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ARAB ENGINEERING BUREAU

17 STANDBY DIESEL GENERATOR SET

17.1 GENERAL

17.1.1 General Reference

- 1 The work of this Section is integral with the whole of the Project Documentation and is not intended to be interpreted outside that context.
- 2 Co-ordinate the work with all other services affecting the work of this Section.
- 3 For voltages and frequencies, regulations and requirements of Kahramaa and relevant authorities should be taken into account.

17.1.2 Description of Work

- 1 The Contractor shall supply, install, commission, test and handover in good operable manner including 400 days guarantee and maintenance of 415 V mains failure, standby diesel generator set and 5 years guarantee for electric motors and alternator, in Client's name, as per the Project Documentation. The set shall be arranged for either automatic or manual start on mains failure, as indicated on the Project Drawings. The set shall be complete with diesel engine, generator, control panel, batteries, starting motor, built-in air cooled radiator, main fuel storage tank, daily fuel storage tank, fuel transfer pumps and all other accessories as specified and mentioned in the BOQ.
- 2 Related Parts and Sections are as follows:

This Section

- Part 1 General Provisions for Electrical Installation
- Part 6 Cables and Small Wiring
- Part 7 Conduits
- Part 8 Trunking
- Part 9 Cable Trays
- Part 22 Earthing and Bonding

17.1.3 References

- 1 The following standards or revised/updated are referred to in this Part.
 - BS 613 Specification for components and filter units for electromagnetic interference suppression
 - BS 800 Specification for limits and methods of measurement of radio interference characteristics of household electrical appliances, portable tools and similar electrical apparatus; (IEC 55014 Electromagnetic compatibility. Requirements for household appliances, electric tools and similar apparatus)
 - BS 822 Terminal markings
 - BS 2613 Electrical performance of rotating machines; (EN 60034 Rotating electrical machines; BS 4999 General requirements for rotating electrical machines)
 - BS 4800 Schedule of paint colours for building purposes
 - BS 4999 Alternators; (General requirements for rotating electrical machines)

- BS 5000Rotating electrical machines of particular types or for particular applications
- BS 5000-99Rotating electrical machines of particular types or for particular applications - Machines for miscellaneous applications
- BS 5514Reciprocating internal combustion engines; (ISO 3046: Reciprocating internal combustion engines- Performance)
- ISO 8528.....Emergency DG Sets

17.1.4 Quality Assurance

1 Manufacturer's Qualification:

- (a) The Diesel Generator Set shall be designed and manufactured complete by a manufacturer regularly engaged as a manufacturer of such equipment.
- (b) The Diesel Generator Set Manufacturer shall have a proven manufacturing experience of minimum 10 years in this field. Reference of previous approvals in similar applications and environmental conditions shall be provided for Engineer's review and approval.
- (c) The DG set manufacture shall have an approved ISO 9001 QA/QC procedure for design, manufacturing and testing of complete DG set. The DG set Manufacturer shall provide minimum the following documents as a part of submittal approval.
 - (i) Quality policy
 - (ii) Quality Policy manual
 - (iii) Manufacturing and storage facilities.
 - (iv) Traceability of components.
 - (v) Design facilities.
 - (vi) Testing facilities.
- (d) The Diesel Generator Set manufacturer shall have full Load testing facilities in his premises for testing the full range of his products at full load as per the relevant BS/ ISO standards.

2 Installer's Qualification:

- (a) all the Diesel Generator installation work shall be carried out by a Diesel Generator sub-contractor. Diesel Generator sub-contractor shall be one who is normally an agent representing one or more of the approved makes of D/G sets. Diesel Generator installation shall be supervised, checked and tested by a qualified representative of the manufacturer and handover the works in perfect running order to the satisfaction of the Engineer.

3 Source Quality Control:

- (a) The Diesel Generator Set Manufacturer shall test the complete Diesel Generator set at the manufacturing facilities. The test shall be performed as per the latest BS/IEC standard and the Factory Acceptance Procedure shall be approved by the Engineer/Client. Any additional test required by the Engineer during the FAT shall be performed by the Diesel Generator Manufacturer in his cost. The Diesel Generator set shall not be shipped from the manufacturing facilities until the test reports have been submitted and approved by the Engineer.

4 Local Agent:

- (a) the manufacturer should have an agent in Qatar who is well experienced in installation and maintenance of diesel generators of the size specified herein. The agent should have been associated with the manufacturer for a minimum period of five years.

5 Design Criteria:

- (a) all materials and equipment shall comply with relevant IEC and BS specifications as regards quality of materials, performance and proving tests.
- (b) the emergency power supply system and its components shall be such as may be properly maintained and serviced without the necessity of carrying expensive spare part stocks, or being subjected to interrupted service due to the lack of spare parts
- (c) emergency generator set shall be designed to allow easy replacement of major items subject to wear.

17.1.5 Submittals

1 Shop Drawings:

- (a) Submit shop drawings for approval in accordance to Part 1
- (b) Shop drawings shall be complete, as to be record drawings, not general outline drawings used for sales and guide layouts
- (c) Submit a complete wiring diagram for the generator set, drawn on a single standard size sheet, showing the following:
- (i) all components of:
 - engine starting control
 - engine alarm
 - generator control
 - battery
 - battery charger
 - earthing
 - transfer switch control relays
 - (ii) interior wiring, terminals and interconnecting wiring
 - (iii) certified dimensions and weights.
- (d) submit a composite wiring diagram of the entire emergency transfer system showing all wiring between the engine starting panel, engine generator set and the automatic transfer switches
- (e) wiring diagrams shall clearly show:
- (i) main current conductors, in heavy lines
 - (ii) control conductors, with colour and/or number coding
 - (iii) location of relays and apparatus
 - (iv) description of function, type and catalogue, of all components.

- (f) alternator Control Panel:
- (i) submit a schematic line diagram showing:
- Interlocks
 - Protection
 - Instruments
- (g) submit general arrangement drawings of the generator installation and the generator building layout.
- 2 Product Data submitted in accordance to Part 1.
- (a) submit curves showing the actual performance of a similar engine (same model, stroke, etc.) to that proposed, superimposed on the standard published performance curves for continuous, and maximum operation
- (b) submit the detailed information together with manufacturer's catalogues for the following:
- (i) generating set manufacturer
 - (ii) name and Address
 - (iii) generating set Model No.
 - (iv) diesel Engine
 - (v) radiator
 - (vi) fuel System
 - (vii) alternator
 - (viii) exciter
 - (ix) starting Battery
 - (x) control Panel
 - (xi) service Facilities
- (c) test certificates
- (d) list of spare parts
- (e) certified factory test reports
- (f) instruction manuals for operation and maintenance
- (g) parts catalogue with manufacturer address.

17.1.6 Period of Maintenance

- 1 During the maintenance period of 400 days the sub-contractor shall repair and replace directly, at his own expense, any of the plant, material or work performed or furnished under the respective works in the Project which may develop under the conditions provided for by the Project and under proper use in the works or that portion thereof taken over by the Engineer. The guarantee period for all electric motors shall be 5 years.
- 2 The sub-contractor shall obtain and submit to the Engineer all guarantees or certificates or warranty available from the manufacturers, but only as supplementary to the sub-contractor's own liabilities under the Project and in no way invalidate them.

- 3 The D/G sub-contractor shall be responsible for the satisfactory operation of the D/G installation during the Maintenance and Guarantee Period. He shall carry out necessary inspection, preventive maintenance and testing to keep the set ready all the time. The set shall function satisfactorily during power failures. The D/G sub-contractor shall carry out routine testing of the installation once in every month throughout the Maintenance and Guarantee Period. The testing shall be carried in presence of Engineer. The sub-contractor shall himself provide all electrical and mechanical spare parts, grease, lubricating oils, touch-up paints, etc., required for the maintenance of the D/G installation. The owner shall be responsible only for providing diesel oil as and when required. The D/G sub-contractor shall prepare log-books listed full details of maintenance work and each log-book entry shall be countersigned by the Engineer.

17.2 PRODUCTS

17.2.1 Diesel Generator Set

- 1 The Diesel Generator Set shall be of rugged reliable design and built for long trouble free service under the worst specified climatic conditions and made by an approved reputable manufacturer.
- 2 Rating:
- (a) The Diesel Generator Set output shall be design for prime rating as specified elsewhere. Detailed design calculations for Engine, Alternator, Cooling system, battery, etc shall be provided for Engineer's approval for the proposed Diesel Generator set.
- (b) The rated output shall be as specified elsewhere or as indicated on the drawings, 415/240 Volts, 3 phase, 4 wire and 50 Hz or different voltage level as indicated elsewhere in the Contract specifications (690 V or 3.3 KV).. The rated output shall mean the net full continuous derated output in Qatar at an ambient temperature up to 50°C at a relative humidity of 95%. The set shall also be capable of 110% load for one hour under these conditions at the rated speed without undue heating of the engine or alternator and without mechanical or electrical troubles.
- 3 Diesel Engine:
- (a) The diesel engine shall be of the stationary heavy duty, turbo charged compression/ignition, multi cylinder 4 stroke operation. The steel base frame shall be provided with spring type vibration isolators. The engine shall be able to deliver full load in the shortest possible time after start. The engine speed shall not exceed 1500 r.p.m. The engine construction shall be in such a way as to allow for dismantling of any engine component for inspection or repair without undue complication i.e. without dismantling of other non-defective parts. The crank case shall be provided with inspection windows
- (b) starting system: The diesel engine shall be equipped with starting system detailed hereunder and as per Engineer's approval.
- (i) Battery Starting System:
- batteries for starting shall be of the nickel cadmium type, 24 Volt, heavy duty diesel starting type and of sufficient capacity to allow 6 consecutive start attempts each of 15 seconds with 1 minute intervals. It shall be

possible by means of a selector to alter the starting sequence to provide a single start attempt of 1 minute before lockout and alarm. The battery used for starting may also be used to energise the diesel plant control system but shall have enough capacity remaining after 3 engine start attempts to energise the system continuously for 24 hours. The control system shall be suitable to continue operating correctly during the voltage dips occurring on the battery during the engine starts.

(c) Cooling System:

- (i) radiator : built-in type with sufficient capacity to dissipate the total joules per hour rejected by the engine cooling system at 110 % full load
- (ii) blower fan: to have sufficient pressure to circulate required quantity of air for engine cooling. The fan shall be provided with a suitable guard. D/G room inside temperature should not exceed 56 °C
- (iii) jacket water heaters: to be provided on engine to facilitate quick starting under low ambient conditions
- (iv) the cooling system shall be capable of keeping the temperature of cooling water at safe limits at all conditions of load required in the specifications. Maximum temperature of cooling water after 10 hours of continuous running at full load at worst Qatar climatic conditions shall not exceed the maximum temperature limits of the diesel engine
- (v) the cooling system shall include an engine shaft driven circulating water pump. The water jacket of the engine cylinder shall be so constructed that the water in the jacket can be drained completely
- (vi) the radiator finned tubes shall have a common inlet and common outlet headers
- (vii) drain valve and a filling valve shall be provided to the radiator for flushing and quick filling
- (viii) Cooling water piping, complete with all necessary supports; control valves, flanges and fittings, thermometers, pressure gauges, relays etc., shall be supplied and installed to form a complete engine water cooling line. Piping shall be as of BS 1387
- (ix) the water pump discharge valve shall preferably be a globe valve, the other valves shall be (sluice) gate valve.

(d) Fuel System

- (i) The engine shall be suitable for running on diesel oil as described below:

-	Specific gravity at 60F distillation :	0.834
-	(P.P. 123/40)	
-	IBM	: 219 C
-	10%	: 250 C
-	50%	: 276 C
-	90%	: 314 C
-	F.E.P.	: 342 C
-	Flash Point PME	: 189 C
-	Sulphur	: 1.1%
-	Calorific value BTU/lb. gross	
-	carbon residue.	: 19750
-	0.01/wt diesel index	: 62
-	Viscosity redwood seconds at 100F	: 34

(ii) Daily Fuel Tank:

- Fuel supply to the engine shall be maintained by a separate day tank located in the room. Daily fuel tank shall be sufficient capacity for continuous run of 8 hours at full load, unless otherwise specified in the Project Documentation. The daily service tank shall be manufactured from mild steel to a rectangular shape in accordance with BS 799 and shall be complete with the following minimum equipment and facilities:-
- Inspection cover
- vent/breather pipe
- filler pipe connection
- overflow connection
- drain valve and sump drain
- emergency dump valve operated by the fire alarm system and by a fusible link mounted over the diesel engine
- dial type contents gauge calibrated in gallons and litres
- level switches to control fuel transfer pump
- level switches to operate high and low fuel level alarm circuits in the diesel alternator set control panel
- lifting lugs.
- the Contractor shall provide and install an external dump sump of sufficient capacity to contain the contents of a full day tank and all pipework necessary to carry the dumped fuel quickly by gravity, to a safe location in the event of a fire being detected in the generator house. The sump shall be constructed to contain the fuel without leakage to the surrounding ground and shall be provided with a lockable cover. Provision to allow emptying of the sump by portable pump shall be provided.

(iii) Main Fuel Storage Tank:

- The Contractor shall supply and install a cylindrical diesel oil storage tank with a capacity to operate the associated diesel generator set continuously on full load for a minimum of 7 days, unless otherwise specified in the Project Documentation.
- the tank shall be welded mild steel construction suitably protected from corrosion in accordance with BS. 2594 and shall be installed in the location indicated on the drawings.
- The storage tank shall be complete with pipes, fittings, feed lines, vents.etc. The tank shall be of the approved type located outside the diesel engine room. The tank shall be provided with 600 mm inspection manhole with cover, 50 mm filling pipe with cooped filling terminal, 50 mm air vent pipe with screen outlets, isolating valve, valved drain etc.
- Electronic fuel indicator with an audio/visual alarm shall be provided for main fuel storage tank
- Also the storage tank and its accessories must comply with the Qatar.Civil Defence Regulations for generator installations. Woqod approval is also required.

(iv) Duplex Diesel Oil Pumping Set:

- Provide packaged type duplex, self priming, fuel oil pumping and straining set with a capacity of four times the total fuel consumption of engine at full load for each individual Diesel Generator Set. Pump sets shall be factory assembled, piped, wired and tested. Pumps shall be activated by a switch in the day tank automatically. All pumps installed in the D/G room shall be flame-proof and fire-resistant as per NFPA Regulations
- Piping shall be complete to suction, discharge and return line connections. Provide gate valves and unions arranged to permit removal of either pump while the system is in operation. Install check valves and relief valves on pump outlet and gate valves prior to pressure gauges
- Suction strainer shall be flanged connection, duplex type, one-piece, cast-iron body, ASTM A48 Class 30, with 1.2 mm perforation brass baskets
- Oil pump set shall be factory assembled on a structural steel channel beam base to include pumps, motors, flexible couplings and guards. Pump set shall be suitable for diesel oil
- Suitable manually operated pump shall be provided.
- The installation of Diesel transfer pump set shall be subject of the Engineer's approval. There shall not be any possibility of flooding of the diesel transfer pumps.

(v) Tank Gauges:

- Provide as shown on the Drawings. Each gauge is to be provided with an aluminium case and calibrated to indicate level of fuel in the tank. Mounted on gauges shall also be a high/low level alarm switch. The switches and gauges shall be designed for operation from a 24 Volt DC, loop powered system. Locate indicating gauges as shown on the Drawings or required
- Tank fittings and pressure fittings shall be made of solid bar stock to prevent leak possibilities.

(vi) Diesel Oil Piping:

- Provide all diesel oil piping from storage tank to day tank fill lines, water tight fill boxes, vents, vent caps, tank foot valves, and accessories
- Provide swing check valves and gate valves at pump inlets. Provide approved anti-siphon valves at high points of suction lines. Provide whatever additional valves that may be required by local regulations
- All piping shall be provided with ground joint unions at piece of apparatus to facilitate connecting and disconnecting
- All piping, unless otherwise specified, shall be schedule 40 standard weight black wrought iron pipe
- Steel vent pipelines shall run from the fuel oil storage tanks, carried to the proper height within building construction and terminating with vent fittings. Fittings shall be "Bronze Ventilating Brick" with thickness of 20 mesh bronze wire gauge in front of louvered opening.

(e) Lubricating System

- (i) The lubricating oil system shall be forced fed type. The details of the system shall be included in the offer. The shaft bearing lubricating shall be directly fed from the lubricating oil pump and not through the main bearings
- (ii) The lubricating oil shall be of a type readily available internationally
- (iii) The lubrication system shall be positive displacement type. By-pass arrangement should be provided in case of filter clogging
- (iv) A heat-exchanger shall be provided for cooling the lubricating oil and this shall be of long-life type i.e. the system shall not require constant cleaning or other maintenance work. A valve for taking oil sample shall be provided. The coolant for the above shall be jacket water of the engine. That is, the cooling system of the engine and the lube-oil heat-exchanger cooling system shall work in parallel or in series. If the lube-oil pressure reaches low value, the engine shall be shut down automatically and also immediately should give audible alarm together with visual indication. The lube-oil system shall be provided with means to monitor pressure at important points at the engine-monitor panel
- (v) a large capacity oil sump shall be provided and incorporated in the construction of the bed plate
- (vi) the system of lubrication shall ensure that adequate oil is pumped to all rotating parts
- (vii) The system shall incorporate a level dipstick, filler cap and tube and crankcase breather pipe or outlet
- (viii) the capacity of the lubricating oil system shall be sufficient to enable the engine to run continuously for 12 hours at any load without replenishment.
- (ix) Suitable manual-pumping arrangement for easy draining of the whole quantity of lube-oil into a drum shall be provided.

(f) Exhaust System:

- (i) Exhaust pipes shall be of Schedule 40 black steel and of adequate size to ensure that back pressure does not exceed the value specified by the manufacturer
- (ii) The exhaust pipe shall be connected through airtight flexible coupling to the engine
- (iii) Exhaust pipes shall be adequately lagged with 75 mm thick (minimum) rock wool covered with aluminium sheaths of minimum thickness 1.5 mm so that to take care of exhaust gas temperature in pipes exceeding 500 °C. When exhaust pipes pass through walls or roof a suitable weatherproof sleeve or thimble shall be provided to isolate exhaust pipe from the building. A silencer of heavy duty residential type shall be provided in the exhaust system and it shall also be lagged. The operation of casting the sleeves in the concrete, if required, will be carried out by a civil contractor
- (iv) Exhaust pipes and silencers shall be supported from the ceiling by special vibration isolating hangers and the pipe shall be slanted away from the engine and a condensate trap fitted at the lowest points. Approved rain caps shall be installed at the discharge end of the exhaust pipes on the roof.

- (v) Suitable flexible expansion joints shall be provided along the pipe run to take care of expansion requirements
- (vi) the completed exhaust system shall be capable of limiting the noise level at the external outlet to 65 dB (A) at three metres from the end of the exhaust pipe
- (vii) suitable guards shall be provided with the exhaust pipe to prevent small animals/reptiles from entering.
- (g) Filters: Cleanable/replaceable elements should be provided.
- (i) Fuel Oil System
- The system shall have the following filters fitted before the fuel injection pumps:
- A primary fuel filter of ample capacity to prevent all particles of 10 microns size or smaller.
 - A secondary filter to prevent all particles down to 3 microns size or smaller.
- (ii) Lubricating Oil System
- This system should have full flow filters of sufficient capacity
- Tenderers shall give full particulars of the filters used. It shall be mentioned in if filter elements are cleanable for replaceable, in which case, the working hours after which the element and the Lubricating oil is to be replaced should be stated.
- (iii) Intake and Exhaust System
- Air is inducted to the engine manifold through
- Precleaner
 - Large capacity air cleaner
 - Both filters are required due to severity of dust storms and dust suspensions in the air
 - The engine exhaust line shall be fitted with flexible fitting efficient silencer to give efficient silencing with minimum back pressure and terminated outside the engine room.
- (h) Ventilation:
- (i) The following ventilation works are required for the diesel engine generator room.
- Aluminium inlet louvres with washable metal filters shall be provided for outside air intake into the engine room. Filters shall be sized to perform their duty with a face velocity not more than 1 metre per second when the engine is running. Filters shall be installed in an appropriate arrangement on the generator room walls. The total filter area shall consider air for engine intakes and radiator cooling requirements. Filters with handles and easily operated retaining latches shall be provided.
 - The radiator shall be provided with a motorised louvre, interlocked with the generator, so that the generator will shut down in the event of the louvre not opening on start up. The louvre shall be capable of being manually opened in the event of drive motor failure. Gravity louvres shall not be allowed for the radiator exhaust.

- (i) Governing System:
- (i) the engine shall run steadily at any load within its rating at its rated speed, and the changes in speed due to change in load shall comply with BS 5514/77 for Class A1 or with ISO/TC 70 Internal combustion engines' Published relevant and equivalent standards
 - (ii) the governor should be of the electronic type to comply with BS 5514/77 Class A1.
- (j) Coupling and Common Bed:
- (i) the engine and the alternator shall be suitably coupled directly without interposing gear arrangement
 - (ii) the common bed shall be provided with spring type anti-vibration mountings devices for fixing to the floor
 - (iii) the engine vibration shall be the minimum possible and shall comply with the relevant BS. The vibratory force induced as the engine passed through resonance revolutions during starting and stopping period shall not cause any damage to the whole system
- (k) Engine Control Panel: The engine-generator control panel shall be of rigid and robust construction and rust-proof and shall be of the electronic modular type utilising environmentally sealed, solid state, micro-processor based modules for engine control and AC metering. The panel shall be capable of operating under the operating temperature range of 0 degrees to + 70 degrees Celsius. Metering accuracy shall be 0.5% true RMS. The electronic control system shall employ solid-state transducers for constant monitoring of oil pressure and coolant temperature through a Single Sire Serial Data Link. Unless otherwise specified in the Project Documentation, the control panel shall provide the following features:
- (i) automatic start/stop engine control with programmable safety shutdowns and associated flashing LED indicators for low oil pressure, high coolant temperature, overspeed overcrank and emergency stop
 - (ii) adjustable 1 to 60 second cycle cranking with rest periods
 - (iii) cool-down timer, adjustable between 0 and 30 sec.
 - (iv) LCD digital readout for:
 - engine oil pressure (N/mg)
 - lubricant oil pressure gauge (N/mg)
 - cooling temperature (°C)
 - exhaust gas temperature gauge (°C)
 - exhaust turbo-blower pressure gauge (N/mg)
 - engine RPM
 - system DC Volts
 - engine run hours
 - eight system diagnostic codes

- generator AC Volts
- generator AC Amps
- Generator frequency

The system diagnostic codes shall be designed to enhance the system protection and to allow for trouble shooting by untrained personnel.

These signals shall be:

- loss of engine speed
- invalid engine control switch
- internal circuit fault
- loss of coolant temperature
- loss of data sending unit
- unscheduled engine shutdown
- invalid programming switch position
- loss of failure of programme setting

These panels shall be provided with the following control switches:

- engine control switch
- ammeter -voltmeter phase selector
- emergency stop
- indicator/display test switch
- voltage adjust potentiometer

4 Alternator and Exciter

- (a) the alternator shall be able to withstand the stresses caused by the sudden application of the loads
- | | | |
|---|---|---|
| (i) Type | : | Self excited, self ventilated, air cooled, splash-proof, synchronous alternator |
| (ii) Output | : | As per Project Documentation, at Qatar Climatic Condition |
| (iii) Voltage | : | 415V(Or as indicated in Project documents) |
| (iv) Frequency | : | 50 Hz |
| (v) No. of poles | : | 4 |
| (vi) No. of phases | : | 3, (ungraded neutral to be brought out) |
| (vii) Power factor | : | 80% lagging |
| (viii) Commercial efficiency not less than 90 % (including excitation and field losses) | | |
| (ix) Voltage regulation | : | Automatic and static. |
- (b) Class F insulation shall be provided for the alternator and exciter windings with the temperature rise as Class B and de-rated for the ambient conditions.
- (c) the alternator shall be suitable for continuous running duty type S1, BS 2613 (latest edition)
- (d) the alternator unit shall be capable of giving 110% of nominal rated output for one hour under site conditions. The rotor shall be capable of withstanding an over-speed test of 15% for 5 minutes
- (e) distortion of no-load voltage wave form at alternator terminals shall be within 5 % from the sinusoidal wave form

- (f) voltage adjustable range of the output voltage by adjusting the exciter shall be not less than 3 % of rated voltage at rated load and not less than $\pm 5\%$ of rated voltage under no-load conditions. This adjustment shall be able to be performed from panel mounted handle or knob
- (g) the voltage of the alternator shall be automatically controlled by electronic static circuits
- (h) the alternator shall not be switched on the load until terminal voltage has reached at least 90 % of the nominal value. It is essential that the voltage regulation equipment shall have sufficient fast response time so that the alternator is ready to accept load in the shortest possible time
- (i) the voltage regulator shall be designed to maintain the alternator terminal voltage constant within $\pm 1\%$ of the nominal value from no load to full load within normal variations of engine speed with change in load
- (k) the exciter shall be brushless, self excited, rotor mounted type. The rectifying elements shall be silicon. The silicon diodes of the three phase rectified bridge assembly shall be protected against surges and overloads such that the generator will continue to run with a diode failure. Diodes shall have heat sinks suitable for the ambient conditions described. Means shall be provided to indicate exciter diode failure on the remote control panel
- (l) the unit shall be suitably protected so that when there is a sudden variation of load, the sudden increase of field current in the rotor shall be curtailed and thus the speed build up of the engine and the voltage build up of generator shall vary proportionately
- (m) alternator protection. The alternator shall be provided with protection against over speed, over voltage, over current, short circuit, reverse power, single phasing earth fault and any other found necessary. The neutral points of alternators shall be solid by connecting to earth
- (n) terminals with cable end boxes shall be provided respectively for the alternator and exciter
- (o) the cooling air for alternator and exciter shall be drawn through openings at the non-drive end and exhausted sideways at the driving end
- (p) the alternator shall be fitted with anti-condensation heater to keep the winding in good, dry and safe condition. The anti-condensation heater shall be automatically cut-off when the machine is running. Necessary on-off switches shall be provided on the control panel and the operation status of the heater shall be indicated
- (q) temperature Rise: Alternator components shall be sound electrically and mechanically in continuous operation lasting over 24 hours at the rated output
- (r) insulation Resistance: Insulation resistance of the machine at strategic points shall be provided along with the submission
- (s) dielectric Strength: The Dielectric strength, the voltage of testing and test procedure at various points of the machine shall be submitted with the shop drawings

- (t) radio and television interference suppression devices shall be provided in accordance with the requirements of BS. 800. Components used for suppression shall be to BS 613
- (u) vibration at the fixed components of the alternator under excited no-load operation shall be as per relevant BS.
- (v) terminal symbols for the alternator shall be in accordance with BS 822 requirements
- (w) panel Wiring:
 - (i) all wiring of battery charger, exciter and control panel shall be P.V.C tropical grade of adequate current carrying capacity to prevent over-heating under worst climatic conditions
 - (ii) all wiring shall conform to the relevant BS and at least 50 % derated with minimum size of 2.5 mm² or its equivalent.
- (x) terminal Board
 - (i) terminal boards shall have pairs of terminals for Incoming and Outgoing wires and not more than two wires shall be connected to any one terminal
 - (ii) insulating barriers shall be provided between adjacent connectors. Labels for wiring designation marks shall be provided on the fixed portion of the terminal boards as well as wires. No live metal shall be exposed at the back of the terminal boards
 - (iii) terminal boards having pressure type terminal lusts or equivalent shall be used so that no terminal clamp is necessary. 10 % spare terminals shall be provided for each terminal board assembly.

5 Guards

- (a) Suitable guards with brackets and securing arrangements of substantial construction shall protect all exposed rotating or moving parts. All guards shall be mechanically fixed to the generator set. Special attention shall be given to guarding the flywheel-coupling and the radiator fan drive.

17.2.2 Control Panel

1 Cabinet

- (a) heavy gauge, 2.5 mm thick, sheet steel construction, totally enclosed, dust and water protected and vermin proof to IP 55
- (b) a hinged, lockable door shall give access to control and instruments
- (c) "live" parts shall be secured to prevent inadvertent contact with them
- (d) controls for diesel engine, alternator, exciter, meters and alarm device shall be positioned to give ample space for removing and installing components.

2 Control Panel Equipment and Instrumentation

- (a) control panel shall include: (unless otherwise specified in the Project Documentation)

- (i) 3 pole air circuit breaker with over-current, short circuit and earth fault protection as specified in this specification. (unless part of a main switchboard, as indicated on the drawings)
- (ii) busbar system as specified in this specification (unless part of a main switchboard, as indicated on the drawings)
- (iii) voltmeter (0-500V) with selector switch to read phase to phase and phase to neutral voltages
- (iv) ammeters of suitable range 3 Nos.
- (v) frequency meter of range 45 - 55 Hz
- (vi) duty selector switch OFF/TEST/MANUAL/AUTO key operated
- (vii) solid state voltage and frequency sensing relays
- (viii) microprocessor control unit incorporating, but not limited to the following:
 - 30 sec engine warm-up with override
 - engine minimum run time of 10 minutes
 - engine cool down time of 10 minutes
 - return to mains time delay of 30 sec.
 - 80% stand-by voltage setting before load transfer
 - 80% stand-by frequency setting before load transfer
 - auto exerciser of seven days from initial command that allows operation with or without load transfer
 - controls for remote operation and alarm signalling to remote SCADA/PLC
- (ix) current transformer for measuring and protection devices
- (x) watt meter for unbalanced phases
- (xi) voltage trimmer
- (xii) visual and audible alarm for engine starting, engine running overspeed, high water temperature, low oil pressure, failure to start, engine stalling or shut down, low fuel level in tanks, overvoltage and alternator overload.
- (xiii) indicator lamps for supply available, battery charger and cooling water heater
- (xiv) manual start, stop, emergency OFF and lamp test push-buttons
- (xv) manual and automatic service push-buttons
- (xvi) control switch for alternator circuit breaker, ON and OFF
- (xvii) mimic diagram with moving coil indicator for position of air circuit breaker
- (xviii) battery charger, automatic type, nominal current 10 Amps. for charging 24 volts nickel cadmium starter battery and all required instruments
- (xix) all other accessories, fuses, terminal boards, small wiring, etc.

17.2.3 Automatic Transfer Switch (A.T.S.)

- 1 The A.T.S. shall consist of 4 pole, 3 phase, break before make except for the neutral, fed as shown on the Drawings in accordance with QGEWC regulations
- 2 with the A.T.S. provide manual change-over switches to by-pass the A.T.S. in case of emergency, maintenance or repair
- 3 the arrangement, wiring and components shall satisfy the requirements of the Diesel generator Manufacturer. His written approval shall be submitted
- 4 control voltage of A.T.S. shall be normally fed from the main supply, in case of failure of the main supply it shall be fed automatically from the emergency supply.
- 5 in addition to transfer switches the A.T.S. arrangement shall be equipped with the following:
 - (a) a selector switch to control the operation of A.T.S. on normal, emergency, automatic and OFF
 - (b) adjustable - 3 phase voltage sensing relays sense failure in a phase/phases and voltage drop below 70 % of the normal voltage (pick-up and drop-out voltages and adjustable within the range 70 - 100 % of the normal voltage)
 - (c) visual Mechanical Indicator for transfer switch position
 - (d) indicator lamps to show transfer switch position normal, emergency and OFF.
 - (e) an adjustable time delay relay of 1 - 3 seconds for starting signal to the Generator set after cutting of main supply
 - (f) an adjustable time delay relay of 0 - 3 minutes which allows A.T.S. from Normal to Emergency after the voltage build up relay of the generator has sensed 90 % rated voltage when frequency within 90 % rated of rated frequency
 - (g) an adjustable time delay relay of 1 - 10 minutes to allow A.T.S. from Emergency to Normal
 - (h) an adjustable time delay relay of 0.5 - 5 seconds to prevent instantaneous transition from EMERGENCY to NORMAL i.e. the delay allows time sufficient For the residual motor voltage to decay to a safe switching level.

17.2.4 System Operation and Performance

- 1 The normal mode of system operation shall provide for unattended automatic transfer of load for the emergency power system. Emergency power shall be supplied to the system emergency loads within 10 seconds after interruption of the normal service. Upon receiving a signal from the ATS indicating a failure or normal power from transformer, the system control unit will signal engine generator to start. Generator circuit breakers are open at this time and the emergency busbar is dead. The generating set to reach approximately 90% of rated frequency and voltage signals to start sensor. The sensor then inhibits the operation of sensors and initiates a closing signal to circuit breaker, connecting this generating set to the emergency busbar. The priority control then initiates operation of the designated transfer switch, applying load up to the total kW rating of the generating set.

- 2 If the generating set fails to start after cranking for the suitable cranking period, it shall be locked off the busbar and the overcrank light on its switchboard shall light and the alarm sound. The control prevents critical transfer switch from operating. The generating set may receive troubleshooting signals after placing its engine control function switch in the "OFF" position. When the generating set is operational, it may again be placed into automatic operation by returning its function switch to the "remote" position.
- 3 If a generating set stalls and shuts down during normal operation, its respective switchboard circuit breaker shall open, removing it from the busbar. The appropriate failure light operates and the alarm sounds. The load shedding contacts in the control close, tripping a breaker in the load circuits, reducing system load to the rating of the remaining available generating capacity. After the generating set is made operable, it can be automatically reconnected to the busbar by resetting the load shed switch and engine control switch.
- 4 After normal power has been restored and the time delay on stop has expired, it shall be possible to manually shut down the generator and restore the mains power.
- 5 Under circumstance or condition operation of an emergency stop push button shall immediately shut down the engine.

17.2.5 Manual Operation

- 1 The manual operation of the Diesel Generator Set shall have the following features:
 - (a) the emergency power system shall have the capacity of being manually operated. The generator may be started by engine control switch located on the engine control unit. Once started and stable, the generator may be manually connected to the emergency busbar through generator circuit breaker
 - (b) the generator control unit shall be equipped with a generator breaker control switch, engine speed adjusting potentiometer and a generator voltage adjust thermostat and facilitate.

17.2.6 System Responsibility

- 1 The generating set, switchboard and automatic transfer switches shall be interconnected according to building load requirements and to manufacturer's recommendations, to prevent the emergency generating system from stalling or faltering due to momentary or temporary overloads beyond system rating, from distribution faults, motor starting loads.

17.2.7 Installation

- 1 Product Delivery, Storage Handling:
 - (a) lift all generator equipment using eyes, yokes and skids provided by the manufacturer
 - (b) do not store equipment assemblies exposed to weather
 - (c) physically protected all generator equipment against damage from work of other trades
 - (d) cover all generator equipment with suitable material to avoid damage to finish.
 - (e) Contractor shall submit the calculation to prove the adequacy of capacity of the crane he intends to use for installation of the D-G set

2 Installation:

- (a) the engine and generator shall be properly aligned and mounted on a common steel base through resilient mountings to prevent vibrations. The whole set shall be fixed on the concrete slabs through suitable number of adjustable spring type vibration isolators. Foundation and other builder's work shall be as recommended by the manufacturer and approved by the Engineer
- (b) except as may be described in this Section or shown on the drawings carry out installation strictly in accordance with the manufacturer's recommendation.

3 Control Boards:

- (a) run all outgoing cables from the generator to the control boards in the floor trench as indicated on the Project Drawings.

4 Record Print:

- (a) fix record print of each generator set, framed behind non-glare plexiglass, on a wall near the generator control room.

17.2.8 Paint Work

- 1 Paint work of each set shall be of the highest quality to withstand the worst weather conditions specified. All steel works such as tanks, pipes, frames, louvers, ladders, platform, etc. shall be given two undercoats of anti-rust paint and two enamel finishing.
- 2 The diesel generator set, day tank internal metalworks and control panel shall be finished to BS 4800, shade 14E53.

17.2.9 Site Quality Control

- 1 Final Testing:
 - (a) testing shall be carried out at full load after completion of installation by the Engine manufacturer's qualified representative in the presence of the Engineer
 - (b) if the above cannot be done then testing shall be done at the manufacturer/supplier's premises at full load in the presence of the Engineer. All arrangements and costs incurred by such a test shall be responsibility of the sub-contractor.

17.2.10 Commissioning

- 1 Simulated Power Failure Test:
 - (a) engine-generator shall be made ready for automatic operation and started by means of the test transfer switch on the automatic transfer switch. Unit shall run for the duration of all time delays and then automatically shut-down. This test shall be made with unit operating, and twice with unit simulated for a starting failure.
- 2 Testing of the Set:
 - (a) Engine:

- (i) the engine shall be tested at site before and after erection to BS 649 and amendments or equivalent including items which are said to be subject to mutual agreement. The test shall include inspection, after testing the following parts
- (ii) subsequent running test of eight hours shall be carried out of the set
- (iii) the engine shall be subjected to vigorous performance tests at site to the satisfaction of the Engineer and the main items shall include:
- Output characteristics
 - Temperature rise
 - Checking of valve clearance, fuel pump setting, governor setting, pipeline connections, exhaust piping and flexible connections
 - Checking the base and set are level in all directions, checking alignment of engine and generator and vibration isolators location and proper installation
 - Checking of proper operation of engine safety devices
 - Checking of fuel pipelines, fuel pumps, tank level gauges and level control switches operation.
- (b) Alternator and Exciter:
- (i) the alternator and exciter shall be tested to BS 5000, P.99 amendments thereof
- (ii) tests at site before erection and after erection prior to handing over shall be carried out to the satisfaction of the Engineer. The main items of tests deemed necessary by the Engineer shall be carried out at the expense of the Contractor. The performance test shall be for 24 hours under the worst climatic conditions prevailing in Qatar
- (iii) the Contractor shall be fully responsible to provide all the necessary facilities for the test at his own expense.

17.2.11 Training of Operation and Maintenance Personnel

- 1 The Contractor shall train a number of persons who will be selected by the Engineer for the operation and maintenance of all the works within the Project before these works are handed over to the Engineer.
- 2 The training has to be carried out by qualified staff of the Contractor for each specified service and shall be provided for a one month period following the certificate of completion.

17.2.12 Reference Data Sheet

- 1 This Form or similar is to be completed by the Electrical sub-contractor as Well as D/G sub-contractor and to be submitted for approval to the Engineer unless otherwise Specified.

1. Name and Address of
D/G sub-contractor

2. Detail of work in hand
now with proposed
D/G sub-contractor

Name of Government Project	Amount of D/G Installation Works
a.	-----
b.	-----
c.	-----
d.	-----
e.	-----

We confirm that the Statements given above are true, to the best of our knowledge
and it is known to us that Engineer reserves the right to refuse to award sub-contract to
us if the above Statements are found to be incorrect.

Name of Electrical Contractor

Name of D/G sub-contractor

Signature

Signature

Position in company of
person signing

Position in company of
person signing

END OF PART