as specified in IEC 60034-9. Procedures for acceptance tests are specified in IEC 60034-9.

.9 Excitation System

.1 The exciter shall be of brushless construction, inboard of the bearing (no external exciters shall be considered), of 3 phase full-wave design with S.C.R. surge suppression generating negligible thermal losses during the normal operation and triggered for a calibrated surge voltage for protection of the rotating bridge.

.2 The alternator shall have the capability of permitting the measurement of the excitation voltage at rated speed. This voltage shall be obtained under any load condition.

.3 The excitation system of the machine shall be designed for a power factor at the generator terminals of 0.8 lagging (overexcited) at rated output and a alternator voltage between 90% and 110% of the rated value.

.4 The current rating of the semiconductors applied in the diode bridge shall not be less than 200% of the maximum current flowing through the elements at maximum continuous excitation current. If parallel connection of semi-conductors is applied, the above current rating shall not be less than 220% of the above values. The repetitive reverse blocking voltage rating of the semiconductors applied in the diode bridge shall be at least 200% of the maximum peak voltage generated by the main exciter. A failure of a diode shall be detected by a

diode failure monitoring device.

.5 The automatic voltage regulator (AVR) controlling the DC voltage for the main exciter field winding shall be of the electronic type. The AVR shall be equipped with a manual control facility.

.6 To avoid overvoltage when the generator is suddenly disconnected from the load, a fast-acting de-excitation system for the main exciter should be provided. Manufacturer shall provide information regarding the maximum transient overvoltage, which may occur when the rated load is suddenly disconnected from the generator.

.10 Automatic Voltage Regulator

.1 The alternator and voltage regulator shall be designed and built by the same manufacturer.

.2 The voltage regulator components shall consist of only semi-conductors, completely static with no electromechanical relays, or fuses. The regulator shall be of S.C.R. type, using a field effect transistor reference amplifier complete with isolation transformer. It shall incorporate circuit breaker for protection of the power circuit. The regulator shall not contain any paper or electrolytic capacitors.

.3 The voltage regulator response time to changes in load shall be less than 9 milliseconds.

.4 Compensation shall be provided to divide the reactive load proportionally between generator units during paralleling operation.

.5 Voltage build-up of the alternator shall be obtained by using the residual voltage of the alternator through a completely static solid-state build-up circuit in the voltage regulator.

.6 When continuous full load is rejected, the voltage overshoot shall not exceed 20% as measured by the light beam oscilloscope.

.11 System Control and Protective Devices

.1 The cubicle containing the electronic AVR shall be provided with a manual/automatic selector switch, a manual voltage adjustment and a door mounted meter indicating the exciter field voltage.

.2 The minimum electrical protection requirements as specified below shall be used as a guideline; the ultimate protection system shall be discussed in detail between the Contractor and the Architect / M&E Engineer.

.1 Diode failure monitoring

.2 Overvoltage protection

.3 Reverse power protection

.4 Overcurrent protection

.5 Earthfault protection

.3 The Contractor shall prepare a setting proposal for the various protection relays involved. The final setting of the relays shall be mutually agreed between Contractor and the Architect / M&E Engineer.

.4 The protection relays shall be an electronic type and installed in a free standing cubicle. This cubicle shall also contain the dedicated power supply for the protection relays, AVR and miscellaneous equipment.

.12 Anti-Condensation Heaters

.1 Adequate provisions shall be made to avoid deterioration of the machine caused by condensation.

.2 Anti-condensation heaters shall be of a fully insulated design and suitable for 240 volts single phase supply.

.3 Anti-condensation heaters shall be arranged to provide uniform heating of stator and rotor windings and shall maintain the temperature of the machine windings approximately 5°C above ambient temperature. The surface temperature of the heater element or of the machine enclosure shall not exceed the limiting temperature specified.

.4 The connecting leads of the heater elements shall be fully insulated or shrouded and brought out to terminals in a separate heater terminal box mounted on the machine frame. A prominent warning label shall be provided on the heater terminal box.

.5 Anti-condensation heaters shall be controlled through the generator control panel and shall be automatically, energised on generator shutdown.

2.15 AUTOMATIC MAINS FAILURE (AMF) C/W INDICATION, ALARMS AND CONTROLS

.1 The Automatic Mains Failure Control Panel to be supplied and installed by the Contractor for the standby generator set shall be a floor-mounted, metal clad, cubicle type panel as generally detailed on Schematic Drawings.

.2 The construction of Automatic Mains Failure Control Panel shall comply with the form of construction in accordance to Section 16420. The AMF Panel shall also comply with full type test requirements in accordance to Section 16420, if busbar section is shown in the design drawings.

.3 The control panel shall each be equipped with the following components and features: -

.1 Four pole air circuit breaker with shunt trip coil, wherever indicated on the relevant. Schematic Diagrams.

.2 I.D.M.T. relay unit of appropriate type and approved make, complete with built-in, hand reset type, mechanical flag indicators. The relay unit shall be provided with current transformers of appropriate capacity, class and ratio, for installation on the busbars.

.3 Voltage sensing relays and associated equipment.

.4 1 set - Adjustable time delay (0 - 10 secs.) equipment to prevent shutting-down of engine in the event of false mains restoration.

.5 1 set - Adjustable time delay (0 - 10 secs.) equipment to prevent set starting in the event of false mains failure or a momentary break in the supply.

.6 1 No. Immersion heater relay.

.7 1 No Voltmeter with a 6-positions selector switch and protection cut-out fitted with HRC fuse-links.

.8 3 Nos. Ammeter of appropriate range, and three (3) current transformer of suitable capacity, class and ratio.

.9 1 No, 3-phase, 4-wire unbalanced load kilowatthour meter of approve type, to be operated off the appropriate current transformers.

.10 1 No, Frequency meter of direct reading type as specified.

.11 Battery chargers with ammeters, voltmeters and control switches (may alternatively be fitted in a separate cubicle).

.12 1 No, power factor meter.

.13 1 No, watt meter.

.14 “Hour run” meter.

.15 1 No, Duty Selector switch for “OFF”, “TEST”, “MANUAL” and “AUTO”.

.16 ”Mains supply on” indicator lamp.

.17 ”Mains on load” indicator lamp.

.18 ”Alternator supply on” indicator lamp.

.19 ”Alternator on load” indicator lamp.

.20 Engine start push button with reset push-button.

.21 Emergency stop-push button (self latching mushroom head type).

.22 Mains failure simulation switch.

.23 “Fail to start” indicator lamp.

.24 ”Low oil pressure” shut-down indicator lamp.

.25 ”Low fuel” indicator lamp.

.26 ”High water temperature” shut-down indicator lamp.

.27 ”Engine overspeed” shut-down indicator lamp.

.28 ”Circuit breaker tripped” indicator lamp.

.29 ”Alternator over voltage” shut-down indicator lamp.

.30 Test start/load transfer/break load switch.

.31 Surge diverters c/w manual ON/OFF switch to enable/disable the surge diverters.

.32 Fault reset push-button.

.33 Alarm acknowledgement push button (this push button should at the same time cancel the audible alarm).

.34 1 No, Plant Receiving Attention lamp (to be used in conjunction with alarm acknowledgement push button).

.35 HRC fuses for A.C. instrument and control circuits.

.36 All necessary internal wiring and interconnections.

.37 Provision for termination of all supplies cables.

.38 1 set – All necessary, black ivory labels with engraved works (plastic, stick-on type labels shall not be permitted). The set shall also include a main label for the panel with 25mm high words: "AUTOMATIC MAINS FAILURE CONTROL PANEL" engraved thereon.

.39 All other control devices etc. as required for the operation of the plant and to provide facilities covered elsewhere in the Specification.

.4 The above mentioned functions (.23) - (.29) inclusive shall, in addition to giving a visual warning, also sound and audible alarm.

.5 Spare terminals shall be provided in the control cubicle for the interconnection wiring between these items and the remote unit. The Contractor shall include for the supply of the remote indication unit which shall be complete with all lamps, switches, etc. internal wiring, terminal blocks and engraved designation labels. Terminals shall be provided in the remote indication unit for the possible connection of an audible alarm.

.6 Automatic engine shut-down shall occur in the event of: -

.1 High coolant temperature
.2 Low oil pressure
.3 Engine overspeed and alternator overcurrent, earth fault or overvoltage conditions.

.7 The "fail to start" indication shall occur upon the completion of three unsuccessful attempts to start, the second and third attempts being automatically recycled by means of the repeat start relay.

.8 The "Alternator on load" indication lamp shall be connected to normally open auxiliary contacts on the alternator contactor terminal located on the same main L.V. switchboard.

.9 The control cubicle shall be vermin proof and of heavy gauge sheet steel construction at least 2mm thick with hinged and gasket front & rear access doors (doors fitted with automobile door handle lock). Where possible all components shall be constructed of non-hygroscopic and non-inflammable materials.

.10 Barriers shall be provided as necessary to segregate the busbars and equipment for the various circuits and the design shall be such as to prevent accidental contact with "live" metal and the spreading of fire or damage from short circuit or other causes.

.11 The control cubicle shall be fitted with an anti-condensation heater and controlling thermostat.

.12 A copper earth bar shall be run inside the cubicle and shall be rigidly supported. The frame of the cubicle, gland plates, cable boxes, etc., shall be bonded to this bar. All units shall be fitted with labels to show the function or designation. Labels shall also be fitted to indicate the function of any internally mounted items of equipment. The labels shall be black engraving on a white background.

2.16 WIRING

.1 Plant Wiring

.1 All plant wiring shall be carried out in orange coloured PVC, fire resistant mineral filled and LSH cables that are impervious to the action of water, fuel and lubricating oils.

.2 Where flexible type cables are used they shall be encased in flexible conduit in order to prevent engine vibration being transmitted and to remit free movement of the power unit on its resilient mountings. Where flexible conduits are used, they shall be of the oil-proof, high temperature type.

.2 Control Cubicle Wiring

.1 All internal panel wiring shall be run in a symmetrical pattern and fixed by PVC strips or other suitable means.

.2 Wiring shall have identification ferrules fitted at each end, marked with circuit reference and numbers so as correspond with the appropriate terminal marking.

.3 All wiring shall be terminated by means of crimped lugs, washers, or where inserted in screw terminals, shall be solder dipped.

.4 Sufficient terminals shall be provided in each panel to enable wiring from each external piece of apparatus to be brought back into the panels to avoid the "looping in" of wiring between individual items of apparatus external to the cubicle.

.3 Interconnection Wiring

.1 The Contractor shall supply, install and connect all the wiring between the component items of plant and equipment supplied by him so as to form a complete installation.

.2 The control and indication wiring, battery wiring, etc., shall be carried out in single or multi core PVC. insulated and sheathed cables installed in galvanised conduit or in PVC/SWA/PVC cables.

.3 PVC/SWA/PVC cables installed in cable trench shall be supported on the side walls of the trench and run in a neat and orderly manner.

.4 The main alternator cables shall also be installed in cable tray / ladder or in the cable trench. The Contractor shall ensure that the application of any de-rating factor, appropriate to the method of installing the cables within the trench, shall not reduce the current carrying capacity of the cables to the a value less than the maximum current which will flow through the cables.

.5 The Contractor shall supply, install and connect the main cables between the L.V. switchboard and the control cubicle, the incoming supply cables to the control cubicle associated with the supplies to the ancillary equipment, and also the monitoring/control cables as stated on the Schematic

Diagram.

.4 General

.1 All cables shall be installed in accordance with the requirements of the I.E.E. Regulations for the Electrical Equipment of Buildings and any other British standard or Code of Practice applicable to these types of installation.

.2 All cables shall be of adequate size and rating for the required duties.

2.17 EARTHING

.1 All electrical equipment, etc., shall be bonded and earthed in accordance with the I.E.E. Regulations and British Standard Code of Practice for earthing BS7430.

.2 For this purpose, the Contractor shall provide within the plant room a main earth bar connected to the main earthing system.

.3 The alternator neutral shall be connected, via the neutral busbar in the control cubicle, to the main earth bar through a bolted test link.

.4 Bonding and earthing of the fuel oil pipework and associated oil plant installation shall be carried out.

.5 After completion of the earthing within the standby plant room the Contractor shall test the main earth system and inform the ARCHITECT/M&E ENGINEER of the results.

.6 Each generator set shall be with its own earthing system.

2.18 TOOLS

.1 The Contractor shall supply sufficient tools to carry out normal maintenance on the plant for a period of two years.

.2 Each generator set shall be supplied with its complete set of maintenance tools.

2.19 TERMINAL MARKING, RATING PLATES, DANGER SIGN AND ROTATION ARROW

.1 The terminal marking plate shall show a plan view of the winding connection by symbol and the terminals with the characters of terminal markings in accordance with IEC 60034-8.

.2 Information provided on the rating plates shall be in accordance with IEC 60034-1 and shall include but not limited to the data stated below. The values provided shall, as far as possible, be actually measured and shall be based on the specified operating conditions.

.1 On the Generator

.1 Manufacturer's name

.2 Manufacturer's serial number and year of manufacture

.3 Degree of protection of generator and terminal boxes

.4 Class of rating or duty type

.5 Rated output in kVA

.6 Rated voltage and winding connection

.7 Rated stator current

.8 Rated frequency and number of phases

.9 Rated speed

.10 Class of insulation and maximum temperature rise

.11 Power factor at full load

.12 Efficiency at full load

.13 Subtransient reactance

.14 Transient reactance

.15 Weight

.3 The terminal marking and rating plates shall be of a durable and corrosion resistant material and its markings shall be permanently legible. The two plates may be combined into a single plate. If, owing to the size of the generator, additional plates shall be mounted on removable parts. The manufacturer's serial number and frame reference shall be repeated on these rating plates.

.4 All electrical equipment in the plantroom, operating at voltage 400V, shall be clearly marked on the outside “DANGER 400V”. These

labels shall be engraved with red letters on a white background

.5 A reversible plate, size 400mm x 250mm. shall be fixed by screws in a prominent position on each side of the set. One side of the plate shall be blank and painted the same colour as the set, the other side of each plate shall be painted signal red with the following inscription in white "DANGER – DO NOT WORK ON UNIT UNTIL THE STARTING EQUIPMENT IS ISOLATED OR DISCONNECTED AND CAUTION NOTICES ARE DISPLAYED."

.6 The direction of rotation of the generator shall be permanently indicated by an arrow. A painted arrow is not acceptable.

.7 Fixing

.1 Unless stated otherwise, nameplates shall be fixed to a non-removable part of the engine and generator by means of proven durable self-threading screws or riverts in a prominent position.

.2 Holes for fixing shall not influence in any way the protection degree of the enclosure.

.8 Colour

.1 Instruction plates shall be yellow.

.2 Warning or caution plates shall be red.

.3 Inscriptions shall be black with the exception of the warning or caution plates, which inscriptions shall be white.

2.20 FINISHING AND PAINTING

.1 All metal structures and sheet steel shall be adequately protected against corrosion. Preparation of surfaces for painting shall be made complying with BS 7079. All mill scale, loose rust and welding slag, shall be removed by hand tools and the metal surfaces shall be cleaned free from dirt, oil, grease, wax and other contaminants. Cast iron/steel surfaces shall be prepared by dry blast cleaning.

.2 Painting shall consist of one coat of zinc-rich epoxy-based primer of 25 to 40µm thick, followed by one epoxy-based tie or sealer coat of minimum 40µm thick and one coat of high-built epoxy finishing paint to give a total dry-film, complete coating system of thickness 150 to 175µm.

.3 The final top coat colour shall be light grey or manufacturer's standard

colour subject to the Architect / M&E Engineer's approval.

.4 Repair painting shall be done when there is development of any detrimental film irregularity, such as lifting, loose, cracked, brittle or non-adherent paint or discoloration after completion of painting.

.5 The equipment manufacturers shall submit details of his painting system and procedures for review and approval of the Architect / M&E Engineer.

3.0 EXECUTION

3.1 GENERAL

.1 The manufacturer shall, during the production of the machine, perform all activities, functions and tests to prove that the requirements of this specification are met. If stated on the requisition, the Architect / M&E Engineer will witness all or part of the production tests.

.2 Before leaving the manufacturer's works, each machine shall have been inspected and tested, the results shall be recorded in the test reports.

.3 Machines offered for inspection shall be complete and ready for shipment with the exception of the final paint finish.

.4 Type test shall be carried out in accordance with this specification and the relevant IEC or BS. Type test certificate shall be submitted for approval.

.5 If the manufacturer's normal test arrangements are not adequate or he is not capable of carrying out the specified test, application of alternative tests shall be approved by the Architect / M&E Engineer before the order is awarded, for example, test under reduced load conditions.

.6 Whether the Employer or his representative will inspect the machine or witness the required tests will be indicated on the requisition or order and confirmed or waived at the time the machines are offered for final inspection. Notification thereof shall reach the Architect / M&E Engineer at least four (4) working weeks before the date the inspection is planned.

3.2 INSTALLATION

.1 Coordinate with other contractors to ensure floor is adequately level.

Install on foundation.

.2 Install generator sets and complete all electrical connections in accordance with manufacturer's instructions.

.3 Carry out wiring checks prior to commissioning and testing.

3.3 PACKING, TRANSPORT, HANDLING, DELIVERY AND STORAGE AT SITE

.1 Engines and generator sets shall be packed and delivered appropriately labelled in accordance with the manufacturers recommendations. Each shall be provided with the respective label as shown in the Contract Documents for easy identification at site. They shall be securely packed to prevent any movement and damage during transport.

.2 Lifting eyes shall be provided to facilitate lifting. Manufacturer shall provide information for unpacking and lifting safely, including details of any special lifting and positioning devices which are necessary.

.3 Each engine and generator set shall be supplied complete with: -

.1 Foundation/mounting brackets

.2 Mounting bolts

.4 On arrival at site, the consignment shall be checked against the delivery notes.

.5 On delivery to site, the engines and generator sets shall be stored indoor in a clean, dry and ventilated place. For prolonged storage, space heaters may have to be switched on to prevent moisture condensation and consequent damage and maloperation.

3.4 TESTS

.1 Type Test

1. Relevant type tests shall be carried out in accordance with the relevant parts of BS 5514, ISO 8528 and IEC 60034. Certificates issued by acceptable independent testing laboratories shall be submitted to the Architect / M&E Engineer.

2. Production Tests

.1 The manufacture shall perform during the production of the equipment all activities, functions and tests to prove that the requirements of this specification are met.

.3 Routine Tests

.1 Before the products leave the works, the manufacturer shall carry out the relevant routine tests in accordance with the relevant IEC and BS when delivered with time intervals, and the results shall be recorded in a test report.

.2 Routine tests shall be carried out on every engine and generator set not subjected to performance tests. The manufacturer shall certify that each machine is identical with the one which was subjected to the performance or type test.

4. Acceptance Tests at Manufacturer's Works

.1 The performance test shall be made on at least one complete assembled generator set of a group of identical items to be supplied. The manufacturer shall state in his tender the availability of test data for identical generators, including auxiliaries, etc. covering all performance test requirements.

.2 The generator set shall be with all equipment included in the order, e.g. motor and auxiliaries, excitation equipment, batteries, voltage regulator and other controls, etc.

.3 All calculations to derive performance data shall be made strictly in accordance with formula given in the relevant standards. Any alterations or deviations from the relevant standard test layout or formula shall be subject to the prior approval of the Architect / M&E Engineer.

.4 The formula used for correcting test results to site conditions shall be subjected to the Architect / M&E Engineer approval and be given with the test results together with calibration details of any measuring instruments.

.1 Diesel Engine

.1 The diesel engine shall be started and run from cold in the presence of the Architect / M&E Engineer and loaded to its full load shop rating.

.2 The engine shall be kept ½ hour at 25% load, ½

hour at 50% load, ½ hour at 75% load, 1 hour at 100% load and 1 hour at 110% load using 0.8 pf inductive load bank

.3 Measurement of fuel consumption and operating conditions shall be taken and recorded for each test sequence.

.4 The following functional checks shall be undertaken during the tests, including but not limited to: -

.1 The ability of the starting system to perform in accordance with the specified requirements.

.2 Uninterrupted continuous operation at the loads stated earlier.

.3 The correct functioning of the overspeed safety devices.

.4 The ability of malfunction protection and warning devices to respond correctly to the fault conditions under which they should operate. For example, low lubricating oil pressure, high lubricating oil temperatures, high coolant temperatures, etc.

.5 The dynamic and steady characteristics of the governing system in accordance with ISO 8528. This shall include the full load rejection test, speed droop test at 20% load reducing from full load to zero load and overspeed test.

.6 The functioning of all automatic pressure and temperature control.

.7 Transient

The regulation and governing test will have been done under controlled conditions to ISO 8528 on the works site and the performance monitored with sophisticated instrument and

recording equipment. The results are recorded on the Works Test Card. The transient test should be carried out using available works site load.

.8 Observation During Load Test

Close observation must be kept during load test for any abnormalities in the operation of the generator. The generator itself should not exhibit any of the following: -

.1 Excessive Vibration
.2 Fuel, oil or coolant leaks
.3 Excessive heat, smell or noise

.9 Inspection After Test

The Architect / M&E Engineer reserves the right to request the Contractor to strip the engine for examination and selected parts for inspection without cleaning and exactly as taken from the engine. Any part examined by the Engineer and deemed need replacement, shall be replaced by the Contractor without any additional cost.

.2 The Contractor shall submit the measured test parameters and calculated values on brake power and specific fuel consumption of the engine. They shall comply with have been guaranteed and stated in the contract.

.3 Pump Test

To submit test report.

.4 Pipework

All piping shall be pressure tested to 10 bars for a period of one (1) hour duration which the leakage shall be zero.

.5 Alternator

For detailed description of the various tests applicable for synchronous generators, reference is made to IEC 60034-1 and IEC 60034-4. When not specified otherwise in the requisition, the performance test of synchronous generators shall at least include the following tests: -

.1 Visual Inspection

.1 Dimensions

.2 Completeness of the data on the rating plate

.3 Degree of protection of generator set enclosure and terminal box

.4 Availability of earthing facility.

.5 Cable entries

.6 Availability and suitability of separate terminal boxes for power cable and heater cable terminations.

.7 Finishes, lifting lugs etc.

.2 Winding resistance test (cold) to IEC 60034-4

.3 Full load heat run to IEC 60034-1 section 5

.6 Insulation Resistance of: -

.1 Generator windings

.1 Before heat run

.2 After heat run

.2 Exciter windings

.1 Before heat run

.2 After heat run

.7 Noise level measurement

.8 Overspeed Test to IEC 60034-1 Section 7

The impedance of the rotor winding shall be measured prior to and after completion of the overspeed test in order to detect loose connections

.9 Waveform analysis

.10 Voltage test

.11 Angular velocity (rpm) check

.12 Direction of rotation check

.13 Phase rotation check

.14 Painting and finishing tests: -

.1 Measurement of paint thickness

.2 Humidity (cyclic condensation) test to BS 3900 Pt. F2. Painted panel shall withstand 1000 hours under test with no blistering of film and corrosion of base metal.

.5 The manufacturer test shall be verified and witnessed by the Architect / M&E Engineer's and his representatives.

.5 <u>Site Tests</u>

.1 At the completion of installation, each generators set shall be field tested by a representative of the manufacturer. A report recording each item of the testing shall be certified by the manufacturer and submitted to the Architect / M&E Engineer.

.2 All calculations to derive performance data shall be made strictly in accordance with formula given in the relevant standards. Any alterations or deviations from the relevant standard test layout or formula shall be subject to the prior approval of the Architect / M&E Engineer.

.3 The formula used for correcting test results to site conditions shall be subjected to the Architect / M&E Engineer's approval and be given with the test results together with calibration details of any measuring instruments.

.1 Diesel Engine

.1 The set shall be started and run from cold in the presence of the Architect / M&E Engineer and performed another functional test.

.2 The following functional checks shall be undertaken during the tests, including but not limited to: -

.1 The ability of the starting system to perform in accordance with the specified requirements.

.2 Uninterrupted continuous operation at the loads stated earlier.

.3 The correct functioning of the overspeed safety devices.

.4 The ability of malfunction protection and warning devices to respond correctly to the fault conditions under which they should operate. For example, low lubricating oil pressure, high lubricating oil temperatures, high coolant temperatures, etc.

.5 The dynamic and steady characteristics of the governing system in accordance with BS 5514. This shall include the full load rejection test, speed droop test at 20% load reducing from full load to zero load and overspeed test.

.6 The functioning of all automatic pressure and temperature control.

.3 Inspection After Test

The Architect / M&E Engineer reserves the right to request the Contractor to strip the engine for examination and selected parts for inspection without cleaning and exactly as taken from the engine. Any part examined by the Engineer and deemed needling replacement shall be replaced by the Contractor without any additional cost.

.4 Leak Test

.1 The storage tanks shall be subjected to a test pressure of 0.33 bar (5 psi) for a period of 1 hour on site to the approval of the Architect / M&E Engineer. Compressed air or dry nitrogen may be used for the pressure test. It is not permissible to use water for on-site testing.

.2 All piping after installation shall also be pressure tested to 10 bars for a period of one (1) hour duration which the leakage shall be zero.

.2 Alternator

.1 Visual Inspection

.1 Location.

.2 Terminal marking, rating plate and danger signs.

.3 Finishes, lifting lugs, etc.

.4 Mounting of engine and generator set.

.5 Cabling system.

.6 Earthing and terminating arrangement.

.4 Functional (Sequence) Test

.1 Operation of AVR

.2 Operation of all indicating and metering devices

.3 Operation of all alarm devices

.3 Noise level measurement.

.4 Angular velocity (rpm) check

.5 Direction of rotation check

.6 Phase rotation check

3.5 MISCELLANEOUS EQUIPMENT

Equip the generator room with the following miscellaneous items: -

.1 Danger sign, No Admittance signs etc.

.2 Artificial respiration (CPR) chart.

.3 Frame up latest approved As-Built schematic wiring diagram (A0 or A1 size) of the switchboards.

.4 A 6 mm thickness and 1000 mm width rubber mat in front and at the back of the entire length of the AMF board.

.5 All the requisite labels.

.6 Approved fire detection and fire fighting apparatus.

.7 Earthing bar installation along the perimeter of the room connected to the main-earth bed system.

3.6 SUBMISSION TO SURUHANJAYA TENAGA AND DEPARTMENT OF ENVIRONMENTAL

.1 The contractor shall obtain and prepare all necessary forms, documents and drawings for submission and approval from Suruhanjaya Tenaga and Department of Environmental.

.2 The contractor shall obtain all endorsement from Architect / M&E Engineer and relevant parties.

3.7 TRAINING OF OPERATION AND MAINTENANCE STAFF

.1 Provide training schedule and agenda and list of instructions from original equipment manufacturers (OEM) and trader contractor.

.2 Provide classroom training.

.3 Provide field training with demonstration on operation, maintenance and trouble shooting.

.4 Review O&M Documentation and Test Results.

3.8 HANDING-OVER AND EMPLOYER'S ACCEPTANCE

.1 Endorse defects list.

.2 Provide all keys