SECTION 26 32 13

DIESEL GENERATOR

PART – 1 - GENERAL

1.01 GENERAL REFERENCE:

A. The work of this Section is integral with the whole of the Contract Documents and is not intended to be interpreted outside that context.

B. Coordinate the work with all other services affecting the work of this Section.

1.02 DESCRIPTION OF WORK:

A. The Contractor shall supply, install, commission, test and handover in good operable manner including two years guarantee and maintenance. 415V automatic start on main failure, prime diesel generator set. The set shall be complete with diesel engine, generator, control panel, switchgear, batteries, starting motor, built-in air cooled radiator and all other accessories as specified and all necessary requirement to be compatible with B.A.S.

1.03 RELATED WORKS SPECIFIED ELSEWHERE:

A. Basic Electrical Materials and Methods

B. Grounding and Bonding

C. Wire and Cables

D. Raceway and Boxes

E. Cable Tray

1.04 APPLICABLE STANDARDS REFERRED TO IN THIS SECTION:

A. BS-5514 : Engines.

B. BS-4999 : Alternators.

1.05 QUALITY ASSURANCE:

A. Manufacturer's Qualifications.

1. The generator sets shall be the product of a single manufacturer regularly engaged as a manufacturer of such equipment.

B. Installer's Qualification.

1. 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.

C. Source Quality Control:

1. Test the combined engine generator set at the factory and submit the certified test copies of all tests to the Engineer for his approval.

D. Design Criteria:

1. All materials and equipment shall comply with relevant IEC and BS specifications as regards quality of materials, performance and proving tests.

2. 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.

3. Emergency generator set shall be designed to allow easy replacement of major items subject to wear.

1.06 CLIMATIC CONDITIONS:

A. Climatic conditions in Kuwait are severe. During summer ambient shade temperature rises to 120°F and drops to 30°F during night in winter. Sun temperature reaches to 183°F as recorded on black bulb thermometer. High temperatures are usually accompanied by low humidities but periods of high humidity are common and humidity of 100% has been recorded at a shade temperature of 85°F. Violent sand and dust storms occur with speeds up to 70 MPH and even on comparatively still days fine dust is suspended in the atmosphere.

1.07 SUBMITTALS:

A. Shop Drawings:

1. Submit 3 copies of shop drawings for approval.

2. Shop drawings shall be complete, as to be as-built drawings, not general outline drawings used for sales and guide layouts.

3. Submit a complete wiring diagram for the generator set, drawn on a single standard sheet, showing the following:

a. All components of:

1. Engine starting control
2. Engine alarm
3. Generator control
4. Battery
5. Battery charger
6. Earthing
7. Transfer switch control relays

b. Interior wiring, terminals and interconnecting wiring.

c. Certified dimensions and weights.

d. Clear indication of all connections to remote equipment.

4. 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 switch.

5. Wiring diagrams shall clearly show:

a. Main current conductors, in heavy lines.
b. Control conductors, with color and/or number coding.
c. Location of relays and apparatus.
d. Description of function, type and catalogue, of all components.

6. Alternator Control Panel:

Submit a schematic line diagram showing:

a. Interlocks
b. Protection
c. Instruments

B. Product Data:

1. 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.

2. Submit the following information together with manufacturer's catalogues:

Generating set manufacturer
Name and Address .....

Generating set Model No. .....

a) Diesel Engine:

1. Manufacturer's Name Address ….....

2. Type of Engine & Model No. ….....

3. Output:

B.H.P at N.T.P
as specified ……..…..

4. Percent derating for Engine ….....

5. Revolutions RPM: …….....

6. Bore x stroke mm x mm: .....…….....

7. Mean effective pressure
Kg/sq.cm .....……....

8. Fuel consumption:

- Full load k/kwh: .....……

- at 1/2 load k/kwh: .....……..

9. Recommended lub. oil capacity
- litre: .....……..

10. Lub. oil temperature at full
rated output under specified
conditions: .....

11.	Design working range of cooling jacket water temperature Deg. F	.....
12.	Turbo charged or not?	.....
13.	Max. outlet cooling water temperature from engine at full rate output when air temperature inlet to radiator is 125 Deg. F.	.....
14.	Safety control setting of cooling water outlet temperature Deg. F.	.....
15.	Type of Governor:	.....
16.	Starting Motor:	.....
17.	Number of starting motors:	.....
18.	Engine Kg.	.....
19.	Alternator Kg.	.....
20.	Complete set (Engine plus alternator plus common bed) Kg:	.....
21.	Overall length of set cm:	.....
22.	Overall height of set cm:	.....
23.	Overall width of set cm:	.....
b.	i) Radiator:	
1.	Manufacturer's Name and address:	.....
2.	Type of Radiator:	.....
3.	Tube material:	.....
4.	Fin or fin core material:	.....
c)	Fuel System:	
i)	Fuel Injection pumps:	
1.	Manufacturer's Name and address:	.....
2.	Type:	.....
	ii) Fuel tank (daily service)	
1.	Height cm:	.....

2.	Width cm:	.....
3.	Depth cm:	.....
4.	Storing capacity:	.....
5.	Material:	.....
e)	Alternator:	
1.	Manufacturer's Name and Address:	.....
2.	Model No.:	.....
3.	Rated voltage:	.....
4.	Rated frequency Hz.	.....
5.	Power factor:	.....
6.	Rated output Kw under Kuwait conditions:	.....
7.	Rated current Amp.:	.....
8.	Efficiency %:	.....
9.	Speed RPM:	.....
10.	Type (brush or brushes):	.....
11.	Alternator field voltage volt:	.....
12.	Alternator field current Amp.	.....
13.	Alternator field power KW:	.....
14.	Enclosure:	.....
15.	Class of insulation:	.....
16.	Max. temperature rise Deg.C:	.....
17.	Suitability for paralleled Operation	.....
f)	Exciter:	
1.	Manufacturer's Name and Address:	.....
2.	Type & Model No.:	.....
3.	Rated current Amp.:	.....
4.	Rated voltage volts:	.....

5.	Rated power KW:	.....
6.	Type of automatic voltage regulator:	.....
7.	Maximum temperature rise Deg. C.:	.....
8.	Enclosure:	.....
9.	Class of insulation	.....
g)	Starting Battery:	
1.	Manufacturer's Name and Address:	.....
2.	Type:	.....
3.	Normal voltage D.C:	.....
4.	Terminal voltage when floating D.C:	.....
5.	No. of cells:	.....
6.	Normal capacity:	.....
7.	Normal charging current Amps:	.....
8.	Normal voltage per cell DC:	.....
9.	Final discharge voltage per cell volts D.C:	.....
h)	Plate Material:	
10.	Positive plate:	.....
11.	Negative plate:	.....
12.	Separator material:	.....
13.	Electrolyte material:	.....
14.	Specific gravity of Electrolyte:	.....
15.	Container materials:	.....
i)	Control panel:	
1.	Manufacturer's Name and Address:	.....
2.	Type	.....
3.	Dimensions: Height cm. Width..cm Depth cm	

4. Other details:

C. Service Facilities:

1. Indicate the nearest location from which service facilities and spare parts may be obtained after the guarantee period. (Should be available in local market).

D. Test Reports:

1. Submit certified copies of data obtained during factory tests of the engine generator test.

E. Operation and Maintenance Data:

1. Submit 3 copies of a maintenance manual containing the following for all equipment:

   a. Manuals for generator sets.
   b. Detailed instruction books.
   c. Operator's manuals.
   d. Maintenance schedules.
   e. Parts catalogues.

2. Submit 3 copies of the following:

   a. Complete instructions covering the operation of the engine generator set and associated equipment.

   b. A manual covering engine operation and maintenance.

   c. Spare parts books for the engine generator and associated equipment.

   d. Standard 35mm microfilm aperture cards photographed from "as-built" drawings.

3. Fix one copy of the composite wiring diagram of the emergency transfer system inside the transfer switch compartment door and another in the generator control panel.

4. Fix as-built print of generator set, framed behind non-glare Plexiglas, on a wall near the generator set and in the generator control room.

F. Spare parts:

1. Provide the following spare parts, properly preserved and packed in a suitable steel tool box with a lock and two keys marked "Spare Parts : Engine Generator Unit".
   a. Valve cover gasket : 1 set.
   b. Cylinder head gasket : 1 set.
   c. Fuel filters, oil filters, air filter: 1 set
   d. Belt set.
   e. Special tools recommended by the manufacturer.
   f. AVR Card.

G. Product Delivery, Storage and Handling.

1. Lift all generator equipment using eyes, yokes and skids provided by the manufacturer.

2. Do not store equipment assemblies exposed to weather.

3. Physically protect all generator equipment against damage from work of other trades.

4. Cover all generator equipment with suitable material to avoid damage to finish.

PART 2 - PRODUCTS

2.01 EMERGENCY GENERATOR SET:

A. The sets shall be of rugged reliable design and built for long trouble free service under the torts climatic conditions and made by an approved reputable manufacturer.

B. The rated output of the Diesel generator set shall be 600 KVA. The capacity shall be set prime at 50^{O}C a 10% overload shall be available and the prime rating per/hour in every 12 hours all as per BS standard.

The above ratings shall be applied at 0.8 PF 240/415 Volts, 3 phase and 50 Hz. The rated output shall mean the net full continuous derated output in Kuwait at ambient temperature up to 120ºF, at relative humidity 50%. A manufacturer's deration calculation shall be enclosed along with the tender documentation.

C. Diesel Engine:

1. Engine Features:

The diesel engine shall be of the stationary heavy duty, turbo charged compression/ignition, multi cylinder (with precombustion chamber) 4 stroke operation, built-in air cooled radiator mounted on heavy welded steel base frame provided with vibration damper. The steel base frame 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 rpm.

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 Crankcase shall be provided with inspection windows.

2. Starting System:

a. Battery System:

i) The engine shall be started by a 24V, D.C starting motor automatically engaging with engine flywheel and positively dis-engaging on engine starting. The engine starting control equipment shall be arranged to disconnect the battery charger to prevent it from being overloaded during starting. The starter motor shall be of adequate power for its duty.

ii) Batteries for starting shall be of the nickel cadmium type, 24V, heavy duty diesel starting type and of sufficient capacity to provide continuous cranking of 1.5 minute duration without

recharging. Batteries should have sufficient capacity to provide three successive starts.

iii) The batteries shall be filled with electrolyte and installed on proper racks with cables and clamp. A hydrometer shall be supplied with the batteries.

iv) The battery charger shall be static type enclosed in an adequately ventilated sheet steel case and incorporated within the control panel with its associated instruments and controls mounted on front of panel.

v) The charger shall be complete with all necessary relays, cut-outs, controls, switches and instruments for automatic charging of batteries. The charger shall automatically control the charging rate to suit state of battery thus charging at high rate following a period of use of battery and, when battery nearly fully charged, reverting to trickle charging automatically.

vi) An ammeter and voltmeter in the control panel shall indicate the state of the battery and its charging rate.

3. Cooling System:

a. Radiator: built-in type with sufficient capacity to dissipate the total joules per hour rejected by the engine cooling system at 100% full load.

b. 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 Deg. C.

4. Fuel System:

a. 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/lbs gross carbon residue	:	19750
-	0.01/wt. diesel index	:	62
-	Viscosity redwood seconds at roof	:	34

b. Daily Fuel Tanks:

Fuel supply to the engine shall be maintained by a separate day tank for each D/G set located in the room. Daily fuel tank shall be sufficient capacity for continuous run of 8 hours at full load, and shall be fitted with strainers (see filters), control cocks, drain cock, piping to the engine and a level indicator with alarm contacts, vents and all other necessary fuel lines and fittings.

c. Duplex Diesel Oil Pumping Set:

1. Provide packaged type duplex fuel oil pumping and straining set with a capacity of four times the total fuel consumption of engine at full load. Pump sets shall be factory assembled, piped, wired and tested. Pumps shall be activated by a switch in the day tank automatically. Pump installed in the D/G room shall be flame-proof and fire-resistant as per KNPC Regulations.

2. 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.

3. Suction strainer shall be flanged connection, duplex type, one-piece, cast-iron body, ASTM A48 Class 30, with 1.2 mm perforation brass baskets.

4. 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.

5. Suitable manually operated pump shall be provided.

d. Tank Gauges:

1. Provide as shown on the Drawings liquid level gauges operating on the hydrostatic principle. Each gauge is to be provided with an aluminum case, drain valve and glass front to protect the indicating tube and scales. Mounted on gauges shall also be high/low level alarm switch. The switches shall be designed for a 240 volt system. Locate indicating gauges as shown on the Drawings or required.

2. Scales to be calibrated on one side in liters (gallons) graduated for equal liter (gallon) units based on actual tank dimensions, on the other side in millimeter/centimeter graduated for every 6mm of tank depth.

3. Each gauge shall be filled with red indicating fluid having a specific gravity of not more than 3.0.

4. Connections between tanks and gauges shall consist of double copper tubing encased in flameproof covering. The copper tubing shall be not less than 3 mm O.D. and provided with suitable end connections.

5. Tank fittings shall be provided with a 38mm male pipe thread with a stuffing box and stuffing box nut through which 13mm pressure pipe extends. The pressure fittings shall be provided with a 13 mm female pipe thread. Tank

fittings and pressure fittings shall be made of solid bar stock to prevent leak possibilities.

e. Fuel Oil Piping:

1. Provide all diesel fuel oil piping from storage tanks today tanks, 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.

2. All piping shall be provided with ground joint unions at piece of apparatus to facilitate connecting and disconnecting.

3. All piping, unless otherwise specified, shall be schedule 40 standard weight black wrought iron pipe.

4. 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 20 mesh bronze wire gauge in front of louvered opening.

5. Oil suction line piping shall be tested at 625 mm vacuum prior to backfilling.

5. <u>Lubricating System:</u>

a. The lubricating oil system shall be forced fed type. The details of the system shall be included in the offer. The shaft bearing lubrication shall be directly fed from the lubricating oil pump and not through the main bearings.

b. The lubricating oil shall be of a type readily available internationally.

c. The lubrication system shall be positive displacement type. By-pass arrangement should be provided in case of filter clogging.

d. A heat-exchanger shall be provided for cooling the lubricating oil and this shall be of long-lift 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 lub-oil heat-exchanger cooling system shall work in parallel or in series. If the lub-oil temperature reaches excessively high 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. The engine shall stop automatically if the pressure reaches below normal level.

e. Suitable manual pumping arrangement for easy draining of the whole quantity of lube-oil into a drum shall be provided.

6. Exhaust System;

a. 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.

b. The exhaust pipe shall be connected through airtight flexible coupling to the engine. Bends in exhaust pipe shall have a radius of not less than three times the pipe diameter.

c. Exhaust pipes shall be adequately lagged with 75mm thick (minimum) rock wool covered with aluminum sheaths so that to take care of exhaust gas temperature in pipes exceeding 500 Deg. C. When exhaust pipes pass through walls of roof a suitable weatherproof sleeve or thimble shall be provided to isolate exhaust pipe from the building. A silencer of heavy duty residential critical type shall be provided in the exhaust system and it shall also be 35dba lagged. The operation of casting the sleeves in the concrete, if required, will be carried out by civil contractor.

d. 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.

e. Suitable flexible expansion joints shall be provided along the pipe run to take care of expansion requirements.

7. Filters;

Cleanable/replaceable elements should be provided.

a. Fuel Oil System.

i. 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.

b. Lubricating Oil System:

i. 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 or replaceable, in which case, the working hours after which the element and the lubricating oil is to be replaced should be stated.

c. Intake and Exhaust System:

Air is inducted to the engine manifold through:

i. precleaner

ii. 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.

8. Ventilation:

The following ventilation works are required for the diesel engine generator room.

a. Metal louvers with metal cleanable filters shall be provided for outside air intake into the engine room. Filters shall be permanent heavy duty metal cleanable type minimum 4" thickness.

Filters to be sized to perform their duty with a face velocity not more than 350 fpm when engine is running. Filters to be installed in an appropriate arrangement on the room walls. Total filter area shall consider air for engine intakes and radiators cooling. Filters with handles and latches shall be provided.

9. Governing System:

a. 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 BSS 5514/77 for Class A1 or with ISO 3067.

b. The governor should be of the electronic type to comply with BS 5514/77 Class A1.

10. Coupling and Common Bed:

a. The engine and the alternator shall be suitably coupled directly without interposing gear arrangement.

b. The common bed shall be provided with suitable damping devices for fixing to the floor.

c. 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.

11. Engine Monitor Panel:

a. Each engine shall be provided with a monitor panel adequately isolated from vibration which shall contain facility to monitor the following:

1. Engine speed
2. Temperature
3. Pressure
4. Engine operation hour counter
5. Other required items.

b. The engine shall be able to operate manually from the monitor panel. Manual speed control facility shall be provided.

D. Alternator and Exciter:

1. The alternator shall be suitable for parallel operation.

The alternator shall be able to withstand the stresses caused by the sudden application of the loads.

a.	Type	:	Self excited, self ventilated, air cooled, splash-proof, synchronous alternator.
b.	Output	:	As shown in the drawings, at Kuwait Rating
c.	Voltage	:	415 V
d.	Frequency	:	50 Hz
e.	No, of poles	:	4
f.	No. of phases	:	3, (neutral to be brought out)
g.	Power factor	:	80% lagging
h.	Commercial efficiency not less than 90% (including excitation and field losses).		
i.	Voltage regulation	:	Automatic and static.

2. Class "F" (minimum) insulation shall be applied to starter, rotor and exciter windings.

3. The alternator shall be suitable for continuous running duty type S1, BS-2613 (latest edition).

4. Distortion of no-load voltage wave from alternator terminals shall be within 5% from the sinusoidal wave from.

5. Voltage adjustable range of the output voltage by adjusting the exciter shall be not less than 2% of rated voltage at rated load and not less than ± 5% of rated voltage under no-load conditions. This adjustment shall be able to performed from panel mounted handle or knob.

6. The voltage of the alternator shall be automatically controlled by electronic static circuits.

7. 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.

8. The voltage regulator shall be designed to maintain the alternator terminal voltage constant within ± 1% of the nominal value from no load to full load within normal variations of engine speed with change in load.

9. The exciter shall be brushless, self excited, rotor mounted type. The rectifying elements shall be silicone.

10. 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 up of generator shall vary proportionately.

11. Terminals with cable end boxes shall be provided respectively for the alternator and exciter.

12. The cooling air for alternator and exciter shall be drawn through openings at the non-drive end and exhausted sideways at the driving end.

13. The alternator shall be fitted with air-condensation heaters to keep the winding in good, dry and safe condition. The air-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.

14. Temperature Rise:

Alternator components shall be sound electrically and mechanically in continuous operation lasting over 24 hours at the rated output.

15. Insulation Resistance:

Insulation resistance of the machine at strategic points shall be provided with the offer submitted with the offer submitted with the shop drawings.

16. 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.

17. Vibration:

a. Vibration at the fixed components of the alternator under excited no-load operation shall be as per relevant BS.

18. Terminal Symbol:

a. Terminal symbols for the alternator shall be in accordance with BS-822 requirements.

b. The alternator shall be provided with protection against over speed, over voltage, over current, short circuit, reverse power, earth fault and any other found necessary.

The neutral points of alternators shall be solid by connecting to earth.

19. Panel wiring:

a. All wiring of battery charger, exciter and control panel shall be PVC tropical grade of adequate current carrying capacity to prevent over-heating under worst climatic conditions.

b. All wiring shall conform to the relevant BS and at least 50% derated with minimum size of 2.5 sq.mm or its equivalent.

20 Terminal Board:

a. 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.

b. 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.

c. Terminal boards having pressure type terminal lugs or equivalent shall be used so that no terminal clamp is necessary. 10% spare terminals shall be provided for each terminal board assembly.

2.02 CONTROL BOARD:

A. Cabinet:

1. Sheet steel construction, totally enclosed, dust protected and vermin proof.

2. A hinged, lockable door shall have access to control and instruments.

3. "Live" parts shall be secured to prevent inadvertent contact with them.

4. Controls for diesel engine, alternator, exciter, meters and alarm devices shall be positioned to give ample space for removing and installing components.

B. Instrument in Control Board:

1. Each control panel shall include the following;

i). 4 Pole ACB if the rated current is more than or equal 800 Amps.

ii). The generator set shall be provided with a microprocessor-based control system which is designed to provide automatic starting, monitoring, and control functions for the generator set. The control system shall also be designed to allow local monitoring and control of the generator set, and remote monitoring and control as described in this specification.

iii). The control shall be mounted on the generator set. The control shall be vibration isolated and prototype tested to verify the durability of all components in the system under the vibration conditions encountered.

iv). The control shall be UL508 listed, CSA282-M1989 certified, and meet IEC8528 part 4. All switches, lamps and meters shall be oil-tight and dust-tight, and the enclosure door shall be gasketed. There shall be no exposed points in the control (with the door open) that operate in excess of 50 volts. The controls shall meet or exceed the requirements of Mil-Std 461 C part 9, and IEC Std 801.2, 801.3., and 801.5 for susceptibility, conducted, and radiated electromagnetic emissions. The entire control shall be tested and meet the requirements of IEEE587 for voltage surge resistance.

v). The generator set mounted control shall include the following features and functions:

a). Three position control switch labeled RUN/OFF/AUTO.

In the RUN position the generator set shall automatically start, and accelarate to rated speed and voltage. In the OFF position the generator set shall immediately stop, bypassing all time delays. In the AUTO position the generator set shall be ready to accept a signal from a remote device to start and accelerate to rated speed and voltage.

b). Red “mushroom-head” push-button EMERGENCY STOP switch.

Depressing the emergency stop switch shall cause the generator set to immediately shut down, and be locked out from automatic restarting.

c). Push-button RESET switch. The RESET switch shall be used to clear a fault and allow restarting the generator set after it has shut down for any fault condition.

d). Push-button PANEL LAMP switch.

Depressing the panel lamp switch shall cause the entire panel to be lighted with DC control power. The panel lamps shall automatically be switched off 10 minutes after the switch is depressed, or after the switch is depressed a second time.

e). Generator Set AC Output Metering:

The generator set shall be provided with a metering set including the following features and functions:

Digital metering set, 0.5% accuracy, to indicate generator RMS voltage and current, frequency, output current, output KW, KW-hours, and power factor. Generator output voltage shall be available in line-to-line and line-to-neutral voltages, and shall display all three phase voltages (line to neutral or line to line) simultaneously.

f). Generator Set Alarm and Status Message Display:

The generator set shall be provided with alarm and status indicating lamps to indicate non-automatic generator status, and existing alarm and shutdown conditions. The lamps shall be high-intensity LED type. The lamp condition shall be clearly apparent under bright room lighting conditions. The generator set control shall indicate the existence of the following alarm and shutdown conditions on a digital display panel:

low oil pressure (alarm)
low oil pressure (shutdown)
oil pressure sender failure (alarm)
low coolant temperature (alarm)
high coolant temperature (alarm)
high coolant temperature (shutdown)
engine temperature sender failure (alarm)

low coolant level (alarm or shutdown-selectable)
fail to crank (shutdown)
overcrank (shutdown)
overspeed (shutdown)
low DC voltage (alarm)
high DC voltage (alarm)
weak battery (alarm)
low fuel-daytank (alarm)
high AC voltage (shutdown)
low AC voltage (shutdown)
under frequency (shutdown)
over current (warning)
over current (shutdown)
short circuit (shutdown)
ground fault (alarm)(optional-when required

by code or specified)
over load (alarm)
emergency stop (shutdown)

In addition, provisions shall be made for indication of two customer-specified alarm or shutdown conditions. Labelling of the customer-specified alarm or shutdown conditions shall be of the same type and quality as the above specified conditions. The non-automatic indicating lamp shall be red, and shall flash to indicate that the generator set is not able to automatically respond to a command to start from a remote location.

g). Engine Status Monitoring:

The following information shall be available from a digital status panel on the generator set control:

engine oil pressure (psi or KPa)
engine coolant temperature (degrees F or C)
engine oil temperature (degrees F or C)
engine speed (rpm)
number of hours of operation (hours)
battery voltage (DC volts)

h). The control system shall also incorporate a data logging and display provision to allow logging of the last 10 warning or shutdown indications on the generator set, as well as total time of operation at various loads, as a percent of the standby rating of the generator set.

i). Control Functions:

The control system provided shall include a cycle cranking system, which allows for user selected crank time, rest time, and # of cycles. Initial settings shall be for 3 cranking periods of 15 seconds each, with 15 second rest period between cranking periods.

The control system shall include an idle mode control, which allows the engine to run in idle mode in the RUN position only. In this mode, the alternator excitation system shall be disabled.

The control system shall include an engine governor control, which functions to provide steady state frequency regulation as noted elsewhere in this specification. The governor control shall include adjustments for gain, damping, and a ramping function to control engine speed and limit exhaust smoke while the unit is starting. The governor control shall be suitable for use in paralleling applications without component changes.

The control system shall include time delay start (adjustable 0-300 seconds) and time delay stop (adjustable 0-600 seconds) functions.

The control system shall include sender failure monitoring logic for speed sensing, oil pressure, and engine temperature which is capable of discriminating between failed sender or wiring components, and an actual failure conditions.

The control system shall include all interfaces necessary for proper operation with the paralleling equipment provided under this contract. The generator set supplier shall be responsible for complete compliance to all specification requirements for both the generator set and the paralleling equipment.

j). Alternator Control Functions:

The generator set shall include an automatic voltage regulation system which is matched and prototype tested with the governing system provided. It shall be immune from mal-operation due to load-induced voltage waveform distortion and provide a pulse width modulated output to the alternator exciter. The voltage regulation system shall be equipped with three-phase RMS sensing and shall control buildup of AC generator voltage to provide a linear rise and limit overshoot. The system shall include a torque-matching characteristic, which shall reduce output voltage in proportion to frequency below a threshold of [58-59] HZ. The voltage regulator shall include adjustments for gain, damping, and frequency roll-off. Adjustments shall be broad range, and made via digital raise-lower switches, with an alpha-numeric LED readout to indicate setting level. The voltage regulation system shall include provisions for reactive load sharing and electronic voltage matching for paralleling applications. Motorized voltage adjust pot is not acceptable for voltage matching.

Controls shall be provided to monitor the output current of the generator set and initiate an alarm when load current exceeds 110% of the rated current of the generator set on any phase for more than 60 seconds. The controls shall shut down and lock out the generator set when output current level approaches the thermal damage point of the alternator.

Controls shall be provided to monitor the KW load on the generator set, and initiate an alarm condition when total load on the generator set exceeds the generator set rating for in excess of 5 seconds.

An AC over/under voltage monitoring system, which responds only to true RMS voltage conditions, shall be provided. The system shall initiate shutdown of the generator set when alternator output voltage exceeds 110% of the operator-set voltage level for more than 10 seconds, or with no intentional delay when voltage exceeds 130%. Under voltage shutdown shall occur when the output voltage of the alternator is less than 85% for more than 10 seconds.

A battery monitoring system shall be provided which initiates alarms when the DC control and starting voltage is less than 25VDC or more than 32 VDC. During engine starting, the low voltage limit shall be disabled, and if DC voltage drops to less than 14.4 volts for more than two seconds a “weak battery” alarm shall be initiated.

When required by National Electrical Code or indicated on project drawings, the control system shall include a ground fault-monitoring relay. The relay shall be adjustable from 100-1200 amps, and include adjustable time delay of 0-1.0 seconds. The relay shall be for indication only, and not trip or shutdown the generator set. Note bonding and grounding requirements for the generator set, and provide relay which will function correctly in system as installed.

k). Control Interfaces for Remote Monitoring:

All control and interconnection points from the generator set to remote components shall be brought to a separate connection box. No field connections shall be made in the control enclosure or in the AC power output enclosure. Provide the following features in the control system:

Form "C" dry common alarm contact set rated 2A @ 30VDC to indicate existence of any alarm or shutdown condition on the generator set.

One set of contacts rated 2A @ 30VDC to indicate generator set is ready to load. The contacts shall operate when voltage and frequency are greater than 90% of rated condition.

A fused 10 amp switched 24 VDC power supply circuit shall be provided for customer use. DC power shall be available from this circuit whenever the generator set is running.

A fused 20 Amp 24VDC power supply circuit shall be provided for customer use. DC power shall be available from this circuit at all times from the engine starting/control batteries.

2.03 COMMISSIONING:

A. Simulated Power Failure Test:

Engine-generator shall be made ready for automatic operation and started by means of the test transfer switch on the automatic transfer switches. Units shall run for the duration of all time delays and then automatically shutdown.

B. Testing of the Sets;

1. Engine:

a. The engine shall be tested at the manufacturer's premises as well as 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:

b. Cylinder heads, main bearings, high-end bearings, fuel and valve cams, camshaft drive, governor and driving gear.

c. Subsequent running test of eight hours shall be carried out after re-assembling of the set that passed the previous tests.

d. The engine shall be subjected to vigorous performance tests at site under the worst environmental conditions prevailing here to the satisfaction of the Engineer and the main items shall include:

i Output characteristics

ii. Temperature rise.

iii. Checking of valve clearances, fuel pump setting, governor setting, pipeline connections, exhaust piping and flexible connections.

iv. Checking that base and set are level in all directions, checking alignment of engine and generator and vibration isolators location and proper installation.

v. Checking of proper operation of engine safety devices.

vi. Checking of fuel pipelines, fuel pumps, tank level gauges and level control switches operation.

2. Alternator and Exciter:

a. The alternator and exciter shall be tested to BS-5000 P-99 amendments thereof at manufacturers' work and at site.

i. Over speed

ii. Sudden 3 phase short circuit

iii. Earth fault

iv. Temperature rise

v. Insulation resistance test of stator, rotor and exciter windings of the generator

vi. Measurement of resistance of cold and warm winding

vii. Plotting of short circuit characteristics

viii. Zero power factor measurement.

ix. Heat run

x. Overload run for two minutes at the value specified in the relevant BS.

xi. Checking of all connections on alternator control panels and at paralleling boards.

xii. Plotting of no-load characteristics.

xiii. Adjustment of exciter and plotting of load characteristics.

xiv. Checking of effectiveness of radio suppression.

xv. Verifying proper starting of motors supplied from the generator.

xvi. Alternator control panels should have auxiliary contacts to contact with B.A.S.

b. 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 are mentioned above but any other item 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 Kuwait.

c. The Contractor shall be fully responsible to provide all the necessary facilities for the test at his own expense.

2.04 TRAINING OF OPERATION & MAINTENANCE PERSONNEL:

A. 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 contract before these works are handed over to the Engineer.

B. The training has to be carried out by qualified staff of the Contractor for each specified service and shall be maintained for a one month period following on the Certificate of Completion.

C. training abroad for minimum 2 engineers in the factory workshop for minimum one week.

2.05 PERIOD OF MAINTENANCE:

A. During the maintenance period of 2 years the 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 contract which may develop under the conditions provided for by the Contract and under proper use in the works or that portion thereof taken over by the Engineer.

B. The Contractor shall obtain and submit to the Engineer all guarantees or certificates or warranty available for the manufacturers, but only as supplementary to the Contractor's own liabilities under the contract and in no way invalidate them.

PART - 3 EXECUTION:

3.01 INSTALLATION

A. General:

1. The engine and generator shall be properly aligned and mounted on a common steel base through resilient mountains 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.

2. Except as may be described in this Section or shown on the drawings, carry out installation strictly in accordance with the manufacturer's recommendation.

B. Control Boards:

1. Run all outgoing cables from the generator to the control boards in the floor trench as indicated on the Drawings.

3.02 PAINT WORK:

A. 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 antirust paint and two enamel finishing coats of approved color.

3.03 SITE QUALITY CONTROL:

A. Final Testing:

1. Testing shall be carried out at full load after completion of installation by the Engine manufacturer's qualified representation by the Engine manufacturer's qualified representative in the presence of the Engineer.

2. 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 Contractor.

END OF SECTION