This section of the specification describes and specifies requirements for the supply, delivery, installation, testing, and commissioning of diesel generator set and handing over in approved working order and providing service and maintenance during the Defects Liability Period as specified thereafter for the period stated in the Condition of Contracts.

The generator set shall comprise a diesel engine directly coupled to a three phase alternator with auxiliary equipment as further described hereinafter and shall capable of delivering and maintaining a continuous power of not less than the kVA specified in this Tender at 0.8 lagging power factor, 415 volts, three phase, 4 wire, 50 Hz supply under the operating conditions specified below and within a guaranteed range of frequency and voltage fluctuations after making full allowance for all internal losses and power consumed by ancillaries.

The operating conditions shall be:

(a)	Total barometric pressure	:	750 mm Hg.
(b)	Air temperature	:	40 deg. C
(c)	Relative humidity	:	95%.

The generator set offered must be approved by Jabatan Kerja Raya, Semenanjung Malaysia and must be supplied by the supplier registered with Jabatan Kerja Raya, Semenanjung Malaysia. Unless otherwise directed by the S.O.'s Representative, the installation, testing and commissioning shall strictly in accordance with the requirements of this specification and the recommendations of the generator set manufacturer.

Both the engine and the alternator must be provided with name plates bearing serial numbers, ratings and other relevant data. In addition, name plate bearing the registered supplier's name and address and date of commissioning shall also be provided.

Tenderer shall submit together with his Tender original catalogues and literatures describing the generator set, engine, alternator, battery and its charger offered in addition to filling in Appendix A-1 (Schedule of Technical Data and Guarantee for Generator Set) and Appendix A-2 (Schedule of Technical Data and Guarantee for Electrical Equipment) to this specification.

The price tendered in the Bill of Quantities is deemed inclusive of, whether or not these items are priced separately in the Bill of Quantities, all necessary equipment, ancillaries and auxiliaries including starting system, exhaust system, air intake system, fuel storage and supply system, and monitoring, protection and control system for the complete installation of the generator set to approved working order as shown in Drawings.

The Tenderer shall allow in his Tender for submissions of applications (together with design calculation if so required by Authorities having jurisdiction over the Works), inspections, tests and approvals including endorsement and/or certification of documents by professional/competent person and thereafter the registration of the whole Works in compliance to the requirements of Suruhanjaya Tenaga Malaysia (STM), Jabatan Alam Sekitar (JAS) and any other relevant Authorities having jurisdiction over the Works. All cost and fee incurred in the application and process of getting the Works inspected, tested, approved and registered by STM, JAS and any other relevant Authorities, whether or not provided in the Bill of Quantities, are deemed to be included in the Contract Sum. No additional costs will be entertained in this respect.

The material, equipment and installation shall conform to the principles of the latest edition standards and codes of practice laid down by the Malaysian Standards (MS), International Electrotechnical Commission (IEC), International Organisation for Standardization (ISO) and/or British Standard Institution (BSI). The "Latest Edition" shall be the edition in force at the time of contract award. The standards and/or relevant parts of the standards and codes of practice include but not limiting to the following:

MS IEC 60364	–	Electrical installations of buildings.
MS IEC 60439	–	Low voltage switchgear and controlgear assemblies.
MS IEC 60947	–	Low voltage switchgear and controlgear.
MS IEC 60950–1	–	Information technology equipment - Safety - General requirements
ISO 3046	–	Reciprocating internal combustion engines.
ISO 8528	–	Reciprocating internal combustion engine driven alternating current generating sets.
IEC 60034	–	Rotating electrical machines.
IEC 60034-22	–	Rotating electrical machines: a.c. generators for reciprocating internal combustion (RIC) engine driven generating sets.

IEC 60085	–	Thermal evaluation and classification of electrical insulation.
IEC 60255	–	Electrical relays
IEC 60947–6	–	Low voltage switchgear and controlgear – Automatic transfer switching equipment
BS 799-5	–	Oil burning equipment. Specification for oil storage tanks.
BS 1449–1.1	–	Steel plate, sheet and strip. Carbon and carbon-manganese plate, sheet and strip. General specification.
BS 1710	–	Specification for identification of pipelines and services.
BS 2594	–	Specification for carbon steel welded horizontal cylindrical storage tanks.
BS 2869	–	Specification for fuel oils for agricultural, domestic and industrial engines and boilers.
BS 4360	–	Specification for weldable structural steels
BS 4999-140	–	General requirements for rotating electrical machines. Specification for voltage regulation and parallel operation of a.c. synchronous generators.
BS 5135	–	Specification for arc welding of carbon and carbon manganese steel
BS 7430	–	Code of practice for earthing.
BS EN 1011	–	Welding. Recommendations for welding of metallic materials.

BS EN 50081	–	Electromagnetic compatibility – generic emission standard.
BS EN 50082	–	Electromagnetic compatibility – generic immunity standard.

This specification shall also read together with the following specifications. Unless specified otherwise in this specification, Bill of Quantities and/or Drawings, the material, equipment and installation shall also conform to the following specifications:-

(a) Specification for Low Voltage Internal Electrical Installation;

(b) Specification for Acoustic Treatment for Generator Room.

The generator set shall capable of delivering and maintaining a continuous power of not less than the kVA specified at 0.8 lagging power factor, 415 volts, three phase, 4 wire, 50 Hz supply under the operating conditions specified. The generator set shall be designed for cold starting and be capable of supplying the rated kVA specified in not more than 15 seconds from initiation of the starting procedure.

The generator set shall comply with relevant parts of ISO 8528. Unless specified otherwise the generator set shall be of performance class G2 of ISO 8528-5 having the frequency and voltage characteristics as following:

(a)	Frequency droop:	< 5 %
(b)	Steady-state frequency band:	< 1.5 %
(c)	Transient frequency deviation -	
	(i) 100% sudden power decrease:	< + 12 %
	(ii) sudden power increase:	< – 10 %
(d)	Frequency recovery time:	< 5 s
(e)	Steady-state voltage deviation -	
	(i) for single operation:	< ± 2.5 %
	(ii) for parallel operation:	< ± 1 %
(f)	Voltage unbalance -	
	(i) for single operation:	< 1%
	(ii) for parallel operation:	< 0.5 %
(g)	Range of voltage setting:	± 5 %
(h)	Transient voltage deviation -	
	(i) 100% sudden power decrease:	< + 25 %
	(ii) sudden power increase:	< – 20 %
(i)	Voltage recovery time:	< 6 s

Unless specified elsewhere, the generator set shall perform within the operating limits for the performance class specified when the generator set is subjected to sudden power increase from 0% to 50%, 50% to 80% and 80% to 100% of the rated kVA at 0.8 lagging power factor specified. In the case where the load profiles are specified, the generator set shall perform within the operating limits with respect to the loading requirements.

The generator set shall be configured and mounted on a base frame and the mounting shall be of fully resilient type. The base frame shall be of prefabricated structural steel channel type of all welded construction. The base frame shall be provided with lifting points for transportation. Spring type vibration damper shall be installed and supplied together with generator set by the registered generator set supplier.

3.1 ENGINE

The engine shall be multi cylinder, vee/in line configuration, four stroke, direct injection, naturally aspirated or turbo charged, water cooled with fan and radiator, instant starting. Engine speed shall be 1500 r.p.m.. The engine shall comply with relevant parts of ISO 3046 and ISO 8528-2 as minimum requirements, and shall capable of producing continuously the service power not less than that required by the alternator and all other necessary equipment, ancillaries and auxiliaries for the generation of the required output under the specified operating conditions. In addition to the steady-state power requirement, the engine shall also capable to meet any transient load requirements caused by motor starting and/or any load profile as specified and/or shown in the Drawings.

The engine shall be able to withstand an overload of 10% at rated speed for one (1) hour in any period of twelve (12) hours consecutive running, and shall also capable of sustaining indefinitely without deterioration to run under low load condition.

3.2 FUEL SYSTEM.

The engine shall be capable of operating on Class A fuel to BS 2869. The fuel pump shall be of the gear type complete with governor and throttle and capable of fuel delivery to injectors under all power conditions of the engine. The pump shall be self-adjusting for wear and fuel viscosity. Fuel filter of heavy duty, replaceable and paper element type shall be provided.

3.3 LUBRICATION SYSTEM

The engine shall be complete with enclosed force-feed lubricating system by gear type oil pump with full flow replaceable paper element type oil filter. Oil pan shall be of the sump type.

3.4 ENGINE GOVERNING

Speed governing of the engine shall comply with ISO 3046-4. Unless otherwise specified, the governing accuracy of the engine shall be of performance class G2 within the operating limit values in accordance with ISO 8528-2. The speed droop shall be less than

5% with steady-state speed band of less than 1.5%. The governor shall be of proportional integral (PI) type.

In the case where the generator set is rated at or more than 1000 kVA or for parallel operation of two or more generator sets, the governor shall be of proportional integral differential (PID) electronic type.

3.5 ENGINE INSTRUMENTATION

The engine shall complete with all instruments and gauges necessary or desired for its proper operation, service and maintenance. The instruments and gauges shall be of the flush-mounting on the metalclad panel and shall include but not limited to the followings:-

(a) Elapsed hours running meter.

(b) Lubricating oil pressure gauge

(c) Cooling water temperature gauge.

(d) Tachometer.

4.1 ALTERNATOR AND EXCITER

The alternator shall be of screen protected, drip-proof, revolving fields, self-regulating, brushless, salient pole type, directly coupled to the engine and fitted with exciter compliance to relevant parts of IEC 60034 and IEC 60034-22 as minimum requirements. The alternator shall be of 415 V, three phase, four wire, 50 Hz and duty type S1 in accordance with IEC 60034-1. The alternator shall be capable of delivering its basic continuous rating not less than the rated kVA specified at 0.8 power factor lagging over the whole range of operating conditions. The principal characteristics of the alternator shall be within the operating limit values compliance to ISO 8528-3 for the performance class specified

Insulation shall be of Class 'H' conforming with IEC 60085 and the alternator shall operate up to the temperature rise limits of Class 'F' complying to IEC 60034-1.

The rotor or armature shall be of one piece, four pole type with lamination pressed and keyed to the shaft.

The stator shall be of the multiplicity type for high or low voltages in Star or Delta connections. Damper windings shall be provided in the pole faces.

For alternator of rated capacity at and exceeding 1000 kVA, the alternator shall be fitted with winding heaters to prevent moisture in the winding. The winding heaters shall complete with automatic thermostat control, maintaining the winding temperature at 5 ^{0}C above ambient temperature when the alternator is at stand-still. The winding heaters shall be arranged for automatic disconnection when the alternator is in operation. Two winding heaters per phase shall be provided – one winding heater shall be connected for operation and the other is for replacement in case the first heater fails. In addition resistance temperature devices (RTD) of Pt100 type shall be provided to monitor the winding temperatures during operation. Two RTD per phase shall be provided.

For parallel operation the alternators and their voltage regulations shall comply with the requirements of BS 4999-140 and relevant parts of ISO 8528.

4.2 VOLTAGE REGULATIONS AND WAVEFORM

The voltage regulation shall be of solid-state transistor amplified type capable of providing voltage regulation conforming to performance class G2 within the operating limit values compliance to ISO 8528-3.

The alternator, when driven its rated speed and operating with its normal excitation control system, shall be capable of maintaining the voltage under steady state conditions within ± 2.5 % (± 1 % for parallel operation) of rated voltage for all loads between no-load and rated load at rated power factor. Following transient changes the voltage shall restore to within these limits in less than 1.5 seconds.

When alternator driven at rated speed and giving its rated voltage on no load under its normal excitation control system is switched on to a sudden load application, the initial voltage drop shall be limited to 20% of rated voltage and the voltage shall recover to rated voltage in less than 1.5 seconds. The transient rise in voltage after a sudden rated load rejection at rated power factor and constant speed shall not exceed 25%.

Normal voltage shall be variable by means of voltage trimmer within ±5% of rated voltage.

The voltage waveform shall approximate closely to a sine wave both at no load and full load with a lagging power factor of 0.8 and shall not exceed the limits as stated in ISO 8528-3.

The automatic voltage regulator (AVR) shall be of three phase sensing electronic type equipped with radio frequency interference (RFI) suppressor to electromagnetic compatibility (EMC) compliance and encapsulated to provide protection against moisture and salt-spray. The AVR shall be mounted on anti-vibration mounts for mechanical protection from engine vibrations.

Separate voltage trimmer shall be provided. Protection against over-excitation, loss of excitation, alternator overload protection and rotating diode failure shall also be incorporated. Triggering or activation of any of these protection device shall cause an alarm and shutdown the generator set.

For parallel operation, AVR shall be of same made and type to ensure stable operation and correct sharing of reactive power. The voltage unbalance shall be 0.5% of the rated voltage.

Unless otherwise dictated by room design engine radiator discharge air shall be directed outdoors through an approved discharged duct that connects the engine radiator to an opening in an external wall. The duct shall be as short as possible. A length of flexible duct shall be provided between the radiator and the fixed air discharge duct.

The engine radiator discharge air duct shall incorporate an efficient radiator air discharge silencer capable of reducing the air discharge noises of the engine to an acceptable level as in the specification – Specification For Acoustic Treatment for Generator Room. Air discharge silencer shall comply with the specification – Specification For Acoustic Treatment for Generator Room, and shall be supplied together with the generator set by the registered supplier.

Acoustic louver with bird mesh made of aluminium shall be provided for the air discharge silencer. The acoustic louver shall be so designed as to prevent rainwater to enter into the radiator discharge air duct and also to keep the noise level to a minimum.

The engine shall be provided with a suitable exhaust system capable of carrying exhaust gases from the engine and dissipating them to the atmosphere as efficiently, quickly and silently as possible.

Exhaust pipes shall be black steel pipes of minimum 3 mm thickness and shall be sized so that the back pressure created will not exceed the amount recommended by the generator set manufacturer and the output power of the engine will not be derated. The whole exhaust system shall be adequately supported with spring isolators. A suitable flexible connection shall be made between the section of piping fixed to the engine and the piping fixed to the building structure to allow for expansion/contraction and for vibration isolation.

The exhaust pipes outside the generator room, where exposed, shall be lagged with non-combustible thermal insulating materials and have a thickness of not less than 75 mm. The lagging shall be protected by a aluminium sheet cladding of minimum 1 mm thick constructed in sections. In similar construction, the exhaust pipe in the generator room shall also be properly lagged in order to protect against any harmful thermal effects to personnel in carrying out operation and maintenance. Penetration between the exhaust pipe and the exterior wall shall be sealed airtight with non-setting resilient caulking compound.

Each section of the cladding shall be removable for replacement of the insulating materials. No flanged joint shall be used.

The non-combustible thermal insulating material provided shall be of non water-absorption type and capable of maintaining the external cladding temperature not exceeding 40 ^{0}C. Asbestos shall not be used for lagging.

Suitable temperature detectors shall be provided for each exhaust manifold to monitor the exhaust temperature. High exhaust temperature shall cause an alarm and the generator set stop to operate.

The exhaust system shall incorporate an efficient primary silencer of reactive type and secondary silencer of absorption-type capable of reducing the exhaust noises of the engine to an acceptable level as in the specification – Specification for Acoustic Treatment for Generator Room. The silencers shall comply with the specification – Specification for Acoustic Treatment for Generator Room, and shall be supplied together with the generator set by the registered supplier.

Air intake system shall incorporate an efficient air intake silencer capable of reducing the noises of the engine outside the generator room to an acceptable level as in the specification – Specification for Acoustic Treatment for Generator Room. The air intake silencer shall comply with the specification – Specification for Acoustic Treatment for Generator Room, and shall be supplied together with the generator set by the registered supplier.

Acoustic rain hood with bird mesh made of aluminium shall be provided for the air intake silencer. The acoustic rain hood shall be so designed as to prevent rainwater to enter into the air intake system and also to keep the noise level to a minimum.

If so required, whether or not provided in the Bill of Quantities or in the Drawings, air intake fan shall be provided to ensure there are sufficient air exchanges required by the generator set to operate efficiently at its ambient operating temperature at all times. The Electrical Contractor is required to submit calculation worksheet together with all engine data/characteristics to meet this requirement. .

Air intake fan shall be of low speed type not more 1000 rpm, 240 V, 50 Hz and of high quality mild steel casing construction with die-cast aluminium alloy aerofoil impeller blades. Air intake fan shall automatically operate upon running of the generator set and automatically stop after pre-set time after shutting down of the generator set.

Suitable ducting system with air inlet/outlet grills shall be incorporated. All openings through walls and ducting system shall be treated acoustically complying with the specification – Specification for Acoustic Treatment for Generator Room.

The Electrical Contractor shall also provide electrical wiring in galvanised steel conduit for the air intake fan complete with all necessary isolation, protection, automatic control and starting/stopping equipment.

If so required, the cost for the provisions of the air intake fan, associated ducting system and electrical work is deemed inclusive in the Contract

If specified in the Bill of Quantities or in the Drawings, air ventilation system shall provide effective generator room cooling and to maintain the ambient temperature rise not higher than 10 ^{0}C when the generator set is not in operation. A fan assisted ventilation system capable of a minimum of twenty air changes per hour within the building shall be designed to provide positive ventilation into the generator room. The Electrical Contractor is required to submit calculation worksheet together with all data/characteristics to meet this requirement.

Ventilation fan shall be of low speed type not more 1000 rpm, 240 V, 50 Hz and of high quality mild steel casing construction with die-cast aluminium alloy aerofoil impeller blades.

Suitable ducting system with air inlet/outlet grills shall be incorporated. All openings through walls and ducting system shall be treated acoustically complying with the specification – Specification for Acoustic Treatment for Generator Room.

The Electrical Contractor shall also provide electrical wiring in galvanised steel conduit for the ventilation fan complete with all necessary isolation, protection, control and starting/stopping equipment.

All pipe lines and silencers shall be rigidly and securely fixed, fastened and supported in place by fasteners such as clamps, clips, anchors, straps, hangers, supports or similar fittings. The fasteners shall be designed and installed as not to damage the pipe lines and silencers. All fasteners shall be of spring steel and/or galvanised steel, and where wires, rods or threaded rods are used with the fasteners, they shall be of rolled carbon steel. The fasteners shall be finished with zinc coatings to resist rust.

All supports and hangers shall be of hot-dip galvanised steel.

Spring isolators shall be used for exhaust silencers.

10.1 SERVICE FUEL TANK

A service fuel tank (or fuel tank) shall be supplied and installed within the generator room at a location to be agreed by the S.O.'s representative. Service fuel tank shall have a capacity for a minimum of 8 hours continuous operation at full load or 1000 litres capacity whichever is larger supported by suitable hot-dip galvanised angle iron supports to permit gravity feed to the engine fuel injection pump. Service fuel tank shall comply with BS 799-5, fabricated from 2.5 mm thick mild steel sheet construction, not galvanised but painted inside and outside with oil resistant prime and externally finished with undercoat and topcoat.

A dial type level indicator calibrated in litres shall be provided.

A breather is to be provided. The breather opening must be adequate to vent gases and air from the service fuel tank without back pressure. The fuel injection pump suction line shall pick fuel about 30 mm from the bottom of the service fuel tank complete with fuel strainer. The fuel return line shall be so located so as to allow separation of the fuel and vapour or gases in the expansion space above the normal fuel level and shall be pointed away from the breather and suction area.

A drain valve complete with padlock shall be provided at a low point in the service fuel tank in an accessible location to allow periodic removal of water condensation and sediment. A spill tray shall be provided beneath the drain valve.

If more than one generator set are installed in the generator room, a common service fuel tank may be used. The common service fuel tank shall be of sufficient capacity to run the generator sets simultaneously for minimum 8 hours continuous operation at full load.

Under this Contract the Electrical Contractor shall supply a full tank of fuel at the time of handing over. The Electrical Contractor shall also supply all fuel required for carrying out all tests including site tests. This shall be in addition to the full tank of fuel mentioned above.

10.2 BULK STORAGE FUEL TANK

A bulk storage fuel tank in the form of skid tank shall be supplied and installed if specified in the Bills of Quantities. The skid tank shall be installed at the location indicated by the S.O.'s Representative. Unless otherwise specified elsewhere, the capacity of the skid tank shall be 9000 litres.

Generally the skid tank shall be fabricated in accordance with the standard design and specification of oil companies in Malaysia compliance with BS 2594. The skid tank shall include a permanent steel ladder providing access to the manhole at the top of the skid tank. Drain pipe with shut-off cork complete with padlock shall be provided at the tank bottom. Fuel level sighting gauge shall also be included.

A filler pipe shall be installed to facilitate the filling of the skid tank from a road fuel tanker. An efficient approved method of sealing this pipe to prevent ingress of moisture shall be provided. A filler coupler to suit and in accordance with the requirement of oil companies in Malaysia shall be provided.

All material and steel plates used shall be new and free from rust. Minimum sizes of steel plates shall be 7.9 mm thick for the end plates and 6.3 mm for the shell. Tank plates and structural steel shall be of carbon steel plates complying with of BS 1449–1.1. Only welded construction complying with the requirements of BS EN 1011 shall be used. Tank is to be hydrostatically tested at a hydrostatic pressure of 103 Kn per sq. m. for a period of 20 minutes.

All rust, scale, oil or grease on the surface of the tank must be removed thoroughly before painting of the skid tank. Immediately all rust is removed, one prime coat of bituminous solution shall be applied on the surface, followed by two coats of bitumen emulsion paint and finished with two coats of bituminous aluminium paint. Interior of the skid tank shall be thoroughly cleaned of dirt such that it can be put into immediate used.

An accurately calibrated brass dip stick graduated in litres at intervals of 200 litres up to save contents of tank shall be supplied with the skid tank.

A concrete foundation for the skid tank shall be constructed and erected. The area approximately 500 mm wide around and below the skid tank shall be covered with cement to 50 mm thickness.

Spillage containment area and fire walls compliance with the requirements of Jabatan Alam Sekitar (JAS) and Jabatan Bomba dan Penyelamat Malaysia respectively shall be constructed. The cost for the construction of spillage containment and fire walls is deemed to be included in this Contract.

Under this Contract the Electrical Contractor shall supply a full tank of fuel at the time of handing over. The cost of supply the fuel shall deem inclusive in the Contract.

10.3 FUEL TRANSFER SYSTEM

Fuel transfer system for transferring fuel from drums into the service fuel tank shall be supplied and installed. The fuel transfer system shall consist of hand-operated pump installed in parallel with an electric motor-driven pump. A filler pipe shall be installed from the inlet point of the service fuel tank to the outlet point of the fuel transfer pumps. A suitable length of flexible transparent oil resistant hose shall be connected from the inlet of the fuel transfer pumps for off-loading from drums. Fuel transfer from the drum into the service fuel tank shall stop automatically by stopping the electric motor-driven fuel transfer pump controlled by means of high fuel level sensor in the service fuel tank.

In the case where the skid tank is provided in the Bill of Quantities, a fuel transfer system for transferring fuel from the skid tank into the service fuel tank shall be provided and installed. The fuel transfer system shall consist of hand-operated pump installed in parallel with an electric motor-driven pump. Fuel transfer from the skid tank into the service fuel tank shall be controlled by means of high and low fuel level sensors in the service fuel tank and the skid tank respectively by stopping and starting the electric motor-driven fuel transfer pump automatically.

The delivery branch pipelines shall include both non-return valves and shut-off valves that have padlocking facility. Overflowing fuel from the engine shall be fed back to the service fuel tank by means of fuel pipe complete with non-return valve near the service fuel tank.

Full-flow duplex fuel filters of the replacement type shall be provided at the entry to the service fuel tank and a full flow single fuel filter with impregnated paper element of the replacement type shall also be provided at the entry to the engine. Spill trays shall be provided beneath the filters.

'Fail-Safe' quick closing emergency valves shall be provided at the fuel entry to the engine in the fuel transfer system to shut-off the fuel supply in the event of engine fuel pump runaway and/or fire. Similar emergency valve shall also be provided at the fuel entry to the service fuel tank from the skid tank if the skid tank is installed.

Flow meters calibrated in litres with accuracy of ± 1% or better shall be fitted in the supply lines from the skid tank to the service fuel tank if skid tank is installed, from the service fuel tank to the engine and from the off-loading fuel drum to the service fuel tank.

The fuel transfer pumps shall be installed as close to the service fuel tank as possible but the exact location shall be decided by the S.O.'s representative on site.

The electric motor-driven fuel transfer pump shall be of the self-priming type and shall have sufficient suction lift to deliver a transfer rate of 50 litres per minute. The pump shall be suitable for operation from single phase, 240 V, 50 Hz supply. The Electrical

Contractor shall carry out wiring in galvanised steel conduit from the electric starter point on nearby wall to the electric motor-driven pump.

10.4 FUEL SUPPLY PIPING

All rigid fuel pipes and fittings shall be of carbon steel. All valves shall be cast steel and designed for the duty they are required to perform. All flexible fuel pipes for connection to the engine fuel inlet and return outlet shall be of seamless synthetic rubber, flame retardant, armoured type with cone connections at both ends. The diameter of the pipe shall be as recommended by the generator set manufacturer. Care must be taken to keep the number of bends to a minimum.

Fuel pipes shall be brown as a basic identification colour in compliance with BS 1710. Flow direction markers shall also be provided.

Fuel supply pipelines inside the generator room shall be installed in the concrete trench covered with hot-dip galvanised checker steel plate of sufficient thickness. Outside the generator room fuel supply pipelines shall be in containment ducting buried 750 mm directly in ground with protective covers laid above the whole length of the pipelines. Pipeline markers shall be at both ends of the pipelines and at every change in direction of the pipeline routes. At road crossings and concrete pavements, fuel supply pipelines in containment ducting shall be protected by galvanised steel pipes. No fuel supply piping shall be installed in the cable trench.

All fuel supply piping shall be hydrostatically tested at a hydrostatic pressure recommended by the manufacturer for a period of 20 minutes.

10.5 FUEL LEVEL SENSOR SWITCHES

Fuel level sensor switches shall be provided in the skid tank, viz.: -

Stage 1: Low fuel level – warning.

Stage 2: Low fuel level – stop the electric motor driven fuel pump from transferring the fuel from the skid tank into the service fuel tank.

For the service fuel tank, fuel level sensor switches shall be provided for:-

Stage 1: High fuel level – stop electric motor driven fuel pump from

transferring the fuel from the skid tank or the fuel drum into the service fuel tank.

Stage 2: Low fuel level – start the electric motor driven fuel pump transferring the fuel from the skid tank into the service fuel tank (if skid tank is provided).

Stage 3: Low fuel level – warning.

Stage 4: Low fuel level – stop generator set operation.

The fuel level sensor switches shall be of hermetically sealed reed switch with float type suitable for oil and gas application. As the float rises and falls with the level of the fuel, the reed switch is activated by means of magnet.

10.6 PADLOCKS

Padlocks shall be provided as specified in Section 7.1 – Service Fuel Tank and Section 7.2 – Bulk Storage Fuel Tank, as the case may be. Padlocks shall also be provided for the opening cover of the service fuel tank and the manhole cover of the skid tank.

Padlocks shall be of high quality water resistant non spring type for outdoor use and the shackles shall be of hardened stainless steel.

Master-key system shall be provided for the all padlocks used for shut-off valves of the fuel supply pipes and drain valves of the service fuel tank and the skid tanks. Three (3) sets of master keys and individual keys for the padlocks shall be provided. All keys shall be properly labelled.

The engine shall be equipped with protective devices to provide warning and automatic shut-down under the following conditions:-

(a)	Low lubricating oil pressure	-	warning and shut-down
(b)	High lubricating oil temperature	-	warning and shut-down
(c)	High exhaust temperature	-	warning and shut-down
(d)	High jacket water temperature	-	warning and shut-down
(e)	Low radiator water level	-	warning and shut-down
(f)	Fail to start	-	warning and shut-down
(g)	Over speed	-	shut-down
(h)	Low battery voltage	-	warning
(i)	Low fuel level (1st.stage)	-	warning
(j)	Low fuel level (2nd.stage)	-	shut-down
(k)	Fuel pump runaway	-	warning and shut-down by shut-off fuel supply to the engine

Protective devices provided shall form the generator set monitoring, protection and control module as in Section 14.0 – Generator Set Control Board and Generator Set Controllers.

The set values for the above warning and shut-down protective devices shall be of the manufacturer's recommendations.

The 'fail to start' warning and shut-down protective devices shall operate if the engine fails to start within a adjustable pre-set time and stop the automatic starting cycle to avoid successive depletion of the battery charge. The time shall be set to allow for 6 attempts in starting each with a rest interval of half the time setting of the attempt to start.

Under any of the above conditions, a common alarm bell of 250 mm diameter installed at the generator set control board and a similar alarm bell of weatherproof type installed externally above the generator room door shall sound. In addition, indication lamps showing operation of each engine protective devices shall also be provided at the generator set control board.

Upon receiving the signal from the fire detection system in the generator room, the generator set, if it is operating, shall automatically shut-down. If the generator set is not

operating, the generator set shall be locked out from starting. In addition, the fuel supply lines shall be automatically isolated and alarm shall be activated.

All control/signalling cables from the generator set control board to the generator set, fuel level sensor switches, main switchboard, etc. shall be multicore 2.5 sq.mm pvc/swa/pvc cables. Sufficient numbers of cores plus 20% or minimum 6 cores for spare shall be provided to serve their purpose. The cable shall be laid on the hot-dip galvanized cable tray which shall be installed on the side wall of the cable trenches. If exposed the cable shall be laid along side with the mains cable on the suspended hot-dip galvanised cable tray. All cores shall be properly labelled with number sleeves and terminated at the rail mounting terminal blocks housed in metalclad box. In the generator set control board and main switchboard, the terminal blocks shall be of the type with isolating knife links. No two or more cores shall be terminated in the same terminal block.

The Electrical Contractor shall ensure and verify with simulation tests and function checks for the operations of each the above protective devices in the presence of the S.O's Representative during testing and commissioning at site on completion of the generator set erection. All tests shall be carried out and recorded, and test results shall be submitted to S.O.'s Representative.

The generator set shall be provided with an electric starting system. The electric starter motor for the engine shall be of automatic type to be controlled by the automatic starting and stopping system.

Unless otherwise specified in the Bill of Quantities and/or Drawings, each engine shall be fitted with its own electric starting system complete with batteries and battery charger.

12.1 BATTERIES

Unless specified otherwise, batteries shall be 24 volt heavy duty nickel cadmium (Ni-Cad) batteries, each cell of 1.2V nominal and of C5 rated capacity.

The capacity of the batteries shall be as recommended by the battery manufacturer for a particular make and model of the generator set offered plus that required to operate the dc indicating, tripping, alarming and control circuits. The batteries shall be of sufficient capacity to provide a minimum of six (6) successive abortive starts of the engine without recharging. The minimum cranking period for each abortive start shall be 15 seconds. The Tenderer shall ensure and guarantee that the capacity offered in the Tender shall meet this requirement. If so required by the S.O.'s Representative, the Electrical Contractor shall submit calculation worksheet together with all battery data and characteristics on the sizing of the batteries to meet the requirements. In the case where the capacity of the batteries offered in the Tender fails to meet the requirement, the Electrical Contractor shall responsible to provide at his own cost the batteries of sufficient capacity that satisfy this requirements.

The batteries shall be connected to the starter motor starting and stopping circuit complete with indicating or signal devices. A double pole isolating switch of suitable rating shall be provided between batteries and the starter motor. Batteries shall be housed in a rack or crate located beside the generator set and the exposed battery terminals shall be protected by insulation cover to prevent accidental shorting of the terminals. The battery rack or crate shall be strong, adaptable and provides good alkali protection.

Low battery voltage protection shall be provided so that an alarm signal is given and engine starting system is cut off when the battery voltage falls below the required voltage for starting the engine.

12.2 BATTERY CHARGER

A battery charger shall be provided and installed for the generator set used in standby operation mode. The battery charger shall be of automatic constant potential current limiting type with two rates of charging, suitable for operating at an ambient temperature range of 25 ^{0}C to 40 ^{0}C, complete with ammeters (milli-ampere meter for trickle charge and ampere meter for boost charge), voltmeters, mains isolator, indicating lights for 'Mains On', 'Trickle Charge', 'Boost Charge', 'A.C. Failure' etc. The battery charger shall be of the type and make recommended by the battery manufacturer. The charging rates shall be in accordance with the battery manufacturer's recommendations.

The battery charger shall be suitable for charging nickel cadmium battery and lead acid battery. Selection of charging for nickel cadmium battery or lead acid battery shall be effected by means of a manually operated changeover switch installed inside the battery charger cubicle.

Miniature circuit breaker (mcb) or high speed fuse shall be used at the input and output circuit for protection against excessive current flow. The charger components shall be protected against over-voltage during battery disconnection or in case of loose termination, and also against reverse battery connection. The battery charger shall also be fitted with surge protection devices to protect against voltage surge due to lightning.

In addition the battery charger shall provide individual indication and common alarm under the following fault conditions:-

(a)	DC low and high volt	-	± 20% of float voltage
(b)	Battery earth fault	-	positive or negative earth fault
(c)	Mains failure	-	mains failure
(d)	Charger failure	-	output voltage drops abnormally
(e)	Load open	-	5% of output rating

The battery charger shall be separately housed in a metalclad enclosure either wall mounted or floor standing type mounted near to the batteries. The cables connecting the batteries to the battery charger and to the engine respectively shall be of suitable size multi-strands copper conductor pvc insulated flexible type, installed in cable trench covered with hot-dip galvanised checker steel plate.

Where the generator set is used for continuous supply, an engine driven alternator of suitable current rating coupled to the engine for charging the batteries shall be provided and shall be supplied by the generator set manufacturer. Automatic cut-off shall be provided when the batteries are fully charged.

13.1 ELECTRICAL PROTECTION RELAYS AND INSTRUMENTATIONS

Whether or not specified in the Bill of Quantities and/or Drawings, the following generator set electrical protection relays and their associated current transformers and electrical measuring instrumentations shall be provided and installed at the generator set switchboard.

For generator set of rated capacity at and exceeding 1000 kVA and for generator sets in parallel operation mode, the electrical protection relays and instrumentations shall be of microprocessor based numeric type as specified herein in Section 13.2 – Generator Protection Relays. Otherwise, the protection relays and electrical measuring instrumentations shall be of digital type.

Electrical protections for the generator set shall include but not limiting to the followings:-

(1) Over current with inverse-time operating characteristic;

(2) Earth fault, instantaneous characteristic;

(3) Restricted earth fault for the neutral, instantaneous characteristics for generator set rated at 1000 kVA and above. The operation of this relay shall also cause to shut down the engine;

(4) Restricted earth fault for the alternator stator windings, instantaneous characteristics for generator set rated at 1000 kVA and above. The operation of this relay shall also cause to shut down the engine;

(5) Over-excitation detection based on volts/hertz measurement for generator set rated at 1000 kVA and above. The operation of this relay shall also cause to shut down the engine;

(6) Over/under-voltage for generator set rated at 1000 kVA and above and for generator sets in parallel operation mode. The operation of this relay shall also cause to shut down the engine;

(7) Synchronising check relays for both manual and automatic synchronisation for generator sets in parallel operation mode. The operation of this relay shall cause to open or prevent the closing of the generator set circuit breakers;

(8) Over/under-frequency for generator set rated at 1000 kVA and above and for generator sets in parallel operation mode;

(9) Reverse power for generator sets in parallel operation mode;

(10) Voltage phase reversal for generator sets in parallel operation mode.

The operation of the electrical protection relays shall cause the generator set circuit breaker to trip.

Measuring instrumentations with LED display shall include:-

(1) Voltmeters (R-phase; Y-phase; B-phase);

(2) Ammeters with maximum indicator (R-phase; Y-phase; B-phase);

(3) Frequency Hz meter;

(4) Hour-run meter;

(5) Power factor meter;

(6) Kilo-watt-hour meter;

(7) Active power meter for generator set rated at 1000 kVA and above and for generator sets in parallel operation mode;

(8) Reactive power meter for generator set rated at 1000 kVA and above and for generator sets in parallel operation mode;

(9) Combined synchroscope and synchronizing check relays of LED type for generator sets in parallel operation mode;

(10) Dual frequency meter for generator sets in parallel operation mode;

(11) Dual voltage meter for generator sets in parallel operation mode.

The Electrical Contractor shall ensure and verify with simulation tests and function checks for the operations of each electrical protection relays in the presence of the

S.O's Representative during switchboard factory acceptance tests and also during testing and commissioning at site upon completion of the generator set erection. All tests shall be carried out and recorded, and test results shall be submitted to S.O.'s Representative

13.2 GENERATOR PROTECTION RELAYS

Notwithstanding specified above or elsewhere, the generator protection relays for the generator set rated capacity at and exceeding 1000 kVA and for generator sets in parallel operation mode shall be microprocessor based numerical relays with the microprocessor deciding on alarm and trip conditions. Relays shall be of approved type complying with relevant part of IEC 60255, and shall be suitable for use in a tropical climate with an operating temperature range of up to 70 ^{0}C and a relative humidity of 90 %. The rated operating voltage of the relays shall 120 Vac – 270 Vac or 16 Vdc – 250 Vdc. The relays shall incorporate surge protective device against voltage surge. There shall be an LED indicating a healthy power supply on the power supply module.

All settings, date, time and fault records shall be stored in non-volatile memory. The settings shall be stored in Electrically Erasable Programmable Read Only Memory (EEPROM). It shall be possible to change the relay settings in the foreground without affecting the actual operating values in the background. This shall make it possible to change the settings on a live circuit breaker, taking the new set values in use only after a final confirmation is done. Upon inception of fault, the protection device shall capture the fault data.

Continuous self-supervision for internal faults on the protection modules and the control modules shall be available. The self-supervision shall inhibit any tripping from occurring if an internal fault is detected and provide an indication for alarm. Relays shall also be provided with a provision for manual operation of supervision function as to be able to check the relay as and when required.

The relays shall have RTD (Resistance Temperature Device) input module to provide the following: -

(a) Thermal model biasing;

(b) Temperature alarm and trip; and

(c) RTD open or short indication

Protection and control modules shall have NUMERICAL displays from which settings, currents, memorised fault values and relay operation shall be displayed. Relays shall also have LED indicators for identification of fault on each phase. All measured values (i.e. phase currents) and fault values shall be displayed in its primary values.

The relays shall have SERIAL COMMUNICATION port for settings as well as monitoring and control of the circuit breaker they protect from a remote station. The port shall also be available to allow local setting of the relay through PC-based software for the purpose of setting the relays and the software shall not be of proprietary software. The software and all documentation shall be provided in this Contract.

The relays shall accept IRIG-B time code synchronization and include a battery-backed time clock to retain date and time during de-energization.

Cases housing the protection and control modules shall be made of non-corrosive materials such as aluminium. The design of the case and modules shall be such that it shall have high immunity against electrical disturbances according to IEC 60255 and electromagnetic compatibility (EMC) compliance.

The generator protection relays shall come with voltage inputs to provide the following protection elements: -

(a) over/under-voltage;

(b) over/under-frequency;

(c) under-power;

(d) reactive power; and

(e) power factor.

The generator protection relays shall also include the following minimum functions: -

(a) Over-speed (12);

(b) Over-excitation detection based on volts/hertz measurement. One definite-time and a composite definite/inverse-time element shall be provided (24);

(c) Under-voltage (27);

(d) Inadvertent generator energization (50/27);

(e) Sensitive directional power elements with flexibility to provide anti-motoring, over-power, or low-forward power indication (32);

(f) Loss of field (40Q);

(g) Negative-sequence over-current elements, including definite-time and inverse-time operating characteristic (46);

(h) Voltage phase reversal (47);

(i) Instantaneous overcurrent (during start-up) (50S);

(j) Phase, residual, and neutral instantaneous, definite-time, and inverse-time non-directional over-current elements (50/51GN);

(k) Voltage restrained phase over-current (51V);

(l) Phase, positive-sequence, negative-sequence, and residual over-voltage elements (59); and

(m) Over and under-frequency (81).

Notwithstanding the functions provided as described above, the generator protection relays shall also provide all electrical protection relays as described in Section 13.1 – Electrical Protection Relays and Instrumentations.

The generator protection relays shall include metering and monitoring functions to indicate the following:-

(a) Measured current and voltage magnitudes and phase angles. Third-harmonic neutral and terminal voltage magnitudes. Volts/Hertz, percent of nominal;

(b) Single- and three-phase real and reactive power (KW, KVAR) and power factor (PF);

(c) Single- and three-phase real and reactive directional energy (KWh, KVARh);

(d) System frequency;

(e) Maximum and minimum log for Ia, Ib, Ic, In, Va, Vb, Vc, Vn, 3∅ KW, and KVAR; and

(f) DC battery voltage monitoring and metering.

In addition, the generator protection relays shall retain in non-volatile memory, the following:

(a) A sequence of events record consisting of the latest time-tagged events; and

(b) No fewer than 15 latest event reports containing voltage and current measurements, contact input and output status, and relay element conditions. Record formats displaying 4 and 16 samples per cycle shall be available.

14.1 GENERATOR SET CONTROL BOARD

A generator set control board housing generator set controllers, control switches and buttons, relays, timers, indicating lights, indicating instruments, selector switches, alarms, etc. shall be supplied and installed. The control board shall be cubicle construction suitable for floor standing fabricated from sheet steel of not less than 2 mm thickness of similar construction as for the generator set switchboard as described hereinafter. The construction of the generator set control board shall be as described in the relevant sections of the specification – Specification for Low Voltage Internal Electrical Installation.

Whether or not shown in the Drawings, the generator set control board shall be of stand-alone type, not forming part of the generator set switchboard but having the same dimensions in height, depth and section width as that of the generator set switchboard.

For parallel operation, the generator set control board shall complete with combined synchroscope and synchronising check relays, dual frequency meter and dual voltmeter. Neutral switch shall be provided in the generator set switchboard for each generator set. The neutral switch shall be capable for carrying for three (3) second the prospective earth fault current available when two numbers or more of generator sets are running in parallel. Auxiliary contacts shall be derived to give an indication of the position of each neutral switch (open / trip / close status). The neutral switches shall be so arranged and interlocked to ensure that only one generator set can be earthed at any one time when the generator sets are running in parallel

A common alarm bell of 250 mm diameter and a self-latching mushroom head type EMERGENCY STOP push-button shall be provided at the generator set control board.

All control wiring shall be not less than 1.5 sq. mm section insulated with pvc and shall be properly labelled with number sleeves.

14.2 GENERATOR SET CONTROLLERS

The generator set control board shall house generator set controllers complete with their function keys, switches and indications. The generator set controllers shall be of microprocessor based type compliance to MS IEC 60950-1, operating at 10 – 40 Vdc suitable for mains input and alternator input of 50 – 275 Vac phase-neutral. The power consumption of the controllers shall be less than 10 W, operating temperature up to 70 ^{0}C and relative humidity up to 95 %. All no-voltage contacts shall be rated minimum at 16 A. The controllers shall provide with protection against over-voltage and reverse polarity.

The controllers shall also compliance to BS EN 50081-2 and BS EN 50082-2 on electromagnetic compatibility on emission and immunity standards respectively.

The controllers shall include the generator set monitoring, protection and control module required for all protective devices for the generator set to suit the generator set operation mode as described in Section 11.0 – Engine Protective Devices. The generator set monitoring, protection and control module shall have expansion capabilities, if so required by the S.O.'s Representative, to meet more monitoring, protection and control functions. All alarm and operation status indication shall be of high visibility LED (light emitting diode) type and/or LCD (liquid crystal display) display board or screen.

The parameter settings for the controllers can be configured on the controller itself without using PC (personal computer) to uploading the parameters via communication port.

The controllers shall have event capture/logging facilities to record minimum 25 events of alarm and shut-down operation of the protective devices. Each event (date, time, type of fault) can be displayed on the LCD display board. If specified, the events can also be downloaded to the handheld and/or remote PC via a communication port described hereinafter.

The controllers shall be of front panel flush mounting type of IP 54 and all cable terminations shall be of IP2X.

If specified elsewhere where the controllers are required for full system integration into the building automation system and/or building management system, the controllers shall allow full telemetry facilities with integrated software to be able to parameter checking and setting, status monitoring and controlling, event logging and downloading using PC. Serial communication shall be of Mod-bus protocol and the communication port shall be of RS232/RS485. Communication software of MS-Window based shall be provided.

If further specified elsewhere, a comprehensive remote communication via RS232 port with RS232 modem link to either PSTN (public switched telephone network) line or GSM (global system of mobile communication) network shall be provided. In the event of the controllers detecting an alarm condition, it will initiate a modem dial out to the host PC and/or to send text messages to the cell phone to inform and indicate the generator set site and alarm condition, the time and date of occurrence.

The generator set controllers shall consist of one or combination of, as the case may be, the following monitoring, protection and control modules to serve their functions as specified in the Bill of Quantities and/or Drawings for the generator set operation modes as described hereinafter:-

(a) Generator set monitoring, protection and control module;

(b) Automatic mains failure module;

(c) Automatic transfer switching module;

(d) Automatic synchronisation and parallel operation module;

(e) Automatic load sharing, balancing and transfer power management module;

Automatic synchronisation and parallel operation module shall complete with digital synchroscope.

14.2.1 CONTINUOUS OPERATION MODE

In continuous operation mode, the generator set is to provide continuous supply to the loads. The generator set controllers shall equip with the monitoring, protection and control module and any other associated modules necessary to provide the minimum operation mode described hereafter.

(1) OFF

In this mode the generator set cannot be started.

(2) START

By pressing push-button START, the generator is started. This push-button has to be pressed until the start-up speed is reached.

(3) STOP

By pressing push-button STOP, the generator is stopped immediately. The STOP command remains active throughout the stopping time.

(4) ALARM SILENCE

By pressing this push-button, the alarm signal is switched off. All warning and automatic shut-down functions of the protective devices are indicated by this alarm signal and flashing indications. All flashing alarm indications are indicated by continuous light

after push-button ALARM SILENCE has been pressed. After 5 minutes, the alarm signal is switched off automatically.

(5) RESET / LAMP TEST

By this push-button all alarms as well as faults which have caused failure indication are reset. Warning and shut-down alarms which are still active cannot be reset. If this push-button is pressed continuously, test of all indication lamps is initiated.

The controllers shall also able to be configured to receive EMERGENCY STOP signals to stop the generator set. Self-latching mushroom head type EMERGENCY STOP push-buttons shall be provided – one to be provided at the generator set control board and another one in the vicinity of the generator set to be decided on site by the S.O.'s Representative.

14.2.2 STANDBY OPERATION MODE

The generator set installed in a standby operation mode is to provide readily and immediate alternative supply to the loads in the event the normal supply from the Licensee or Supply Authority (hereinafter as "mains") fails. The generator set controllers shall equip with (a) generator set monitoring, protection and control module, (b) automatic mains failure module, (c) automatic transfer switching module and any other associated modules necessary to provide the minimum operation mode described hereafter.

(1) AUTOMATIC mode

When mode AUTOMATIC is selected, the automatic emergency operation of the generator set is activated, and this places the generator set in its normal standby mode. In case of mains fails or the mains voltage falls below 15% of the rated voltage, the generator set is started automatically. After the speed and voltage of the generator set are within the normal limits, automatic changeover shall then take place whereby the loads are connected to the generator set.

When the mains is restored, the loads are changed over to the mains automatically. Thereafter the loads are supplied by the mains again. After a certain pre-set time, the generator set is stopped.

Time durations for each operation shall be as following:-

a timer (t_1) – adjustable up to 15 seconds for starting the generator set;

a timer (t_2) – adjustable up to 60 seconds for load connection to the generator set after starting up the generator set;

a timer (t_3) – adjustable up to 5 minutes before the automatic load transfer to the mains after mains restoration;

a timer (t_4) – adjustable up to 10 minutes for shutting down the generator set after load connection to the mains on mains restoration. All timers shall have calibrated scales in seconds or minutes as appropriate.

(2) TEST mode

In this mode no-load and load test run of the generator set is possible. In mode TEST the generator set is automatically started and supervised without actually changing over the load from the mains to the generator set. However if mains fails during TEST mode, the mains emergency operation is initiated automatically and load connection to the generator set must operate.

(3) OFF mode

In this mode the generator set cannot be started.

(4) MANUAL mode

In this MANUAL mode, the manual operation of the generator set is selected. In this operational mode, the generator does not react to mains failure. The generator set can only be started manually. The generator set can be started manually by push-button START and stopped by push-button STOP.

The controller shall also incorporate the following key functions in the form of push-buttons:

(1) START

By pressing push-button START, the generator is started. This push-button is only activated in MANUAL operational mode and has to be pressed until the start-up speed is reached.

(2) STOP

By pressing push-button STOP, the generator is stopped immediately. The STOP push-button has precedence over the START push-button and is only activated in MANUAL operational mode. The STOP command remains active throughout the stopping time.

(3) ALARM SILENCE

By pressing this push-button, the alarm signal is switched off. All warning and automatic shut-down function of the protective devices are indicated by this alarm signal and flashing indications. All flashing alarm indications are indicated by continuous light after push-button ALARM SILENCE has been pressed. After 5 minutes, the alarm signal is switched off automatically.

(4) RESET / LAMP TEST

By this push-button all alarms as well as faults which have caused failure indication are reset. Warning and shut-down alarms which are still active cannot be reset. If this push-button is pressed continuously, test of all indication lamps is initiated.

The controllers shall also able to be configured to receive EMERGENCY STOP signals to stop the generator set. Self-latching mushroom head type EMERGENCY STOP push-buttons shall be provided; one to be provided at the generator set control board and another one in the vicinity of the generator set to be decided on site:

14.2.3 PARALLEL OPERATION MODE

In parallel operation mode, two or more generator sets are installed to provide either supply to the loads continuously (continuous operation mode) or as the alternative supply to the loads in the event the normal mains supply fails (standby operation mode), as the case may be, as specified in the Bill of Quantities and/or Drawings.

The generator set controllers for continuous operation mode shall equip with (a) generator set monitoring, protection and control modules, (b) automatic synchronisation and parallel operation module (c) automatic load sharing, balancing and transfer power management module. For standby operation mode, the controllers, in addition to the modules required for continuous operation mode, shall equip with (i) automatic mains failure module and (ii) automatic transfer switching module.

Automatic active and reactive load sharing, frequency and voltage adjustments between the generator sets shall also be included.

The controllers for parallel operation mode shall also provide for programming the selection, sequential starting-up, synchronizing, sharing the load, automatic duty cyclic operation and stopping of the generator sets. Generator set can also be selected to operate singly in the event the other generator set is out of service.

The controllers shall complete with any other associated modules for the minimum operation modes described hereafter.

In continuous operation mode, the pre-selected lead generator set shall start manually and then follow by the second generator set and other generator sets in sequence automatically. However if in standby operation mode the lead generator set shall start automatically upon failure of the supply from the Licensee or Supply Authority. The generator sets are synchronised to run in parallel, automatically or manually as predetermined, with the closing of the generator circuit breakers. When the generator sets are running in stable conditions, the main generator supply circuit breaker is then closed, automatically or manually as predetermined, to provide electrical supply to the loads.

After the loads are connected, the active and reactive loads shall be shared automatically between the generator sets. At pre-set loading conditions, automatic load transfer shall take place where full load shall be transferred to the selected lead generator set. After the full load is transferred to the selected lead generator and the generator sets are running in stable conditions, the second generator set shall automatically shut down after the predetermined time. In the event the load increases and reaches the pre-set value, the second generator set shall start-up, synchronise and share the loads automatically.

For a pre-set condition, the lead generator set is allowed to run continuously for a set time (after 8 hours operation). Thereafter, the second generator set shall automatically start up, synchronise with the lead generator set and share the load. Full load shall then be transferred to the second generator set. The lead generator set shall automatically stop at predetermined time. Vice versa operation shall take place after a set cycle time.

In the case of continuous operation mode, when STOP command is activated, the generator set circuit breakers shall open and the generator sets shall shut-down in sequence automatically. In the case of standby operation mode, the generator sets shall shut-down in sequence automatically after load connection to the mains on restoration of the supply from the Licensee or Supply Authority.

In both operation modes, when EMERGENCY STOP command is activated, the main generator set supply circuit breaker and the respective generator set circuit breakers shall open and the generator sets shall shut-down instantly.

The neutral switch of the selected lead generator set which is brought to service shall be closed automatically. If the duty neutral switch opens inadvertently, the second neutral switch shall automatically be closed.

All interlocks, either electrically or mechanically or both, shall be provided. The selection switches for operational requirements and interlock of the circuit breakers and neutral switches shall be expressed in a truth table which shall be submitted to S.O's Representative for approval. Operation of the switches and circuit breakers in accordance to the approved truth table shall be verified in the presence of the S.O's Representative during testing and commissioning at site.

The automatic transfer switching equipment (ATSE) shall comprise of a transfer switching device and a necessary monitoring and transfer control device (automatic transfer switching module as described in Section 14.0 – Generator Set Control Board and Generator Set Controllers) for monitoring supply circuits and for transferring load circuits from the normal supply to an alternative supply in the event of a monitored supply deviation and automatically returning the load to the normal supply when it is restored.

ATSE shall be of utilization category AC 33B and shall comply to MS IEC 60947-1 and IEC 60947-6-1.

Unless otherwise specified, the operating mechanism of the ATSE shall be reliably, electrically and mechanically interlocked to prevent simultaneous connection to both normal mains and alternative supplies.

15.1 TRANSFER SWITCHING DEVICE

Unless specified otherwise in the Bill of Quantities and/or Drawings, the transfer switching device of an ATSE shall be of automatic changeover contactors Class PC type in accordance with IEC 60947-6-1. The automatic changeover contactors shall be bar mounted type with fixed bar and moving shaft made of steel and bearing supports made of aluminium/bronze alloy. They shall be of double air-break, quick-make and quick-break type complying with MS IEC 60947-1 and IEC 60947-4-1. They shall be dust-proof, rust protected, fully tropicalised and suitable for use on 240 V/415 V, 50 Hz A.C. system.

The operating coil shall be 240 V/415 V 50 Hz A.C. type and shall operate satisfactorily when the voltage at the coil terminals is between 85% and 110% of the nominal voltage. The electromagnet shall be of laminated type.

The automatic changeover contactors shall be four pole type. Each pole shall comprise three main parts: -

(a) The main contacts shall be of 'butt-contact' pattern without sliding or rolling and shall operate with absolute minimum contact bounce.

(b) The blow out coil shall be rated to carry the total current flowing through the main pole and according to the thermal rating of the contactor.

(c) The arc chute shall be De-ion type or the type having 'arc splitter' for rapid extinction of electric arc. Each arc chute shall have a steatite disc on its internal faces for preventing rapid erosion of the chute by the effect of arcs. The arc chutes shall be easily removable to allow inspection of the main contacts and where necessary their replacement.

The main contacts shall able to carry continuously the rated current, capable of making and withstanding short-circuit currents without damage in an enclosure having an ambient temperature up to 40 ^{0}C.

Unless otherwise specified, a minimum of four normally close and four normally open auxiliary contacts shall be provided.

A transparent protection screen of full compartment size shall be provided in front of the automatic changeover contactors.

For Class CB where the circuit breakers are specified as transfer switching devices, the circuit breakers shall comply with MS IEC 60947-1 and MS IEC 60947-2. Unless specified otherwise, the rated short-time withstand current shall be of the same rating for the circuit breaker receiving supply from the Licensee or Supply Authority.

15.2 MONITORING AND TRANSFER CONTROL DEVICE

ATSE shall complete with a monitoring and transfer control device for monitoring supply circuits and for transferring load circuits from the normal mains supply to an alternative supply in the event of a monitored supply deviation and automatically returning the load to the normal mains supply when it is restored.

The monitoring and transfer control device shall be of microprocessor based controller comprising automatic transfer switching module or combination of automatic transfer switching module and automatic mains failure module. The device shall form part of the generator set controller to serve its functions in standby operation mode as described in Section 14.0 – Generator Set Control Board and Generator Set Controllers.

The generator set switchboard shall be of the self-contained cubicle type, free standing floor mounted, metalclad, flush fronted suitable for front and rear access housing switchgear and controlgear, protective relays, meters, indicating lamps, cable terminating boxes, and all other necessary items of equipment whether specified hereinafter or on the Drawings or not, suitable for operation on a 240 V/415 V, 3 phase, 4 wire, 50 Hz system with solidly earthed.

Whether or not shown in the Drawings, the generator set switchboard for all operation modes described in Section 17.0 – Operation Modes shall be of stand-alone type, not forming part of the main switchboard but having the same dimensions in height, depth and section width as that of the main switchboard.

Unless otherwise specified elsewhere, the generator set switchboard shall be in general compliance with MS IEC 60439-1, and capable of withstanding without damage fault condition of not less than 50 kA at 415 volts for 1 second.

Unless specified otherwise, the generator switchboard shall be of Form 2b. The frame work of the switchboard shall be fabricated from rolled steel sections of thickness not less than 2.5 mm and shall be self-supporting when assembled, uniform in height and depth from front to back. The rigid construction shall be designed to withstand without any sag, deformation or warping, the loads likely to be experienced during normal operating, maintenance or maximum fault conditions.

The front shall be provided with covers/doors of box formation. The rear shall be provided with hinged removable doors of box formation. The rear doors shall be of double-leaf type with rebated edges and each leaf should preferably not be wider than 450 mm. Each leaf of door shall have 2 pairs of approved hinges. The door shall be fitted with approved type of surface-mounted espagnolette or cremone bolts complete with approved locking device operated by a satin chrome lever handle at the centre fixing. The top and sides shall be of removable panels. All panels, covers and doors shall be fabricated from sheet steel of thickness not less than 2.0 mm and so constructed as to provide a clear, flush and pleasing appearance. The panels, covers and front doors shall be secured to the enclosure by means of chrome type of screws with cylindrical knurled head complete with retaining clips. Welded cross struts shall not be used.

The generator set switchboard shall be dust and vermin proof. All covers and doors shall be provided with grummets and seals to exclude dust and dirt. Louvres or ventilation vent with filter shall be provided at the sides and back for adequate ventilation.

The whole cubicle shall undergo de-rusting treatment, followed by anti-rust treatment and the exterior finished with epoxy dry-powder and oven baked semi-gloss enamel grey and interior finished matt white.

Busbars shall be tinned hard drawn high conductivity copper of adequate rectangular cross section to carry continuously the rated normal current at a rated frequency of 50 Hz with a temperature rise in accordance with the requirements of BS 159. Busbar sizes must not be less than specified in the Drawings. However if not specified, then the busbar rating shall be based on the current density of not more than 1.5 A/sq.mm. Busbars shall be arranged and rigidly mounted on non-hygroscopic insulators so as to withstand any mechanical forces to which they may be subjected under the maximum fault conditions. Where multiple parallel bars are used, they shall be separated by tinned copper spacers at spacing equal to the bar thickness.

The main busbars shall be run for the full length of the generator set switchboard without reduction in size and shall be arranged in the horizontal plane and in the order Red phase, Yellow phase, Blue phase and Neutral from back to front. In each panel, connections shall be Red phase, Yellow phase, Blue phase and Neutral from left to right, viewed from the front of the panel. The neutral busbar shall be of full size and full length as that of the phases. Tinned copper earthing bar of 6 mm x 25 mm cross section shall run to the full length at the base of the generator set switchboard.

Busbars shall be identified with standard colour code Red, Yellow, Blue, Black and Green at appropriate points to distinguish the phases, neutral and earth respectively.

Connections from busbars to the switchgears shall be effected by means of copper bars or copper insulated conductors and shall be identified by means of coloured plastic sleeves or painting in accordance with the standard colour code. All connections shall be made up with bronze or other copper alloy bolts and nuts utilizing tension washers on both outer faces.

Precautions shall be taken to prevent overheating through hysteresis and Eddy current losses.

All secondary wiring shall be minimum 1.5 sq.mm. section insulated with PVC and shall be fixed securely without strain by cleats of the compression type. All secondary wiring shall be properly labelled with number sleeves. Flexible protective conductor of not less than 2.5 sq. mm section insulated with PVC shall be fixed securely between the lids, doors, cover plates etc. with electrical equipment attached to them and the main cubicle to ensure continuity of the protective circuits.

All switchgears, controlgears, indicating and measuring instruments, measuring transformers, electrical protection relays etc. provided shall comply with the relevant sections in this Specification and/or specifications stated elsewhere.

Whether or not specified elsewhere, the circuit breakers for the generator sets for parallel operation shall be of motorised type and where four pole circuit breakers are specified the neutral pole shall be of full size as those of the phases.

One number anti-condensation heater shall be installed for every two (2) sections at the generator set switchboards. Each heater shall be complete with automatic thermostat, control switch and indicating lamp.

A tools compartment of sufficient size shall be provided at the base of the generator set switchboard for storage of tool kit used for the generator set. The door for tools compartment shall be hinged type complete with lockable handle with keys.

Engraved labels with white lettering on a black background made of laminated materials shall be provided and fastened on the front panels for each and every switchgear and items of equipment. Wording shall be clear and coincide and shall be approved by the S.O.'s Representative. Engraved name plate showing the relevant earth fault setting, overcurrent setting, current transformer ratio, fuse rating, name of the circuit to which it is connected, etc. shall be fixed to the switchgear panel to which it refers.

Notwithstanding specified above, the generator set switchboard shall comply with the requirements of relevant sections of the specification – Specification for Low Voltage Internal Electrical Installation.

The generator sets are installed to operate under one or combination of the following operation modes as specified in the Bill of Quantities and/or Drawings. The operation modes described in general hereinafter shall conform to those described in Section 14.0 – Generator Set Control Board and Generator Set Controllers.

(1) Continuous operation mode;

(2) Standby operation mode;

(3) Parallel operation mode

17.1 CONTINUOUS OPERATION MODE

The generator set is started by pressing push-button START. This push-button has to be pressed until the start-up speed is reached. By pressing push-button STOP, the generator is stopped immediately. The STOP command remains active throughout the stopping time.

In OFF mode the generator set cannot be started.

17.2 STANDBY OPERATION MODE

In AUTO mode, when the mains supply from Licensee or Supply Authority fails or when the mains supply voltage falls below 15% of the rated voltage, the voltage sensing control relays shall operate to start the generator set automatically in 5 seconds (timer t_1). After the speed and voltage of the generator set are within the normal limits, the main contacts of the automatic transfer switching equipment (ATSE) shall be closed after a time delay of 10 seconds (timer t_2).

When the normal mains supply is restored, the ATSE shall change over to the normal mains supply position after a time delay of 3 minutes (timer t_3). After the changeover has taken place the generator set shall continue to run for 5 minutes (timer t_4) before it shuts down automatically.

Unless otherwise specified, the timers t_1, t_2, t_3 and t_4 shall be set as stated above.

In all events the generator set supply shall not be allowed to run in parallel with supply from the Licensee and/or Supply Authority.

17.3 PARALLEL OPERATION MODE

The generator sets shall provide for automatic duty cyclic operation.

In continuous operation mode, the pre-selected lead generator set shall start manually and then follow by the second generator set automatically. In the standby operation mode, the pre-selected lead generator set is started automatically. The generator sets are synchronised to run in parallel, automatically or manually as predetermined with the closing of the generator set circuit breakers. When the generator sets are running in stable conditions, the main generator set supply circuit breaker is then closed, automatically or manually as predetermined, to provide electrical supply to the main switch board.

After the loads are connected to the generator sets, the active and reactive load shall be shared automatically between the two generator sets. At pre-set loading conditions, automatic load transfer shall take place where full load shall be transferred to the selected lead generator set. After the full load is transferred to the selected lead generator set and the lead generator set is running in stable conditions, the other generator set shall automatically shut down after the predetermined time. In the event the load increases and reaches the pre-set value, the second generator set shall start-up, synchronise and share the load automatically.

For a pre-set condition, the lead generator set is allowed to run continuously for a set time (after 8 hours operation). Thereafter, the second generator set shall automatically start up, synchronise with the lead generator set and share the load. Full load shall then be transferred to the second generator set. The lead generator set shall automatically stop at predetermined time. Vice versa operation shall take place after a set cycle time.

In the case of continuous operation mode, when STOP command is activated, the generator set circuit breakers shall open and the generator sets shall shut-down in sequence automatically. In standby operation mode, the generator sets shall shut-down in sequence automatically after load connection to the mains on restoration of the supply from the Licensee or Supply Authority.

Generator set can also be selected to operate singly in the event the other generator set is out of service.

All system earthing and equipment earthing shall comply with Electricity Regulations 1994 and relevant parts of MS IEC 60364. Earthing methods shall base on and comply with BS 7430.

Main earthing bar for the generator set (hereinafter as "main earthing bar") shall be provided at a position near to the generator set switchboard as indicated in the Drawings. Main earthing bar shall be of tinned copper bar mounted on porcelain insulators and of dimension as in Table 1 with respect to the prospective earth fault current indicated in the Drawing. If prospective earth fault current is not specified in the Drawing, then the value shall base on the calculation with respect to the rated capacity, the transient reactance and sub-transient reactance of the generator set. The calculation shall be made available by the generator set manufacturer, and the Electrical Contractor shall provide such calculation to the S.O.'s Representative before the construction of the main earthing bar. Main earthing bar shall be of sufficient length to accommodate terminations for all protective conductors, earth conductors, main equipotential bonding conductors and neutral earthing conductors of the generator set installation. Means shall be provided for disconnecting the earth conductors to permit measurement of the resistance of the earthing arrangements. The joints shall be disconnectable only by means of a tool and mechanically strong to ensure electrical continuity. A transparent protective cover of sufficient thickness and dimensions with label engraved and marked in red legibly with words 'Generator Main Earthing Terminals - Safety Electrical Connections - Do Not Remove' shall be installed to cover full length of the main earthing bar. All connections to the main earthing bars shall be soundly made and electrically satisfactory by means of bolts and nuts with spring washers and jam nuts.

Two earthing conductors of tinned copper tape of dimension as in the Table 1 below shall be provided to connect the main earthing bar to two different earth electrodes. The earthing conductors shall be protected, where necessary, by means of galvanised steel conduit and buried in the ground at a depth of not less than 450 mm below finished ground level.

Protective conductors between generator set control board, generator set switchboard and main earthing bar for the generator set shall be effected by tinned copper tape of same dimensions as the main earthing bar and they shall be protected by running in insulated PVC rectangular channel flushed with the floor slab.

TABLE 1: Dimensions of Main Earthing Bars for Generator Set and Earthing Conductors

Prospective Earth fault currents (I) for 1 s duration	Main Generator Earthing Bars (mm x mm)	Earthing Conductors (No. x mm x mm)
$I \leq 20$ kA	25 mm x 6 mm	1 x 25 mm x 3 mm
20 kA < $I \leq 30$ kA	31 mm x 6 mm	2 x 25 mm x 3 mm
30 kA < $I \leq 40$ kA	38 mm x 6 mm	2 x 25 mm x 3 mm
40 kA < $I \leq 50$ kA	50 mm x 6 mm	2 x 25 mm x 3 mm

Earth electrodes shall be of copper-jacketed steel core rods with 16 mm diameter and supplied in 1500 mm length and shall have provision for screw coupling with another standard length. The copper jacket of 99.9 % purity electrolytic copper shall be of minimum radial thickness 0.25 mm and shall be molecularly bonded to the steel core to ensure that the copper jacket and steel core are non separable. Each earth electrode shall be driven 3000 mm in depth. Where the desired earth resistance value cannot be achieved after the first earth electrode have been driven, sufficient number of earth electrodes in parallel shall be installed outside the resistance area until required value is reached. Mutual separation between two earth electrodes shall be more than, but less than twice, the driven depth of the earth electrode. Earth electrodes shall not be installed close to a metallic fence. Unless the metallic fence is separately earthed, the fence shall be separated from the electrical earthing system by at least 2000 mm. Interconnection between different earth electrodes shall be by means of 25 mm x 3 mm annealed copper tape.

Two test earth electrodes namely potential test probe and current test probe shall be provided. The test earth electrodes shall be one length of 1500 mm in depth. The current test probe shall be placed 30 m from the first earth electrodes with potential test probe midway between. Test leads of 2.5 sq. mm PVC insulated cable connecting test earth electrodes shall be terminated independently on the porcelain insulators next to the main earthing bar. The test leads shall be protected by means of non metallic conduit and buried in the ground at a depth of not less than 450 mm below finished ground level. Termination shall be identified with permanent labels durably and legibly marked with words 'Potential Earth Test Probe - Do Not Remove' and 'Current Earth Test Probe - Do Not Remove'. Similar labels of not less than 4.75 mm high shall be permanently fixed in a visible position at earth electrodes

The connection of the earthing conductor and/or the earth electrode to the earth electrode shall be soundly made by the use of plumbed joints, either by brazing using zinc-

free material with a melting point of at least 600 ^{0}C or by thermic welding or by cold pressure welding.

Each earth electrodes shall be provided with heavy duty type inspection chamber with removable cover. The compressive strength of the inspection chamber and cover shall be minimum 6 N/mm^2. Lifting hook shall be provided in the cover.

A permanent label durably marked with words 'Safety Electrical Connection - Do Not Remove', in legible type not less than 4.75 mm high, shall be permanently fixed in a visible position at or near: -

(a) the point of connection of every earthing conductor to an earth electrode, and

(b) the point of connection of every bonding conductor to extraneous conductive parts.

In addition each earthing point shall be identified by permanent label legibly marked with the words `Generator Earth' or any other appropriate words permanently fixed to the point of connection of every earthing conductor and earth electrode.

Protective conductor between the generator set frame and the main earthing bar shall be provided for each generator set and shall be effected by 2 x 3 mm x 25 mm copper tape or single core 150 mm^2 pvc green cable. In addition bonding conductor between the main earthing bar and the main earthing bar for the electrical installation shall also be provided and shall be effected by a single core 150 mm^2 pvc green cable. The bonding conductors shall be protected by running in insulated pvc rectangular channel/circular tube flushed with the floor slab and/or clipped along the inside wall of the cable trench. Termination at the main earthing bar shall be identified with permanent labels durably and legibly marked with words 'Generator # Frame' and 'MSB Bond' respectively.

The neutral earthing of each alternator shall be brought out and connected via a single core 150 mm^2 pvc insulated black cable to main earthing bar. The cable shall be protected by running in insulated pvc circular tube flushed with the floor slab, clipped to the side walls of the cable trench or clipped along the cable tray or cable ladder as the case may be. Termination at the main earthing bar shall be identified with permanent labels durably and legibly marked with words 'Generator # Neutral'

Four (4) sets of earthing test results, duly certified by the Electrical Contractor's competent person of qualification in accordance with the requirements of the Electricity Supply Act 1990 and Electricity Regulations 1994, shall be submitted to the S.O.'s Representative before testing and commissioning of the generator set.

Within three weeks after award of the Tender or such shorter period as may be required by the S.O.'s Representative, the Electrical Contractor shall submit to the S.O.'s Representative for his approval of the following working drawings:

(a) Details of the layout of the generator set, fuel tank, generator set control board, generator set switchboard, radiator air discharge duct, exhaust system, fuel supply system, air intake system, air ventilation system etc. in the generator room provided;

(b) Details of the schematic installation diagrams of the fuel pipe lines with respect to generator set, service fuel tank and bulk storage fuel tank including all the fuel valves and fuel filters;

(c) Details of dimensions and weight loading of the foundations for the generator set, service fuel tanks and bulk storage fuel tank;

(d) Details of the layout and schematic wiring diagrams of the generator switchboard and generator set control board; and

(e) Relative locations of earthing points for the generator set with respect to the Generator Room.

If necessary as required by the S.O.'s Representative, the drawings submitted are to be modified and shall be resubmitted for final approval.

It is to be understood that approval of the drawings will not exonerate the Electrical Contractor from any responsibility in connection with the Work in this Contract.

Before any tests stated hereinafter being carried out, all apparatus, instruments and equipment required for the tests shall have been calibrated by approved accredited laboratory for accuracy within the preceding 12 months. The Electrical Contractor shall be responsible for all costs of all such calibrations and present the calibration certificates to the S.O.'s Representative for approval

Any defects and deficiencies of workmanship, materials, performance and design of equipment or other irregularities which become apparent during the tests shall be rectified by the Electrical Contractor and the tests shall be repeated at the Electrical Contractor's expense to the satisfaction of the S.O.'s Representative.

No inspection or approval by the S.O.'s Representative of the workmanship, equipment or materials covered by this Contract, whether carried out or supplied by the Electrical Contractor, shall release him from any of his obligations under the Contract.

Before commencement of any tests stated hereinafter, due advance notice not less than fourteen (14) days providing details of dates, times, location/place, types of tests, test methods/procedures and test records/formats and details of competent persons responsible for the tests shall be given to and agreed by S.O.'s Representative. All test methods/procedures and test records/formats other than those specified in this specification shall be approved by the S.O.'s Representative before tests being carried out.

The Electrical Contractor shall be responsible for all the costs and expenses incurred associated with the testing, inspection and commissioning of the Works. These include the costs and expenses for the provision of competent persons, assistance, instrument, machines, labour, consumable materials such as water, fuels and electricity etc. and any other facilities and equipment as may be necessary in all respect complying with the appropriate health and safety regulations. The qualifications of the competent persons provided during the tests shall be in accordance with requirements and provisions of the Electricity Supply Act 1990 and Electricity Regulations 1994.

20.1 WORKS TEST

Prior to installation at site the generator set shall be load tested at various percentage of the rated kVA of the generator set offered. The test shall be carried out in the presence of the S.O.'s Representative and/or his representatives. During this test, it should have maintained the highest possible standards for voltage regulation, frequency regulation, sudden load increase, load rejection and other characteristics.

Tests shall be carried out in accordance with ISO 8528-6.

The generator set shall be tested at rated power factor (i.e. 0.8 lagging power factor) for the following loads and durations:-

(a)	No load	–	30 minutes.
(b)	25% rated kVA	–	30 minutes.
(c)	50% rated kVA	–	60 minutes.
(d)	75% rated kVA	–	60 minutes.
(e)	100% rated kVA	–	180 minutes.
(f)	110% rated kVA	–	60 minutes.

For the purposes of this test, dummy loads, all measuring and recording instruments and apparatus that are required and necessary to measure and record all parameters such as amperes, voltages, power factor, frequency, atmospheric pressures, temperatures, relative humidity and fuel consumption shall be provided by the Electrical Contractor and/or his supplier. In addition, suitable recorders or tracers with print-outs to record transients such as frequency deviations, voltage and current deviations for all three phases during load application, sudden load increase and sudden load rejection tests shall also be provided. Certified results as per Appendix B (Generator Set Test Results) to this specification shall be provided for all readings. Every 15-minute reading of fuel consumption, lubrication oil temperature and pressure, cooling water temperature and engine speed governor trails shall be carried out.

Transient voltage deviation and voltage recovery time shall be recorded during load tests according to the load profiles as specified and 100% sudden power decrease. For motor starting application, simulation test for motor starting shall be carried out to ensure that the performance of the generator set is within the operation limits for the performance class specified. Otherwise, transient voltage deviation and voltage recovery time shall be recorded for 100% sudden power decrease and sudden power increase from 0% to 50%, 50% to 80% and 80% to 100% of the rated kVA at 0.8 lagging power factor and shall be within the operating limits as specified in Section 2.0 – Generator Set.

In the case of the generator sets installed for parallel operations, the generator sets shall also be tested together with their generator set control boards and generator set switchboards to ensure the safe and correct working operations of synchronisation, load sharing and load transfer as specified. The test load provided for the generator sets shall be the sum of the rated kVA of the generator sets.

Functional checks for all protective devices for the generator set shall also be carried out to ensure their correct functioning and operations in accordance with ISO 3046-1 and ISO 8528-6.

The above tests may be carried out at the workshop of the generator set supplier. However, if the tests are to be carried out outside Peninsular Malaysia, the Electrical Contractor shall bear the cost of food, accommodation, transportation and travelling expenses and all Government approved allowances for two Electrical Engineers to witness the tests.

20.2 COMMISSIONING TEST

On completion of plant erection, tests on completion shall be carried out. Tests for the generator set shall be carried out in accordance with the operation mode specified, comprising of starting, stopping, automatic/manual synchronising, automatic transfer switching and running on no load and loads. Simulation tests and function tests on the operation of the protective devices for the engine and the electrical protection relays shall also be carried out. All tests shall be carried out and recorded in the presence of the S.O's Representative, and four (4) sets of these test results shall be submitted to S.O.'s Representative.

All electrical protection relays shall be tested and calibrated by an Electrical Services Engineer with special right to test electrical equipment issued by Suruhanjaya Tenaga Malaysia. Four (4) sets of these test results duly certified by the Electrical Services Engineer shall be submitted. The Electrical Contractor shall pay all costs and expenses incurred in connection with these tests.

Under this Contract, the Electrical Contractor shall provide and carrying out comprehensive service and maintenance of the generator set, its control board and generator set switchboard during the Defects Liability Period in accordance with Appendix C (Schedule of Services and Maintenance) to this specification as minimum requirement.

The Electrical Contractor shall supply and provide all materials including consumable materials, except fuel, as and when required in Appendix C for the comprehensive service and maintenance of the generator set, its control board and generator switchboard.

The Electrical Contractor shall provide a service and maintenance record book for each generator set and its control board being serviced and maintained. The Electrical Contractor shall enter details of service, maintenance and repair carried out into this book for checking purposes. The record book shall be kept in the generator room.

In addition, a full report in duplicate of each service and maintenance carried out and the condition of the generator set and its control board shall be submitted to the S.O.'s Representative. This report shall be countersigned by responsible Government Officer of the client department before submission.

Whether or not provided in the Bill of Quantities, all cost for providing and carrying out comprehensive service and maintenance of the generator set, its control board and generator set switchboard during the Defects Liability Period in accordance with Appendix C shall deem included in the Contract.

Whether or not provided in the Bill of Quantities, following safety signage and devices shall be supplied and installed in the generator room and the generator switch room:

(a) One unit. 9 kg dry powder fire distinguisher for A, B,C class of fire complete with pressure gauge, discharge hose with nozzle and wall bracket, installed on the wall near the door or at the position to be decided by the S.O.'s Representative. The extinguisher shall be certified by Jabatan Bomba Dan Penyelamat Malaysia valid to be used for a period of twelve months from the completion date of the Contract.

(b) Approved type of rubber mats shall be provided in front of the switchboards and any other control boards. The rubber mats of thickness not less than 6 mm and width 1000 mm shall extend to the full length of the switchboards and control boards.

(c) One unit Electric Shock Treatment Chart;

(d) One unit standard notice displaying the words `BAHAYA' conforming to Electricity Regulations 1994;

(e) One unit standard notice displaying the words `DILARANG MASUK' conforming to Electricity Regulations 1994;

(f) One unit standard signage `DILARANG MEROKOK';

(g) One unit 300 mm x 150 mm signage displaying the words `BILIK JANAKUASA' for generator room;

(h) One unit 300 mm x 150 mm signage displaying the words `BILIK SUIS JANAKUASA' for generator switch room and

(i) One unit epoxy power coating finish metal writing top with drawer of suitable size shall be provided for keeping the service and maintenance record book in the generator room. The writing top shall be wall mounted at the position to be decided by the S.O.'s Representative.

All trenches in the generator room and generator switch room shall be clear from debris and filled up with clean sand to a level above cable ducts. All cable duct entry into the cable trench shall be sealed tight with cement against water and rodent entry.

One set of the following approved as-installed drawings of durable quality shall be framed up in the generator switch room:

(a) Location layout of earthing points with respect to the Generator Room;

(b) Layout and schematic control wiring of the generator set control board; and

(c) Layout and schematic wiring of the generator set switchboard.

The Tenderer shall complete Appendix D (Schedule of Recommended Spares) to this specification and submit together with his Tender. This Schedule should contain the price and delivery period of each item of the spares recommended. The Tenderer shall also recommend the quantity for each item to be stored for purpose of maintenance. The prices of these spares shall not be included in the total Tender Price and the purchase of all or any of these spares listed shall be at the option of the S.O.'s Representative. These prices shall be valid for acceptance up to the end of the Defects Liability Period.

All spares delivered shall be properly packed and labelled in a suitable manner to prevent deterioration during prolonged storage in tropical climate.

24.1 AS INSTALLED DRAWING

Within three (3) calendar months after the practical completion of the Works, one set of true to scale negatives (155/165 gm/sq.m, ISO size AO or A1) and four sets of prints for each of the following drawings shall be submitted:-

(a) Site plan.

(b) Installation of generator set.

(c) Location layout of earthing points with respect to the Generator Room.

(d) Layout and schematic control wiring of the generator set control board.

(e) Layout and schematic wiring of the generator set switchboard.

(f) Any other drawings deemed necessary by the S.O.'s Representative for record and maintenance purposes.

All drawings submitted by the Electrical Contractor shall be properly stencilled and shall have at the lower right hand corner the Electrical Contractor's name and address, date of commissioning, scale, drawing number (to be obtained from S.O.'s Representative), titles and the following particulars:

JABATAN KERJA RAYA
CAWANGAN KEJURUTERAAN ELEKTRIK

Contract No:
Tender No:

Each of the above four sets of prints shall be arranged, indexed and filed in a stiff cover ring file together with the manuals stated hereinafter.

In addition to the aforesaid negatives and prints, as-installed drawings shall be properly arranged, indexed and stored in electronic media or any other media as specified. For electronic media they shall be in CD rewritable (CD-RW) optical disks format. The software programme shall be AutoCAD of latest release. Two sets or copies appropriately titled and stored in container or casing shall be submitted.

24.2 MANUALS

The Electrical Contractor shall provide four sets of the following manuals and documents for each generator set installed:

(a) Installation manual

(b) Operation manual

(c) Service and Maintenance Manual

(d) Parts List

(e) Product data and catalogue of equipment

(f) Test certificates and test results

Only original copies of the above manuals and documents will be accepted. Each of the four sets submitted shall be arranged, indexed and filed in a stiff cover ring file together with the as-installed drawings.

The following particulars shall be printed on the cover of each file:

(a) Name of project.

(b) Tender Number.

(c) Contract Number.

(d) Name, address and telephone number of the Electrical Contractor.

24.3 TOOLS

Whether or not provided in the Bill of Quantities, one complete set of tools comprising of the following items as minimum complete with proper lockable tools kit(s) shall be provided for each generator set installed:

(a) 200 mm adjustable wrench;

(b) 165 mm combination pliers;

(c) Feeler gauge set (0.10, 0.15, 0.25, 0.30, 0.40 mm);

(d) 125 mm and 200 mm screw drivers;

(e) 800 mm ball pein hammer;

(f) Combination spanners set (6, 7, 8, 9, 10, 11, 12, 13, 14, 17, 19, 22, 24, 27, 30, 32 mm);

(g) Bihexagon socket set (10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22, 24, 27, 30, 32 mm);

(h) Reversible ratchet;

(i) 125 mm and 250 mm extension bars;

(j) Hexagon head allen key set (1.5, 2, 2.5, 3, 4, 5, 6, 8 mm);

(k) Other tools recommended and/or provided by the manufacturer; and

(l) Other special tools necessary for normal maintenance of the generator set.

If the generator set is manufactured in Imperial Units then the above shall be supplied in Imperial Units.

(A) GENERATOR SET

No.	Parameter	Unit	Specification	Generator set offered
1.	Model	-	-	
2.	Make	-	-	
3.	Country of origin		-	
4.	Name and address of local authorised agent		-	
5.	Rated kVA at 0.8 power factor, continuous	kVA		
6.	Rated voltage	V	415	
7.	Rated current	Amp	-	
8.	Performance class (ISO 8528-3)		G2	
9.	Type of mounting		Resilient	
10.	Type of coupling		Direct	
11.	Noise level without silencer at 100% load	dBA		

No.	Parameter	Unit	Specification	Generator set offered
12.	Overall Dimension (L x W x H)	cm		

(B) DIESEL ENGINE

No.	Parameter	Unit	Specification	Generator set offered
1.	Model	-	-	
2.	Make	-	-	
3.	Country of origin			
4.	Type of RIC engine			
5.	Number of cylinders / configuration			
6.	Number of strokes			
7.	Bore / stroke	mm		
8.	Displacement per cylinder	litre		
9.	Rated engine speed	Rpm	1500	

No.	Parameter	Unit Specification	Generator set offered
10.	Direction of rotation		
11.	Continuous service power at rated speed (ISO 3046-1)	kw	
12.	Maximum engine intake air temperature	^{0}C	
13.	Maximum permissible intake pressure loss	kPa	
14.	Maximum permissible back pressure in the exhaust system	kPa	
15.	Type and Grade of lubricating oil		
16.	Type of lubricating oil filter		
17.	Type and grade of fuel		
18.	Type of fuel filter	Paper	
19.	Type of vibration dampers	Spring isolator	
20.	Engine efficiency		
	(1) At 100% load	%	

No.	Parameter	Unit	Specification	Generator set offered
	(2) At 75% load	%		
	(3) At 50% load	%		
21.	Fuel consumption, taking into account the engine efficiency			
	(1) At 100% load	cc/s		
	(2) At 75% load	cc/s		
	(3) At 50% load	cc/s		
22.	Lubricating oil consumption			
	(1) At 100% load	cc/hr		
	(2) At 75% load	cc/hr		
	(3) At 50% load	cc/hr		

(C) ENGINE STARTING EQUIPMENT

No.	Parameter	Unit	Specification	Generator set offered
1.	Model	-	-	
2.	Make	-	-	
3.	Country of origin			
4.	Type of engine starting equipment	-	Electric	
5.	Rated power	Kw		
6.	Rated voltage	V		
7.	Breakaway current	Amp		
8.	Mean cranking current	Amp		

(D) ENGINE GOVERNOR

No.	Parameter	Unit	Specification	Generator set offered
1.	Model	-	-	

No.	Parameter	Unit	Specification	Generator set offered
2.	Make	-	-	
3.	Country of origin			
4.	Nature of governor		Proportional integral (*)	
5.	Type of governor		(**)	
6.	Performance class		G2	

(*) For parallel operation, proportional integral differential type.

(**) For parallel operation or at and exceeding 1000 kVA, electronic type.

(E) ALTERNATOR

No.	Parameter	Unit	Specification	Generator set offered
1.	Model	-	-	
2.	Make	-	-	
3.	Country of origin			

No.	Parameter	Unit	Specification	Generator set offered
4.	Type of alternator		Synchronous	
5.	Excitation system		Brushless	
6.	Nature of cooling			
7.	Connections			
8.	Rated kva at 0.8 power factor	kVA		
9.	Rated voltage	V	415	
10.	Rated current	Amp		
11.	Insulation class		H	
12.	Maximum temperature rise		Class F	
13.	Winding heaters with automatic temperature control		2 per phase	

(F) AUTOMATIC VOLTAGE REGULATOR (AVR)

No.	Parameter	Unit	Specification	Generator set offered
1.	Model	-	-	
2.	Make	-	-	
3.	Country of origin			
4.	Type of AVR			

(G) BATTERIES

No.	Parameter	Unit	Specification	Batteries offered
1.	Model	-	-	
2.	Make	-	-	
3.	Country of origin			
4.	Type of batteries		Nickel cadmium	
5.	Battery AH at 5 hour rate			

No.	Parameter	Unit	Specification	Batteries offered
6.	Battery voltage, nominal		24	
7.	Rated voltage per cell	V	1.2	
8.	Amp on discharge to 0.85V per cell for 90 seconds	Amp		
9.	Amp on discharge to 0.85V per cell for 1 second	Amp		

(H) BATTERY CHARGER

No.	Parameter	Unit	Specification	Battery Charger offered
1.	Model	-	-	
2.	Make	-	-	
3.	Country of origin			
4.	Type of battery charger		Automatic constant potential current limiting	

No.	Parameter	Unit	Specification	Battery Charger offered
5.	Rated supply voltage	V	240	
6.	Constant voltage output	V		
7.	Output voltage stability	%		
8.	Output ripple voltage	%		
9.	Current output stability	%		
10.	Fault indication and alarm		Yes	
11.	Output short circuit protection		Yes	
12.	Reverse polarity protection		Yes	
13.	Battery protection		Yes	
14.	Input voltage surge protection		Yes	

(I) FUEL TRANSFER PUMP

No.	Parameter	Unit	Hand operated	Electric operated
1.	Model	-		
2.	Make	-		
3.	Country of origin			
4.	Type of propeller			
5.	Type of motor		-	
6.	Rated voltage	V	-	
7.	Rated watt	w	-	
8.	Transfer rate	Litre per min.		

(J) FUEL TANK

No.	Parameter	Unit	Service fuel tank	Bulk storage fuel tank
1.	Model	-		
2.	Make	-		
3.	Country of origin			
4.	Dimension (L x W x H)	cm		
5.	Declared capacity	litre		
6.	Type of material			
7.	Thickness of material	mm		
8.	Material treatment			
9.	Gross weight without fuel	kg		
10.	Gross weight with full capacity fuel	kg		

(K) FUEL TRANSFER SYSTEM - OTHERS

No.	Parameter	Model Make	Country of origin	Type
1.	Fuel flow meter			
2.	Fuel level sensor switches			
3.	Fuel gauge, dial type			
4.	Fuel filters			
5.	Fuel pipe			

(L) AIR INTAKE AND VENTILATION SYSTEM (If required)

No.	Parameter	Unit	Air intake fan	Ventilation fan
1.	Model	-		
2.	Make	-		
3.	Country of origin			
4.	Type of motor			

No.	Parameter	Unit	Air intake fan	Ventilation fan
5.	Rated voltage	V		
6.	Rated speed	Rpm		
7.	Air exchange rate	Litre per min		

(Cop dan Tandatangan Kontraktor Elektrik) (Tarikh)

(A) MAIN SWITCHBOARD

(1) Manufacturer :

(2) Suruhanjaya Tenaga Certificate of Registration *(Copy enclosed)* :

(3) Certificate of Short Circuit Rating *(Copy enclosed)* :

(4) Rated Voltage *(V)* :

(5) Rated Short Time Withstand Circuit *(kA, 1 s)* :

(6) Form :

(B) AIR CIRCUIT BREAKERS

(1) Make :

(2) Country of Manufacture :

(3) Model No. :

(4) Type :

(5) Rated Voltage *(V)* :

(6) Rated Short Time Withstand Current *(kA, 1 s)* :

(7) Rated Service Short Circuit Breaking Capacity *(kA)* :

(8) Rated Ultimate Short Circuit Breaking Capacity *(kA)* :

(9) Utilization Category :

(C) MOULDED CASE CIRCUIT BREAKERS

(1) Make :

(2) Country of Manufacture :

(3) Model No. :

(4) Type :

(5) Rated Voltage *(V)* :

(6) Rated Short Time Withstand Current *(kA, 1 s)* :

(7) Rated Service Short Circuit Breaking Capacity *(kA))* :

(8) Rated Ultimate Short Circuit Breaking Capacity *(kA)* :

(9) Utilization Category :

(D) MINIATURE CIRCUIT BREAKERS

(1) Make :

(2) Country of Manufacture :

(3) Model No. :

(4) Type :

(5) Rated Voltage *(V)* :

(6) Rated Interrupting Current Capacity *(kA, 1 s)* :

(E) PROTECTION RELAYS

(1) Make :

(2) Country of Manufacture :

(3) Model No. :

(4) Type :

(5) Rated Voltage *(V)* :

(6) Overcurrent Element:

(a) Low-set setting I> :

(b) High-set setting I>> :

(c) Time multiplier k t> :

(d) High-set definite time t>> :

(7) Earth-fault Element:

(a) Low-set setting I_o> :

(b) High-set setting I_o>> :

(c) Time multiplier k t_o> :

(d) High-set definite time to_o>> :

(F) GENERATOR PROTECTION RELAYS (GPR)

(1) Make :

(2) Country of Manufacture :

(3) Model No. :

(4) Type :

(G) GENERATOR SET MONITORING, PROTECTION AND CONTROL MODULE

(1) Make :

(2) Country of Manufacture :

(3) Model No. :

(4) Type :

(G) AUTOMATIC MAINS FAILURE MODULE

(1) Make :

(2) Country of Manufacture :

(3) Model No. :

(4) Type :

(H) AUTOMATIC TRANSFER SWITCHING MODULE

(1) Make :

(2) Country of Manufacture :

(3) Model No. :

(4) Type :

(I) AUTOMATIC SYNCHRONISATION AND PARALLEL OPERATION MODULE

(1) Make :

(2) Country of Manufacture :

(3) Model No. :

(4) Type :

(J) AUTOMATIC LOAD SHARING, BALANCING AND TRANSFER MODULE

(1) Make :

(2) Country of Manufacture :

(3) Model No. :

(4) Type :

(K) AUTOMATIC TRANSFER SWITCHING EQUIPMENT

(1) Make :

(2) Country of Manufacture :

(3) Model No. :

(4) Type :

(5) Rated Voltage *(V)* :

(6) Rated Short Time Withstand Current *(kA, 1 s)* :

(7) Rated Service Short Circuit Breaking Capacity *(kA))* :

(8) Rated Ultimate Short Circuit Breaking Capacity *(kA)* :

(9) Utilization Category :

....

(Cop dan Tandatangan Kontraktor Elektrik) (Tarikh)

Sheet No: of

PROJECT NAME:	
CONTRACT NO.	
CONTRACTOR'S NAME AND ADDRESS	

GENERATOR SET DETAILS

ENGINE		Remarks
Make		
Model		
Serial No.		
Year of Manufacture		

GOVERNOR		Remarks
Make		
Model		
Serial No.		
Year of Manufacture		

FUEL PUMP		Remarks
Make		
Model		
Serial No.		
Year of Manufacture		

ENGINE RADIATOR		Remarks
Make		
Model		
Serial No.		
Year of Manufacture		

ALTERNATOR		Remarks
Make		
Model		
Serial No.		
Year of Manufacture		

AUTOMATIC VOLTAGE REGULATOR		Remarks
Make		
Model		
Serial No.		
Year of Manufacture		

Sheet No: of

TEST SITE CONDITION

	Before Test	After Test	Remarks
Pressure (mm Hg.)			
Temperature (^{0} C)			
Dry			
Wet			
Relative Humidity (%)			

INSULATION RESISTANCE TEST (500V, M.Ohm)

	Before Test	After Test	Remarks
ALTERNATOR			
Armature			
Field			
EXCITER			
Armature			
Field			

NO LOAD VOLTAGE RANGE TEST

	AVR maximum set	AVR minimum set	Remarks
VOLTAGE (V)			
RY			
YB			
BR			
FREQUENCY (Hz)			

PROTECTIVE DEVICE TESTS

	Set Values		Test Values		Remarks
	Alarm	Trip	Alarm	Trip	
Overspeed (rpm)					
Lubricating Oil Low Pressure (Kg/cm^2)					
Lubricating Oil High Temperature (^{0}C)					
Cooling Water High Temperature (^{0}C)					

SUDDEN LOAD INCREASE / DECREASE TEST - see remark (2)

	Load (%) (see remarks below)					
	Sudden Increase - see remark (1)			Sudden Decrease - 100% to 0%		
	Before	Instant	After	Before	Instant	After
Frequency (Hz)						
Voltage (V)						
Engine Speed (rpm)						
Time of Stability (sec)						

Remarks: (1) If not specified elsewhere, record all readings for sudden load increase:
Stage 1: 0% to 50%; Stage 2: 50% to 80% and Stage 3: 80% to 100%
(2) Use transient recorders for all parameter recordings. All recordings shall be submitted.

Sheet No: of

ALTERNATOR PERFORMANCE

Load (kW / %)	Time	Voltage (V)			Current (A)			Power Factor	Output (kW)	Frequency (Hz)
		RY	YB	BR	R	Y	B			

REMARKS

TEST SITE: Name and Address

JKR	**SPECIFICATION FOR THREE PHASE GENERATOR SET**	**L -S5** **Issue: 1** **Date: 25/04/2005**
APPENDIX : B	**GENERATOR SET TERT RESULTS**	**Revision: 0** **Date:** **Page: B/ 4 of 4**

Sheet No. of

ENGINE PERFORMANCE

Load (kW / %)	Time	Fuel Comsumption			Temperature (^{0}C)				Lub Oil Pressure(Kg/cm^2)	Engine Speed (rpm)	Colour of Exhaust Gas
		Flow meter Reading	Weight (kg)	Litre/min or kg/min	Cooling Water	Lubricating Oil	Room				
							Dry	Wet / %			

REMARKS

TESTED BY: (Name & Designation)		WITNESSED BY: (Name & Designation)	
DATE:		**DATE:**	

Item	Description	Every month	6th month	12th month
A.	**Generator Room**			
A.1	Clean the generator room	✓	✓	✓
A.2	Record all generator set parameters into the log book	✓	✓	✓
B.	**Lubricating System**			
B.1	Check lubricating oil level, replenish if necessary	✓	✓	✓
B.2	Change lubricating oil filters half-yearly or 250 hours whichever occurs first		✓	✓
B.3	Check hydraulic governor oil level, replenish if necessary		✓	✓
B.4	Change hydraulic governor oil at 12th month or 1500 hours whichever occurs first			✓
B.5	Visual inspection for indication of unusual conditions	✓	✓	✓
C.	**Fuel System**			
C.1	Check operation of fuel transfer pumps	✓	✓	✓
C.2	Change fuel filters half-yearly or 250 hours whichever occurs first		✓	✓
C.3	Visual inspection for indication of fuel leaks	✓	✓	✓

Item	Description	Every month	6th month	12th month
C.4	Check and clean air intake filters	✓	✓	✓
C.5	Change air intake filters			✓
D.	**Cooling System**			
D.1	Check coolant level, replenish if necessary	✓	✓	✓
D.2	Check condition of hose and connections	✓	✓	✓
D.3	Change coolant and coolant filters		✓	✓
D.4	Check coolant and clean radiator	✓	✓	✓
D.5	Check conditions of fan belts, tension if necessary	✓	✓	✓
E.	**Electrical System**			
E.1	Check battery electrolyte level and specific gravity, replenish if necessary	✓	✓	✓
E.2	Check the conditions of the battery charger and/or battery charging alternator	✓	✓	✓
F.	**Alternator**			
F.1	Check and clean vent screens	✓	✓	✓
F.2	Check and grease the bearings		✓	✓

Item	Description	Every month	6th month	12th month
G	**Generator Set Control Board and Switchboards**			
G.1	Inspect and service the control system, meters, appearance, etc..	✓	✓	✓
G.2	Check the indicator lamps. Replace if necessary	✓	✓	✓
H.	**General**			
H.1	Run the generator set without load for 30 minutes	✓	✓	✓
H.2	Simulate mains failure. Check and test the operation of ATSE	✓	✓	✓
H.3	Run the generator set on load	✓	✓	✓
H.4	Check and test the operation of protective devices for the generator set: (a) Low lubricating oil pressure – warning and trip (b) High lubricating oil temperature – warning and trip (c) High exhaust temperature – warning and trip (d) High jacket water temperature – warning and trip (e) Low radiator water level – warning and trip (f) Fail to start – warning and trip (g) Over speed – trip	✓	✓	✓

Item	Description	Every month	6th month	12th month
(h)	Low battery voltage – warning			
(i)	Low fuel level (1st.stage) – warning			
(j)	Low fuel level (2nd.stage) – trip			
(k)	Fuel pump runaway – warning and trip by shut-off fuel supply to the engine			

The Tenderer shall submit this Schedule of Spares recommended by the generator set manufacturer. The prices for these spares shall NOT be included in the total Tender Price and the purchase of all or any of the the spares listed shall be at the option of the S.O.'s Representative. These prices shall be valid for acceptance up to the end of Defects Liability Period of the Contract.

Item	Description and Part No.	Quantity	Unit Price RM	Price RM

Delivery Period:……Weeks Total Price: RM ……..……

…… ……..
Tarikh . Tandatangan dan Chop Pemborong