

**SECTION 26 32 13
ENGINE-GENERATORS**

PART 1 - GENERAL

1.1 DESCRIPTION

- A. This section specifies the furnishing, installation, and testing of the 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 23 10 00, FACILITY FUEL SYSTEMS: Fuel supply and storage requirements.
- B. Section 26 05 11, REQUIREMENTS FOR ELECTRICAL INSTALLATIONS: General electrical requirements and items common to more than one section of Division 26.
- C. Section 26 05 21, LOW-VOLTAGE ELECTRICAL POWER CONDUCTORS AND CABLES (600 VOLTS AND BELOW): Low voltage conductors.
- D. 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.
- E. Section 26 05 33, RACEWAY AND BOXES FOR ELECTRICAL SYSTEMS: Conduits for cables and wiring.
- F. Section 26 24 16, PANELBOARDS: Panelboards.
- G. 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 4 hours maximum of notification.

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 local control cubicles, remote annunciator panels, remote derangement panels, remote monitoring panels, remote exercising panel, automatic transfer switches, paralleling switchgear, and fuel storage tanks, as applicable), 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, torsional vibration, and control and supervisory equipment.
 2. Description of operation.
 3. Short-circuit current capacity and subtransient reactance.
 4. Sound power level data.
 5. Include a list of Modbus registers.
- 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 four copies of the updated maintenance and operating manual to the COTR:
 - 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 COTR 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 COTR.
3. Two weeks prior to the final inspection, submit four copies of the following to the COTR:

- 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 COTR.

1.7 JOB CONDITIONS

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.
 - 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
- 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.....Stationary 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

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.
- B. Provide a factory-assembled, wired (except for field connections), complete, fully automatic engine-generator system.
1. Acceptable Manufacturers:
- a. Cummins Power Generation model DFEK or similar.
- C. Engine-Generator Parameter Schedule:
- Power Rating: Emergency Standby
- Voltage: 277/480V
- Standby Rating: 500 kW
- Power Factor: 0.8 lagging
- Engine-Generator Application: Stand-alone
- Fuel: Diesel

Maximum Speed: 1800 RPM

Frequency Bandwidth (steady state): +/- 0.25%

Voltage Regulation: +/- 0.5% (maximum) (No Load to Full Load)

Frequency: 60 Hz

Phases: 3 Phase, Wye

Total Harmonic Distortion: <5% (No Load to Full Linear Load)

Installation Elevation: 85 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, with an overall velocity limit of 0.866 in/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 ambient temperature while using No. 2 diesel fuel oil without the use of starting aids such as glow plugs and ether injections.
- D. 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. 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.
- B. Day Tank:
 - 1. Each engine-generator shall be provided with a welded steel separate self-supporting day tank.
 - 2. Each day tank shall have capacity to supply fuel to the engine for a 2-hour period at 100% rated load without being refilled, including fuel that is returned to the main fuel storage tank. The calculation of the capacity of each day tank shall incorporate the requirement to

- stop the supply of fuel into the day tank at 90% of the ultimate volume of the tank.
3. Secure, pipe, and connect the tank adequately for maximum protection from fire hazards, including oil leaks.
 4. Incorporate a vent, drain cock, shutoff cocks, and gauge glass. Terminate the vent piping outdoors with mushroom vent cap. Utilize existing vent if applicable.
 5. Incorporate a float switch on the day tank to control the fuel oil transfer pump and to actuate an alarm when the oil level in the tank drops below the level at which the transfer pump should start to refill the tank.
 - a. The float switch contacts controlling the fuel oil transfer pump shall be set to energize the pump when the liquid level in the tank reaches one-third of the total volume of the tank.
 - b. The float switch contacts that actuate the low fuel oil day tank alarm device shall be set to alarm and energize the second fuel transfer pump when the liquid level in the tank reaches one-quarter of the total volume of the tank.
 6. Day tank and engine supply line elevations shall be below the elevation of the injector return outlet on the engine.
- C. Fuel Transfer Pump - Main Storage Tank to Day Tank(s):
1. Electric motor-driven, duplex arrangement, close-coupled, single-stage, positive-displacement type with built-in pressure relief valves. When the fuel is used for cooling components of the fuel injection system, the engine's fuel return line shall be returned to the main storage tank, rather than the day tank.
 2. Include a heavy-duty automatic alternator and H-O-A switch to alternate sequence of pumps. Pumps shall be controlled with the float switch on the day tank and H-O-A selector switch such that the day tank will be refilled automatically when the oil level lowers to the low limit for the float switch. The H-O-A selector switches shall enable the pumps to be operated manually at any time.
 3. For all engines, the related transfer pump and its electrical and plumbing connections shall be sized to provide a flow rate of at least four times the engine's fuel pumping rate.
 4. Provide a manually-operated, rotary-type transfer pump connected in parallel with the electric motor-driven transfer pumps so that oil can be pumped to the day tank while the electric motor-driven pumps are inoperative.

- D. Piping System: Black steel standard weight ASTM A-53 pipe and necessary valves and pressure gauges between:
1. The engine and the day tank.
 2. The day tank and the supply and return connections at the underground storage tank. Connections at the engine shall be made with flexible piping suitable for the fuel furnished.

2.6 COOLING SYSTEM

- A. Liquid-cooled, closed loop, with fin-tube radiator mounted on the engine-generator.
- 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. Coolant shall be extended-life antifreeze solution, 50% ethylene glycol and 50% soft water, with corrosion inhibitor additive as recommended by the manufacturer.
- D. Fan shall be driven by multiple belts from engine shaft.
- E. Coolant hoses shall be flexible, per manufacturer's recommendation.
- F. Self-contained thermostatic-control valve shall modulate coolant flow to maintain optimum constant coolant temperature, as recommended by the engine manufacturer.
- G. 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:
1. 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.
6. May be provided by same manufacturer/supplier as generator.
- C. Condensate drain at muffler shall be made with schedule 40 black steel pipe through a petcock. Route drain line to existing daylight to exterior through wall. Field-verify current conditions.
- D. Exhaust Piping and Supports: Black steel pipe, ASTM A-53 standard weight with welded fittings.
- E. Insulation for Exhaust Pipe and Muffler:
 1. Calcium silicate minimum 3 in thick.
 2. The installed insulation shall be covered with aluminum jacket 0.016 in thick. The jacket is to be held in place by bands of 0.015 in thick by 0.5 in wide aluminum.
 3. 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. Reuse existing if applicable. Field verify exact conditions and verify new installation requirements. The exhaust pipe shall be positioned within the thimble by four 6 inch 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 near the generator.

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

- A. Provide a thermostatically-controlled electric heater to automatically maintain the oil temperature within plus or minus 3° F of the control temperature.

2.10 JACKET COOLANT HEATERS

- A. Provide a thermostatically-controlled electric heater mounted in the engine coolant jacketing to automatically maintain the coolant within plus or minus 3° F 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(s) shall be molded-case, electronic-trip type, and 100% rated, complying with UL 489. Tripping characteristics shall be adjustable long-time and short-time delay and instantaneous. Provide shunt trip-to-trip breaker when engine-generator is shut down by other protective devices.
- B. Breakers shall include:
 - 1. (2) 400amp, 3-pole, 600volt.
 - 2. (1) 600amp, 3-pole, 600volt, shunt-trip on loss of normal electrical power. (load bank connection breaker).

2.13 CONTROLS

- A. Shall include Modbus communication.
- 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. Coordinate controls with the automatic transfer switches shown on the drawings so that the systems will operate as specified.
5. 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.
6. The equipment, wiring terminals, and wires shall be clearly and permanently labeled.
7. The appropriate wiring diagrams shall be laminated or mounted under plexi-glass within the frame on the inside of the cubicles and panels.
8. All indicating lamps and switches shall be accessible.
9. The manufacturer shall coordinate the interfacing of the control systems with all related equipment supplied in accordance with other sections of the project specification.

2.14 SPARE PARTS

- A. For 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 battery charger:

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

Three complete sets of fuses.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Provide temporary emergency back-up power source, sized to match new, prior to removal of any existing generator components/systems. Temporary system shall be online and functioning prior to and during entire construction including commissioning of new generator system(s).
 1. Field-verify exact connection location.
 2. Coordinate with VA representative prior to connection/modification to existing system.
- B. Provide 3,000psi concrete base (pad) as shown on the drawings.
- C. Installation of the engine-generator shall comply with manufacturer's written instructions and with NFPA 110.
- D. 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.

E. Balance:

The vibration velocity in the horizontal, vertical, and axial directions shall not exceed 0.65 in 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.

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

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

H. 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 wide.
2. Crimp and fasten the fabric to the sheet metal with screws 2 in on center. The fabric shall not be stressed, except by the air pressure.

I. 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 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.
6. Connect exterior exhaust pipe to existing lighting protection system. Re-use existing if applicable. Make bracket connection to exhaust pipe above rain shield. Do not allow cable to lay upon rain shield.

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 COTR 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.
- D. Visual Inspection: Visually verify proper installation of engine-generator and all components per manufacturer's pre-start installation checklist.
- E. 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, either 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.
- F. 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.
- G. 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.
- H. At the completion of the field tests, fill the main storage tank and day tank with fuel of grade and quality as recommended by the manufacturer of the engine. Fill all engine fluids to levels as recommended by manufacturer.
- I. When any defects are detected during the tests, correct all the deficiencies and repeat all or part of the 8-hour continuous test as requested by the COTR, at no additional cost to the Government.
- J. Provide test and inspection results in writing to the COTR.

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 COTR.
- 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 COTR.

- - - E N D - - -