SECTION 26 32 13
ENGINE-GENERATORS

PART 1 - GENERAL

1.1 DESCRIPTION

A. This section specifies the furnishing, installation, and testing of the low-voltage engine-generator system. This includes, but is not limited to: air filtration, starting system, generator controls, instrumentation, lubrication, fuel system, cooling system, and exhaust system.

B. The engine-generator system shall be fully automatic and shall constitute a unified and coordinated system ready for operation.

1.2 RELATED WORK

A. Section 08 9 00, LOUVERS AND VENTS

B. Section 26 32 13,FACILITY FUEL SYSTEMS

C. Section 23 07 11, HVAC, PLUMBING, AND BOILER PLANT INSULATION: Requirements for hot piping and equipment insulation.

D. Section 23 10 00, FACILITY FUEL SYSTEMS: Fuel supply and storage requirements.

E. Section 26 05 11, REQUIREMENTS FOR ELECTRICAL INSTALLATIONS: General electrical requirements and items common to more than one section of Division 26.

F. Section 26 05 21, LOW-VOLTAGE ELECTRICAL POWER CONDUCTORS AND CABLES (600 VOLTS AND BELOW): Low voltage conductors.

G. Section 26 05 26, GROUNDING AND BONDING FOR ELECTRICAL SYSTEMS: Requirements for personnel safety and to provide a low impedance path for possible ground fault currents.

H. Section 26 36 23, AUTOMATIC TRANSFER SWITCHES: Requirements for automatic transfer switches for use with engine-generators.

1.3 QUALITY ASSURANCE

A. Refer to Paragraph, QUALIFICATIONS, in Section 26 05 11, REQUIREMENTS FOR ELECTRICAL INSTALLATIONS.

1.4 QUALITY ASSURANCE

A. The supplier of the engine-generator shall be responsible for satisfactory total operation of the system and its certification. This supplier shall have had experience with three or more installations of systems of comparable size and complexity. Each of these installations shall have been in successful operation for three or more years. Prior to review of submittals, the Government reserves the right to:

1. Have the manufacturer submit a list of locations with similar installations.

2. Inspect any of these installations and question the user concerning the installations without the presence of the supplier.

B. A factory-authorized representative shall be capable of providing emergency maintenance and repairs at the project site within 2 hours maximum of notification.

C. Factory Test: The Government shall have the option of witnessing the following tests at the factory. The tests shall be performed on the specific engine-generator(s) being manufactured for this project. The Government will pay all expenses for the Government representative's trip to witness these tests. The contractor shall notify the Contracting Officer’s Representative/COR 15 days prior to date of testing. The manufacturer shall furnish load banks, testing instruments, and all other equipment necessary to perform these tests.

1. Load Test: Shall include six hours of continuous operation; four hours while the engine-generator is delivering 100% of the specified kW and two hours while delivering 110% of the specified kW. During this test record, the following data at 20-minute intervals:

Time	Engine RPM	Oil Temperature Out
kW	Water Temperature In	Fuel Pressure
Voltage	Water Temperature Out	Oil Pressure
Amperes	Oil Temperature In	Ambient Temperature

2. Quick Start Test: Record time required for the engine-generator to develop specified voltage, frequency, and kW load from a standstill condition.

1.5 SUBMITTALS

A. In accordance with Section 26 05 11, REQUIREMENTS FOR ELECTRICAL INSTALLATIONS, submit the following:

B. Shop Drawings:
Scaled drawings, showing plan views, side views, elevations, and cross-sections.

C. Diagrams:
Control system diagrams, elementary diagrams, control sequence diagrams or tables, wiring diagrams, interconnections diagrams between the ;load exercising panel, automatic transfer switch, , and fuel storage tank, emergency stop pushbutton, engine jacket water heater, battery charger, alternator strip and other accessories requiring interconnection or

input power), illustrative diagrams, flow diagrams, and other like items.

D. Technical Data:
   1. Published ratings, catalog cuts, pictures, and manufacturers' specifications for engine-generator, governor, voltage regulator, radiator, muffler, dampers, day tank, pumps, fuel tank, batteries and charger, jacket heaters, tensional vibration, and control and supervisory equipment.
   2. Description of operation.
   3. Short-circuit current capacity and subtransient reactance.
   4. Sound power level data.

E. Calculations:
   Detailed engineering calculations with all equations, graphs, assumptions, and approximations shown and data sources referenced. Include any calculated performance derations appropriate to installed environment.

F. Manuals:
   1. When submitting the shop drawings, submit complete maintenance and operating manuals of the engine-generator and auxiliaries, including technical data sheets, wiring diagrams, and information for ordering replacement parts.
   2. Two weeks prior to the final inspection, submit Contracting Officer’s Representative/COR:
      a. Include complete "As Installed" diagrams, which indicate all items of equipment and their interconnecting wiring.
      b. Include complete diagrams of the internal wiring for each of the pieces of equipment, including "As Installed" revisions of the diagrams.
      c. The wiring diagrams shall identify the terminals to facilitate installation, maintenance, operation, and testing.
      d. Include complete lists of spare parts and special tools recommended for two years of normal operation of the complete system.

G. Certifications:
   1. Prior to fabrication of the engine-generator, submit the following to the Contracting Officer’s Representative/COR for approval:
      a. A certification in writing that an engine-generator of the same model and configuration, with the same bore, stroke, number of cylinders, and equal or higher kW/kVA ratings as the proposed engine-generator, has been operating satisfactorily with connected

loads of not less than 75% of the specified kW/kVA rating, for not fewer than 2,000 hours without any failure of a crankshaft, camshaft, piston, valve, injector, or governor system.

b. A certification in writing that devices and circuits will be incorporated to protect the voltage regulator and other components of the engine-generator during operation at speeds other than the rated RPM while performing maintenance. Submit thorough descriptions of any precautions necessary to protect the voltage regulator and other components of the system during operation of the engine-generator at speeds other than the rated RPM.

c. A certification from the engine manufacturer stating that the engine exhaust emissions meet the federal, state, and local regulations and restrictions specified. At a minimum, this certification shall include emission factors for criteria pollutants including nitrogen oxides, carbon monoxide, particulate matter, sulfur dioxide, non-methane hydrocarbon, and hazardous air pollutants (HPAs).

2. Prior to installation of the engine-generator at the job site, submit four copies of certified factory test data to the Contracting Officer’s Representative/COR .

3. Two weeks prior to the final inspection, submit four copies of the following to the Contracting Officer’s Representative/COR :

a. Certification by the engine-generator manufacturer that the equipment conforms to the requirements of the drawings and specifications.

b. A certified report of field tests from the contractor that the engine-generator has been properly installed, adjusted, and tested.

1.6 STORAGE AND HANDLING

A. Equipment shall withstand shipping and handling stresses in addition to the electrical and mechanical stresses which occur during operation of the system. Protect radiator core with wood sheet.

B. Store the equipment in a location approved by the Contracting Officer’s Representative/COR .

1.7 JOB CONDITIONS

A. Shall conform to the arrangements and details shown on the drawings. The dimensions, enclosures, and arrangements of the engine-generator system shall permit the operating personnel to safely and conveniently operate and maintain the system in the space designated for installation.

1.8 APPLICABLE PUBLICATIONS

A. Publications listed below (including amendments, addenda, revisions, supplements, and errata) form a part of this specification to the extent referenced. Publications are referenced in the text by designation only.

B. American National Standards Institute (ANSI):

C37.50-00.....Low-Voltage AC Power Circuit Breakers Used In Enclosures-Test Procedures

C39.1-81 (R1992) .....Requirements for Electrical Analog Indicating Instruments

C. American Society of Testing Materials (ASTM):

A53/A53M-07.....Standard Specification for Pipe, Steel, Black, and Hot–Dipped, Zinc Coated Welded and Seamless.

B88-03.....Specification for Seamless Copper Water Tube

B88M-03.....Specification for Seamless Copper water Tube (Metric)

D975-09b.....Diesel Fuel Oils

D. Institute of Electrical and Electronic Engineers (IEEE):

C37.13-08.....Low Voltage AC Power Circuit Breakers Used In Enclosures

C37.90.1-02.....Surge Withstand Capability (SWC) Tests for Relays and Relay Systems Associated with Electric Power Apparatus

E. National Electrical Manufacturers Association (NEMA):

ICS 6-06.....Enclosures

ICS 4-05.....Terminal Blocks

MG 1-07.....Motor and Generators

MG 2-01.....Safety Standard and Guide for Selection, Installation and Use of Electric Motors and Generators

PB 2-06.....Dead-Front Distribution Switchboards

250-08.....Enclosures for Electrical Equipment (1000 Volts Maximum)

F. National Fire Protection Association (NFPA):

30-08.....Flammable and Combustible Liquids Code

37-06.....Installations and Use of Stationary Combustion Engine and Gas Turbines

70-08.....National Electrical Code (NEC)

99-05.....Health Care Facilities

110-10.....Standard for Emergency and Standby Power Systems

G. Underwriters Laboratories, Inc. (UL):

50-95.....Enclosures for Electrical Equipment
142-06.....Steel Aboveground Tanks for Flammable and Combustible Liquids
2085-97.....Insulated Aboveground Tanks for Flammable and Combustible Liquids
2200-98.....Stationery Engine Generator Assemblies
1236-06.....Battery Chargers for Charging Engine-Starter Batteries
467-07.....Grounding and Bonding Equipment
489-09.....Molded-Case Circuit Breakers, Molded-Case Switches and Circuit-Breaker Enclosures
508-99.....Industrial Control Equipment
891-05.....Switchboards

PART 2 - PRODUCTS

2.1 ENGINE-GENERATOR

A. The engine-generator system shall be in accordance with NFPA, UL, NEMA and ANSI, and as specified herein. All information required by these specifications shall be shown on the drawings.

B. Provide a factory-assembled, wired (except for field connections), complete, fully automatic engine-generator system.

C. Engine-Generator Parameter Schedule:
Power Rating: Optional Standby
Voltage:120/208V
Service Load: 100 kVA (maximum)
Starting kVA (Max.): 92 kVA
Power Factor: 0.8 lagging
Engine-Generator Application: stand-alone Fuel: diesel
Maximum Speed: 1800// RPM
Frequency Bandwidth (steady state): 5%
Voltage Regulation: +/- 0.5 %(maximum) (No Load to Full Load) (standalone applications)
Voltage Bandwidth: +/-1% (steady state)
Frequency: 60 Hz
Phases: 3 Phase, Wye separately derived
Minimum Generator Subtransient Reactance: 6 %
Max Step Load Increase: Refer to load step schedule on the drawings
Transient Recovery Time with Step Load Increase (Voltage): less than 5 seconds

Transient Recovery Time with Step Load Increase (Frequency):less than 5 seconds
Maximum Frequency Deviation with Step Load Increase: less than 5 % of rated frequency
Max Step Load Decrease (without shutdown): 100% of service load at 0.8 PF
Max Time to Start and be Ready to Assume Load: 60 seconds
Max Summer Indoor Temp (Prior to Engine-Generator Operation): 105 degrees F
Min Winter Indoor Temp (Prior to Engine-Generator Operation): 40 degrees F
Max Allowable Heat Transferred To Engine-Generator Space at Rated Output Capacity: 905 BTU/hr
Installation Elevation: 500 feet above sea level

D. Assemble, connect, and wire the equipment at the factory so that only the external connections need to be made at the construction site.
E. Unit shall be factory-painted with manufacturer's primer and standard finishes.
F. Connections between components of the system shall conform to the recommendations of the manufacturer.
G. Couplings, shafts, and other moving parts shall be enclosed and guarded. Guards shall be metal, ruggedly constructed, rigidly fastened, and readily removable for convenient servicing of the equipment without disassembling any pipes and fittings.
H. Engine-generator shall have the following features:
   1. Factory-mounted on a common, rigid, welded, structural steel base.
   2. Engine-generator shall be statically and dynamically balanced so that the maximum vibration in the horizontal, vertical, and axial directions shall be limited to 0.0059 in [0.15 mm], with an overall velocity limit of 0.866 in/sec [24 mm/sec] RMS, for all speeds.
   3. The isolators shall be constrained with restraints capable of withstanding static forces in any direction equal to twice the weight of the supported equipment.
   4. Shall be capable of operating satisfactorily as specified for not fewer than 10,000 hours between major overhauls.

2.2 ENGINE

A. Coupled directly to a generator.
B. Minimum four cylinders.

C. The engine shall be able to start in a 40˚ F [4.5˚ C] ambient temperature while using No. 2 diesel fuel oil without the use of starting aids such as glow plugs and ether injections.

D. Fuel oil consumption of the engine rate shall not exceed the following values:

Size Range Net kW	% of Rated Output capacity	Fuel Usage kg/kWH (lbs/kWH)
100 -299	75 and 100	0.272 (0.600)
	50	0.292 (0.643)
300 -999	75 and 100	0.261 (0.575)
	50	0.272 (0.600)
1000 -2500	75 and 100	0.243 (0.536)
	50	0.260 (0.573)

E. Equipped with electric heater for maintaining the coolant temperature between 90-100˚ F [32-38˚ C]), or as recommended by the manufacturer.
   1. Install thermostatic controls, contactors, and circuit breaker-protected circuits for the heaters.
   2. The heaters shall operate continuously except while the engine is operating or the water temperature is at the predetermined level.

2.3 GOVERNOR

A. Isochronous, electronic type.

B. Steady-state speed band at 60 Hz shall not exceed plus or minus one-third of 1%.

C. While the engine is running, manual speed adjustments may be made.

2.4 LUBRICATION OIL SYSTEM

A. Pressurized type.

B. Positive-displacement pump driven by engine crankshaft.

C. Full-flow strainer and full-flow or by-pass filters.

D. Filters shall be cleanable or replaceable type and shall remove particles as small as 3 microns without removing the additives in the oil. For by-pass filters, flow shall be diverted without flow interruption.

E. Extend lube oil sump drain line out through the skid base and terminate it with a drain valve and plug.

2.5 FUEL SYSTEM

A. Main fuel storage shall be an integral belly tank with double wall construction with 110% rupture containment tank and shall comply with the requirements of Section 23 10 00, FACILITY FUEL SYSTEMS.

B. Shall comply with NFPA 37 and NFPA 30, and have the following features:
   1. Injection pump(s) and nozzles.
   2. Plungers shall be carefully lapped for precision fit and shall not require any packing.
   3. Filters or screens that require periodic cleaning or replacement shall not be permitted in the injection system assemblies.
   4. Return surplus oil from the injectors to the main storage tank by gravity or a pump.
   5. Filter System:
      a. Dual primary filters shall be located between the main fuel oil storage and day tank.
      b. Secondary filters (engine-mounted) shall be located such that the oil will be thoroughly filtered before it reaches the injection system assemblies.
      c. Filters shall be cleanable or replaceable type and shall entrap and remove water from oil as recommended by the engine manufacturer.
      d. The main fuel tank shall be equipped with float control switches for high fuel (90% of tank capacity), low fuel (50% of tank capacity), and overfill/rupture basin alarm for control panel annunciation and for extension to fuel oil fill station. The floats shall be wired by the manufacturer back to the control panel for local and remote monitoring.
      e. The contractor shall extend the fuel fill line, using standard weight ASTM- A-53 black screwed steel pipe to an outdoor fill station with spill containment and full, high fuel alarm and rupture tank alarms to prevent overfilling of tank and filling tank, if a tank rupture has occurred.
      f. The contractor shall extend the fuel tank vent piping thru the building roof area using standard weight ASTM- A-53 black screwed steel pipe and Ul listed vent cap.

2.6 COOLING SYSTEM

A. Liquid-cooled, closed loop, with fin-tube radiator mounted on the engine-generator, and integral engine driven circulating pump.
B. Cooling capacity shall not be less than the cooling requirements of the engine-generator and its lubricating oil while operating continuously at 110% of its specified rating.

C. Water circulating pumps shall be the centrifugal type driven by engine. Incorporate pressure relief devices where required to prevent excessive pressure increase after the engine stops.

D. Coolant shall be extended-life antifreeze solution, 50% ethylene glycol and 50% soft water, with corrosion inhibitor additive as recommended by the manufacturer.

E. Fan shall be driven by multiple belts from engine shaft and totally enclosed electric motor.

F. Coolant hoses shall be flexible, per manufacturer's recommendation.

G. Self-contained thermostatic-control valve shall modulate coolant flow to maintain optimum constant coolant temperature, as recommended by the engine manufacturer.

H. Motor-Operated Dampers:

1. Dampers, which are provided under Section 23 31 00, HVAC DUCTS AND CASINGS, shall be two-position, electric motor-operated.
2. Dampers shall open simultaneously with the starting of the diesel engine and shall close simultaneously with the stopping of the diesel engine.

2.7 AIR INTAKE AND EXHAUST SYSTEMS

A. Air Intake:

Provide an engine-mounted air cleaner with replaceable dry filter and dirty filter indicator.

B. Exhaust System:

2. Exhaust Muffler:

Shall be critical grade type and capable of the following noise attenuation:

Octave Band Hertz (Mid Frequency)	Minimum db Attenuation (.0002 Microbar Reference)
31	5
63	10
125	27
500	37
1000	31
2000	26
4000	25
8000	26

3. Pressure drop in the complete exhaust system shall be small enough for satisfactory operation of the engine-generator while it is delivering 110% of its specified rating.
4. Exhaust pipe size from the engine to the muffler shall be as recommended by the engine manufacturer. Pipe size from muffler to air discharge shall be two pipe sizes larger than engine exhaust pipe.
5. Connections at the engine exhaust outlet shall be made with a flexible exhaust pipe. Provide bolted type pipe flanges welded to each end of the flexible section.

C. Condensate drain at muffler shall be made with schedule 40 black steel pipe through a petcock. Refer to details on the drawings.

D. Exhaust Piping and Supports: Black steel pipe, ASTM A-53 standard weight with welded fittings. Spring type hangers, as specified in Section 23 05 41, NOISE AND VIBRATION CONTROL FOR HVAC PIPING AND EQUIPMENT, shall support the pipe.

E. Insulation for Exhaust Pipe and Muffler:
1. Calcium silicate minimum 3 in [75 mm] thick.
2. Insulation shall be as specified in Section 23 07 11, HVAC, PLUMBING, AND BOILER PLANT INSULATION.
3. The installed insulation shall be covered with aluminum jacket 0.016 in [0.4 mm] thick. The jacket is to be held in place by bands of 0.015 in [0.38 mm] thick by 0.5 in [15 mm] wide aluminum.
4. Insulation and jacket are not required on flexible exhaust sections.

F. Roof Sleeves: Pipe sleeves (thimble) shall be Schedule 40 standard weight steel pipe. Flash exhaust pipe thimble through roof with 16 oz soft sheet copper, flanged, and made watertight under built-up roofing and extended up around pipe thimble. The exhaust pipe shall be positioned within the thimble by four 6 in [150 mm] wide spiders welded to the exhaust pipe.

G. Vertical exhaust piping shall be provided with a hinged, gravity-operated, self-closing rain cover.

2.8 ENGINE STARTING SYSTEM

A. Shall start the engine at any position of the flywheel.

B. Electric cranking motor:
1. Shall be engine-mounted.
2. Shall crank the engine via a gear drive.
3. Rating shall be adequate for cranking the cold engine at the voltage provided by the battery system, and at the required RPM during five consecutive starting attempts of 10 seconds cranking each at

10-second intervals, for a total of 50 seconds of actual cranking without damage (the fifth starting attempt will be manually initiated upon failure of a complete engine cranking cycle).

C. Batteries shall be lead-acid high discharge rate type.
   1. Each battery cell shall have minimum and maximum electrolyte level indicators and a flip-top flame arrestor vent cap.
   2. Batteries shall have connector covers for protection against external short circuits.
   3. With the charger disconnected, the batteries shall have sufficient capacity so that the total system voltage does not fall below 85% of the nominal system voltage with the following demands:
      Five consecutive starting attempts of 10 seconds cranking at 10 second intervals for a total of 50 seconds of actual cranking (the fifth starting attempt will be manually initiated upon failure of a complete engine cranking cycle).
   4. Battery racks shall be metal with an alkali-resistant finish and thermal insulation, and secured to the floor.

D. Battery Charger:
   1. A current-limiting battery charger, conforming to UL 1236, shall be provided and shall automatically recharge the batteries. The charger shall be capable of an equalize-charging rate for recharging fully depleted batteries within 24 hours and a floating charge rate for maintaining the batteries at fully charged condition.
   2. An ammeter shall be provided to indicate charging rate. A voltmeter shall be provided to indicate charging voltage.

2.9 LUBRICATING OIL HEATERS

Provide a thermostatically-controlled electric heater to automatically maintain the oil temperature within plus or minus 3˚ F [1.7˚ C] of the control temperature.

2.10 JACKET COOLANT HEATERS

Provide a thermostatically-controlled electric heater mounted in the engine coolant jacketing to automatically maintain the coolant within plus or minus 3˚ F [1.7˚ C] of the temperature recommended by the engine manufacturer to meet the starting time specified at the minimum winter outdoor temperature.

2.11 GENERATOR

A. Synchronous, amortisseur windings, bracket-bearing, self-venting, rotating-field type connected directly to the engine.

B. Lifting lugs designed for convenient connection to and removal from the engine.
C. Integral poles and spider, or individual poles dove-tailed to the spider.
D. Designed for sustained short-circuit currents in conformance with NEMA Standards.
E. Designed for sustained operation at 125% of the RPM specified for the engine-generator without damage.
F. Telephone influence factor shall conform to NEMA Standards.
G. Furnished with brushless excitation system or static-exciter-regulator assembly.
H. Nameplates attached to the generator and exciter shall show the manufacturer's name, equipment identification, serial number, voltage ratings, field current ratings, kW/kVA output ratings, power factor rating, time rating, temperature rise ratings, RPM ratings, full load current rating, number of phases and frequency, and date of manufacture.
I. The grounded (neutral) conductor shall be electrically isolated from equipment ground and terminated in the same junction box as the phase conductors.

2.12 GENERATOR OVERCURRENT AND FAULT PROTECTION

A. Generator circuit breaker shall be molded case type. Molded case circuit breaker shall have automatic, trip free, non-adjustable, inverse time, and instantaneous magnetic trips for 100 A frame size or less. Magnetic trip shall be adjustable from 3x to 10x for breakers with 600 A frame size and higher. Factory setting shall be LOW unless otherwise noted. Provide shunt trip-to-trip breaker when engine-generator is shut down by other protective devices.

2.13 CONTROLS

A. Shall include Engine Generator Control Panel
B. General:
   1. Control Equipment shall be in accordance with UL 508, NEMA ICS-4, ICS-6, and ANSI C37.90.1.
   2. Panels shall be in accordance with UL 50.
   3. Cubicles shall be in accordance with UL 891.
   4. Coordinate controls with the automatic transfer switch shown on the drawings so that the systems will operate as specified.
   5. Cubicles:
      a. Code gauge steel: manufacturer's recommended heavy gauge steel with factory primer and light gray finish.

b. Doors shall be gasketed, attached with concealed or semi-concealed hinges, and shall have a permanent means of latching in closed position.
c. Panels shall be mounted on the equipment
d. Door locks for panel shall be keyed identically to operate from a single key.

6. Wiring: Insulated, rated at 600 V.
a. Install the wiring in vertical and horizontal runs, neatly harnessed.
b. Terminate all external wiring at heavy duty, pressure-type, terminal blocks.
7. The equipment, wiring terminals, and wires shall be clearly and permanently labeled.
8. The appropriate wiring diagrams shall be laminated or mounted under plexiglass within the frame on the inside of the cubicles and panels.
9. All indicating lamps and switches shall be accessible and mounted on the cubicle doors.
10. Meters shall be per the requirements of Section 25 10 10, ADVANCED UTILITY METERING.
11. The manufacturer shall coordinate the interfacing of the control systems with all related equipment supplied in accordance with other sections of the project specification.

C. Engine-Generator Control Cubicle:
1. Starting and Stopping Controls:
a. A three-position, maintained contact type selector switch with positions marked "AUTOMATIC," "OFF," and "MANUAL." Provide flashing amber light for OFF and MANUAL positions.
b. A momentary contact push-button switch with positions marked "MANUAL START" and "MANUAL STOP."
c. Selector switch in AUTOMATIC position shall cause the engine to start automatically when a single pole contact in a remote device closes. When the generator's output voltage increases to not less than 90% of its rated voltage, and its frequency increases to not less than 58 Hz, the remote devices shall transfer the load to the generator. An adjustable time delay relay, in the 0 to 15 minute range, shall cause the engine-generator to continue operating without any load after completion of the period of operation with load. Upon completion of the additional 0 to 15 minute (adjustable) period, the engine-generator shall stop.

d. Selector switch in OFF position shall prevent the engine from starting either automatically or manually. Selector switch in MANUAL position shall also cause the engine to start when the manual start push-button is depressed momentarily.
e. With selector switch is in MANUAL position, depressing the MANUAL STOP push-button momentarily shall stop the engine after a cool-down period.
f. A maintained-contact, outdoor rated red mushroom-head push-button switch marked "EMERGENCY STOP" will cause the engine to stop without a cool down period, independent of the position of the selector switch. Refer to the drawings for its location.

2. Engine Cranking Controls:
   a. The cranking cycles shall be controlled by a timer that will be independent of the battery voltage fluctuations.
   b. The controls shall crank the engine through one complete cranking cycle, consisting of four starting attempts of 10 seconds each and 10 seconds between each attempt.
   c. Total actual cranking time for the complete cranking cycle shall be 40 seconds during a 70-second interval.
   d. Cranking shall terminate when the engine starts so that the starting system will not be damaged. Termination of the cranking shall be controlled by self-contained, speed-sensitive switch. The switch shall prevent re-cranking of the engine until after the engine stops.
   e. After the engine has stopped, the cranking control shall reset.
3. Supervisory Controls:
   a. Overcrank:
      1) When the cranking control system completes one cranking cycle (four starting attempts), without starting the engine, the OVERCRANK signal light and the audible alarm shall be energized.
      2) The cranking control system shall lock-out, and shall require a manual reset.
   b. Coolant Temperature:
      1) When the temperature rises to the predetermined first stage level, the HIGH COOLANT TEMPERATURE - FIRST STAGE signal light and the audible alarm shall be energized.
      2) When the temperature rises to the predetermined second stage level, which shall be low enough to prevent any damage to the engine and high enough to avoid unnecessary engine shutdowns,

the HIGH COOLANT TEMPERATURE - SECOND STAGE signal light and the audible alarm shall be energized and the engine shall stop.

3) The difference between the first and second stage temperature settings shall be approximately 10˚ F [-12˚ C].

4) Permanently indicate the temperature settings near the associated signal light.

5) When the coolant temperature drops to below 70˚ F [21˚ C], the "LOW COOLANT TEMPERATURE" signal light and the audible alarm shall be energized.

c. Low Coolant Level: When the coolant level falls below the minimum level recommended by the manufacturer, the LOW COOLANT LEVEL signal light and audible alarm shall be energized.

d. Lubricating Oil Pressure:

1) When the pressure falls to the predetermined first stage level, the OIL PRESSURE - FIRST STAGE signal light and the audible alarm shall be energized.

2) When the pressure falls to the predetermined second stage level, which shall be high enough to prevent damage to the engine and low enough to avoid unnecessary engine shutdowns, the OIL PRESSURE - SECOND STAGE signal light and the audible alarm shall be energized and the engine shall stop.

3) The difference between the first and second stage pressure settings shall be approximately 15% of the oil pressure.

4) The pressure settings near the associated signal light shall be permanently displayed so that the running oil pressure can be compared to the target (setpoint) value.

e. Overspeed:

1) When the engine RPM exceeds the maximum RPM recommended by the manufacturer of the engine, the engine shall stop.

2) Simultaneously, the OVERSPEED signal light and the audible alarm shall be energized.

f. Low Fuel - Day Tank:

When the fuel oil level in the day tank decreases to less than the level at which the fuel oil transfer pump should start to refill the tank, the LOW FUEL DAY TANK light and the audible alarm shall be energized.

g. Low Fuel - Main Storage Tank:

When the fuel oil level in the storage tank decreases to less than one-third of total tank capacity, the LOW FUEL-MAIN STORAGE TANK signal light and audible alarm shall be energized.

h. Reset Alarms and Signals:
Overcrank, Coolant Temperature, Coolant Level, Oil Pressure, Overspeed, and Low Fuel signal lights and the associated audible alarms shall require manual reset. A momentary-contact silencing switch and push-button shall silence the audible alarm by using relays of solid state devices to seal in the audible alarm in the de-energized condition. Elimination of the alarm condition shall automatically release the sealed-in circuit for the audible so that it will be automatically energized again when the next alarm condition occurs. The signal lights shall require manual reset after elimination of the condition which caused them to be energized. Install the audible alarm just outside the generator room in a location as directed by the audible alarm shall be rated for 85 dB at 10 ft [3 M].

i. Generator Breaker Signal Light:
1) A flashing green light shall be energized when the generator circuit breaker is in the OPEN or TRIPPED position.
2) Simultaneously, the audible alarm shall be energized.

4. Monitoring Devices:
a. Electric type gauges for the cooling water temperatures and lubricating oil pressures. These gauges may be engine mounted with proper vibration isolation.
b. A running time indicator, totalizing not fewer than 9,999 hours, and an electric type tachometer.
c. A voltmeter, ammeter, frequency meter, kilowatt meter, manual adjusting knob for the output voltage, and the other items shown on the drawings shall be mounted on the front of the generator control panels.
d. Install potential and current transformers as required.
e. Individual signal lights:
1) OVER-CRANK
2) HIGH COOLANT TEMPERATURE - FIRST STAGE
3) HIGH COOLANT TEMPERATURE - SECOND STAGE
4) LOW COOLANT TEMPERATURE
5) OIL PRESSURE - FIRST STAGE
6) OIL PRESSURE - SECOND STAGE
7) LOW COOLANT LEVEL
8) GENERATOR BREAKER
9) OVERSPEED
10) LOW FUEL - DAY TANK

11) LOW FUEL – MAIN STORAGE TANK

f. The control panel shall include a summary alarm contact wired to the Summary Alarm Control Panel shown on the drawings. The contact shall change state and report alarm and trouble conditions for the engine generator set including fuel alarms.

f. Lamp Test: The LAMP TEST momentary contact switch shall momentarily actuate the alarm buzzer and all the indicating lamps.

5. Automatic Voltage Regulator:

a. Shall correct voltage fluctuations rapidly and restore the output voltage to the predetermined level with a minimum amount of hunting.

b. Shall include voltage level rheostat located inside the control cubicle.

c. Provide a 3-phase automatic voltage regulator immune to waveform distortion.

2.14 RADIATOR MOUNTED RESISTIVE LOAD BANK

A. An engine radiator airflow cooled, resistive Load Bank is required for permanent, on site installation as a component of the standby engine generator.

B. The Load Bank shall be installed within the air outflow of the engine unit mounted radiator and shall be cooled by the radiator airflow with a bolted attachment to the radiator with duct and flex coupling to air outlet in wall.

C. Electrical Connection

1. Power source to Load Bank connection is 3-phase, 3-wire plus ground.

D. Load Bank Rating

1. Capacity: 50 KW, 1.0 p.f.

2. Load Steps 10 KW load step resolution

3. Voltage: 208V AC, 3-ph., 3-W

4. Frequency: 60 Hertz

5. Air intake temperature: 155°F max (radiator air outflow)

6. Airflow requirements: Radiator air outflow

7. Duty Cycle: Continuous

8. Air temp. rise: 100°F, nominal

9. Air back pressure: .25-.50" water column

E. Load Bank Design

1. The Load Bank shall be a completely self-contained unit which includes all resistive load elements, load control devices, load element branch circuits.

2. The Load Bank shall be the manufacturer's standard product that has been investigated, tested and listed by Underwriters Laboratories as a system.

3. Enclosure to be NEMA type 1, galvanized steel, unit construction, consisting of a power section, for installation and wiring of the load elements and a contactors.

4. Load elements shall be UL listed, labeled or recognized, totally enclosed, sealed and weatherproof with an electrically grounded outer sheath.

5. Load element short circuit protection: Branch circuit fuses, per each 10KW load branch circuit. Fuses shall be 200,000 A.I.C current limiting type.

6. Load control: One magnetic contactor per each fused branch circuit.

7. Load Bank power wiring shall be 150°C XLP insulated.

8. Main terminals: Barrier type power terminal block with compression type terminal to accept stranded building wire. Provide chassis ground stud with compression lug.

9. Control wiring shall be 105°C XLP insulated.

10. Control power shall be derived internally from the main load bus. Control and protective circuits shall operate at 120V via control power transformer.

11. The Load Bank shall include a comprehensive protection system to protect against overheating. The system shall function to disconnect the load bank.

12. A NEMA 1 integral control panel for (automatic, manual) operation shall be provided. The panel shall include:

    a. Control power on-off pushbuttons

    b. "Normal operation" indicator lamp

    c. Master load control switch

    d. Load step control switches

    e. "Cooling failure" alarm indicator lamp

    f. Control panel shall be UL listed

13. The Load Bank manufacturer is to provide one day start-up service of the Load Bank, on site, after the Load Bank has been installed.

14. The Load Bank shall be a product of a firm regularly engaged in the design and manufacture of generator Load Banks. The Load Bank shall demonstrate at least five years experience with at least twenty-five successful installations of Load Banks similar or equal. Add the manufacturer following section to provide for Load Bank operation as an automatic load regulator to maintain a preset load level.

15. The Load Bank is to be equipped with an automatic controller which will be activated when the Load Bank mode control selector switch is placed in the “automatic mode. In automatic mode, the Load Bank is to be on-line and continuously operative whenever the power source runs. The automatic controller shall include control logic, solid-state sensors and time delays which shall act to apply/remove Load Bank component in multiple step. The automatic controller shall function to maintain total load upon the power source within a preset bandwidth. The automatic controller shall sense load (amperes,

kilowatts).Full manual control of the Load Bank shall be restored when the mode selector switch is placed in the “manual” position. The automatic controller shall include a solid-state load sensor with level and time delay adjustment and output contacts for each load step.

2.18 SPARE PARTS

A. For each engine generator:
   1. Six lubricating oil filters.
   2. Six primary fuel oil filters.
   3. Six secondary fuel oil filters.
   4. Six intake air filters.

B. For each battery charger:
   Three complete sets of fuses.

C. For each control panel:
   Three complete sets of fuses.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install concrete bases of dimensions shown on the drawings.

B. Installation of the engine-generator shall comply with manufacturer's written instructions and with NFPA 110.

C. Mounting:
   1. Support the base of engine-generator on vibration isolators, each isolator bolted to the floor (pad), and the generator base bolted to isolator.
   2. Install sufficient isolators so that the floor (pad) bearing pressure under each isolator is within the floor (pad) loading specification.
   3. Install equal number of isolators on each side of the engine-generator's base.
   4. Locate isolators for approximately equal load distribution and deflection per isolator. The base of the engine-generator shall be drilled at the factory for the isolator bolts.
   5. Isolators shall be shipped loose with the engine-generator.
   6. All connections between the engine-generator and exterior systems, such as fuel lines, electrical connections, and engine exhaust system and air exhaust shroud, shall be flexible.

D. Balance:
   The vibration velocity in the horizontal, vertical, and axial directions shall not exceed 0.65 in [16.25 mm] per second peak at any specific frequency. These limits apply to main structural components such as the engine block and the generator frame at the bearings.

E. Connect all components of the generator system so that they will continue to be energized during failure of the normal electrical power supply system.

F. Install piping between engine-generator and remote components of cooling, fuel, and exhaust systems.

G. Flexible connection between radiator and exhaust shroud at the wall damper:

1. Install noncombustible flexible connections made of 20-oz neoprene-coated fiberglass fabric approximately 6 in [150 mm] wide.
2. Crimp and fasten the fabric to the sheet metal with screws 2 in [50 mm] on center. The fabric shall not be stressed, except by the air pressure.

H. Exhaust System Insulation:

1. Adhesive and insulation materials shall be applied on clean, dry surfaces from which loose scale and construction debris has been removed by wire brushing.
2. Fill all cracks, voids, and joints of applied insulation material with high temperature 2000˚ F [1093˚ C] insulating cement before applying the outer covering.
3. The installation shall be clean and free of debris, thermally and structurally tight without sag, neatly finished at all hangers or other penetrations, and shall provide a smooth finish surface.
4. Insulation and jacket shall terminate hard and tight at all anchor points.
5. Insulate completely from engine exhaust flexible connection through roof or wall construction, including muffler.

3.2 ACCEPTANCE CHECKS AND TESTS

A. Provide the services of a factory-authorized, factory-trained representative of the engine-generator manufacturer to inspect field-assembled components, and equipment installation and supervise the field tests.

B. When the complete engine-generator system has been installed and prior to the final inspection, test all components of the system in the presence of the Contracting Officer’s Representative/COR .for proper operation of the individual components and the complete system and to eliminate electrical and mechanical defects.

C. Furnish fuel oil, lubricating oil, anti-freeze liquid, water treatment, and rust-inhibitor and load bank for testing of the engine-generator. The generator fuel tank shall be left full after the load testing.

D. Visual Inspection: Visually verify proper installation of engine-generator and all components per manufacturer’s pre-start installation checklist.

F. Field Tests:

1. Perform manufacturer’s after-starting checks and inspections.
2. Test the engine-generator for eight hours of continuous operation as follows:
   a. First six hours while the engine-generator is delivering 100% of its specified kW rating.
   b. Last two hours while the engine-generator is delivering 110% of its specified kW rating.
   c. If during the 8-hour continuous test, a failure occurs, the diesel engine shuts down or the full kW rating of the load bank is not achieved, the test is null and void. The test(s) shall be repeated at no additional cost to the Government until satisfactory results are attained.
3. Record the following test data at 30-minute intervals:
   a. Time of day, as well as reading of running time indicator.
   b. kW.
   c. Voltage on each phase.
   d. Amperes on each phase.
   e. Engine RPM.
   f. Frequency.
   g. Engine water temperature.
   h. Fuel pressure.
   i. Oil pressure.
   j. Outdoor temperature.
   k. Average ambient temperature in the vicinity of the engine-generator.
4. Demonstrate that the engine-generator will attain proper voltage, frequency, and will accept the specified block load within the specified time limit from a cold start after the closing of a single contact.
5. Furnish a resistance-type load for the testing of the engine-generator. Test loads shall always include adequate resistance to assure stability of the loads and equipment during all of the testing operations. The test load kW rating shall not be less than 110% of the specified kW rating of the engine-generator.

G. Starting System Test:

1. Demonstrate that the batteries and cranking motor are capable of five starting attempts of 10 seconds cranking each at 10-second intervals with the battery charger turned off.

H. Remote Monitoring Panel Tests:
Simulate conditions to verify proper operation of each indicating lamp, alarm device, meter, interconnecting hardware and software, and reset button.

I. Fuel systems shall be flushed and tested per Section 23 10 00, FACILITY FUEL SYSTEMS: Fuel supply and storage requirements.

J. Automatic Operation Tests:
Test the engine-generator to demonstrate automatic starting, loading and unloading. The load for this test shall utilize both load banks and actual loads to be served. Initiate loss of normal source and verify the specified sequence of operation. Restore the normal power source and verify the specified sequence of operation. Verify resetting of controls to normal.

3.3 FOLLOW-UP VERIFICATION

Upon completion of acceptance checks, settings, and tests, the contractor shall demonstrate that the engine-generator(s) and control and annunciation components are in good operating condition and properly performing the intended function.

3.4 INSTRUCTIONS AND FINAL INSPECTIONS

A. Laminate or mount under acrylic resin a set of operating instructions for the system and install instructions within a frame mounted on the wall near the engine-generator at a location per the Contracting Officer’s Representative/COR.

B. Furnish the services of a competent, factory-trained technician for three 4-hour periods for instructions to VA personnel in operation and maintenance of the equipment, on the dates requested by the Contracting Officer’s Representative/COR.

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