

SECTION 26 32 13
ENGINE GENERATORS

PART 1 - GENERAL

1.1 DESCRIPTION

- A. This section specifies the furnishing, complete installation, connection and testing of the engine generator system. This includes: 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.
- C. The engine generator system shall include, but not be limited to the following:
 - 1. Diesel Engine.
 - 2. Lubrication Oil System.
 - 3. Fuel Oil System.
 - 4. Cooling System.
 - 5. Intake and Exhaust Air Systems.
 - 6. Starting System.
 - 7. Generator.
 - 8. Controls, Supervision and Distribution.
 - 9. Outdoor Generator Enclosure.
 - 10. Spare Parts.

1.2 RELATED WORK

- A. Section 23 10 00, FACILITY FUEL SYSTEMS: Requirements for fuel tanks, fluid level monitoring and alarm systems, and leak detection systems.
- B. Section 26 05 11, REQUIREMENTS FOR ELECTRICAL INSTALLATIONS: General electrical requirements and items that are common to more than one section of Division 26.
- C. Section 26 05 13 Medium-Voltage Cables: Requirements for cables above 600 V.
- D. Section 26 05 21, LOW-VOLTAGE ELECTRICAL POWER CONDUCTORS AND CABLES (600 VOLTS AND BELOW): Cables and Wiring.
- E. Section 26 13 00, MEDIUM-VOLTAGE SWITCHGEAR: Requirements for medium-voltage switchgear for use with medium-voltage generators
- F. Section 26 36 23, AUTOMATIC TRANSFER SWITCHES: Requirements for automatic transfer switches.
- 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 24 11, DISTRIBUTION SWITCHBOARDS: Requirements for secondary distribution switchboards.

1.3 QUALITY ASSURANCE

- A. The supplier of the diesel-engine generator set 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 in regards to coordinating, engineering, testing and supervising. Each of these installations shall have been in successful operation for three or more years. Prior to review of submittals, the Department of Veterans Affairs reserves the right to:
1. Have the manufacturer submit a list of locations of similar installations.
 2. Inspect any of these installations and operations of engine-generator set, and question the user concerning the installations without the presence of the supplier.
- B. Factory authorized representative shall be capable of providing emergency maintenance and repairs at the project site within 2 hours maximum of notification.
- C. Engine generator and auxiliary components shall be supplied from a single manufacturer.
- D. Noise level developed by the generator set shall be as herein specified.
- E. Factory Test: The Government shall have the option of witnessing the following tests at the factory. The Government will pay all expenses for the Government representative's trip to witness these tests. Contractor shall notify the COTR 15 days prior to date of testing. Manufacturer shall furnish load banks, testing instruments and all other equipment as necessary to perform these tests.
1. Load Test: Shall include six hours of continuous operation; four hours while the set is delivering 100 percent of the specified KW and two hours while delivering 100 percent of the specified KW for standby rated generators and 110 percent for prime rated generators. 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 set to develop specified voltage, frequency and KW load from a standstill condition.
3. Water Ingress Test: The Sound attenuated enclosure shall be tested for water intrusion by subjecting it to a pressurized water spray at a pressure of 15 psi at a distance of 10 feet from the enclosure for 10 minutes per side at a flow rate of 10 gallons per minute with no water ingress into the enclosure. Proof of water ingress testing for the actual provided enclosure shall be provided.

1.4 SUBMITTALS

- A. Submit in accordance with Section 26 05 11, REQUIREMENTS FOR ELECTRICAL INSTALLATIONS.
- B. Shop Drawings:
 1. Sufficient information, clearly presented, shall be included to determine compliance with drawings and specifications.
 2. Data shall be submitted in the following form:
 - a. Technical data sheets (TDS): These include published performance, rating and derating curves, published ratings, catalog cuts, pictures, manufacturer's specifications, material composition, and gauge thickness.
 - b. Description of operation (DO): Manufacturer's literatures and, if suitable, diagrams.
 - c. Calculations (CALC): Detailed engineering calculations with all equations, graphs, assumptions, and approximations shown, and data sources referenced.
 - d. Certification (CERT): Written confirmation as to the document's accuracy, and genuineness.
 - e. Shop Drawings (SD): Scaled drawings showing plan views, side views, elevations and cross sections.
 - f. Diagrams (DGM): These include control system diagrams, elementary diagrams, control sequence diagrams or table, wiring diagrams, interconnections diagrams (between local control cubicles, remote annunciator panels, remote derangement panels, remote monitoring panels, remote exercising panel and underground fuel storage tanks), wireless connection diagrams, illustrative diagrams, flow diagrams, and other like items.
 3. Prior to fabrication, submit for approval the following data for each engine-generator set, transfer device and control and supervisory equipment:
 - a. Engine generator set: TDS, SD including subtransient reactance and short-circuit current capacity.

- b. Engine jacket water heaters: TDS
- c. Muffler assembly: TDS, SD
- d. Motor-operated damper assembly: TDS
- e. Integral sub-base fuel tank: TDS, CALC, SD
- f. Batteries, racks and charger: TDS, CALC
- g. Torsional Vibration: CERT
- h. Control and Supervisory Equipment: TDS, DGM, DO, SD
- i. Performance:
 - 1) Voltage regulating equipment: TDS
 - 2) Frequency regulating equipment: TDS
 - 3) Voltage and frequency dips and recovery times due to specified motor loading: CALC
 - 4) Antifreeze derating: TDS
 - 5) Ambient derating: TDS
- k. Fuel oil system: DGM
- l. Cooling system: DGM
- m. Vibration isolators: TDS, CALC
- n. Sound power level data for the packaged outdoor generator.
- o. Vibration isolation system performance data from no-load to full-load. This must include seismic qualification of the engine-generator mounting, base and vibration isolation.
- p. A detailed dimensionl drawing of the proposed generator enclosure (1/4-inch-equals-1-foot) 1:50 scale or larger as required by specification 26 05 11 COORDINATION DRAWINGS FOR ELECTRICAL INSTALLATION. All components in the enclosure shall be drawn to scale and all dimensions of the interior shall be indicated, including the engine-generator, all electrical components, battery racks, and all other components.

C. Manuals:

- 1. Submit, simultaneously with the shop drawings, companion copies of complete maintenance and operating manuals of the engine generator set and auxiliaries including technical data sheets, wiring diagrams, and information, such as telephone number, fax number, and web sites, for ordering replacement parts.
- 2. Two weeks prior to the final inspection, submit four copies of the updated maintenance and operating manual to the Resident Engineer:
 - 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 items 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. Complete lists of spare parts and special tools recommended for two years of normal operation of the complete system.
- D. Certifications:
- 1. Prior to fabrication of the engine-generator set, submit the following for approval, to the COTR:
 - a. A certification in writing that a diesel engine of the same model and configuration, with the same bore, stroke, number of cylinders, and equal or higher BMEP and RPM ratings as the proposed diesel engine has been operating satisfactorily, with connected loads of not less than 75 percent of the specified KW/KVA rating, for not less 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 auxiliary electrical power system during operation of the diesel engine-generator set at speeds other than the rated RPM while performing maintenance. Include thorough descriptions with submittal of any precautions, which will be necessary to protect the voltage regulator and other components of the system during operation of the diesel engine-generator set at speeds other than the rated RPM.
 - 2. Prior to installation of the engine-generator set at the job site, submit four copies of the following to the COTR:
 - a. Certified test data, alternator temperature rise test and strip chart recordings, and photographs showing test setup and equipment.
 - 3. Two weeks prior to the final inspection, submit four copies of the following, to the COTR:
 - a. Certified test report by the manufacturer of the engine-generator set that the auxiliary electrical power system conforms to the requirements of the drawings and specifications.
 - b. Certified report of field tests from the contractor that the engine-generator set and major auxiliaries have been properly installed, adjusted and tested.

1.5 STORAGE AND HANDLING

- A. Equipment shall withstand the mechanical stresses caused by rough handling during shipment 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 Resident Engineer.

1.6 JOB CONDITIONS

- A. Shall conform to the arrangements and details shown on the drawings. The dimensions, enclosures and arrangements of the engine-generator set shall permit the operating personnel to safely and conveniently operate and maintain the system in the space designated for installation.
- B. Unless specified otherwise, each component of the engine-generator system shall be capable of operating as specified herein at 334 meters (1000 feet) above sea level in a ventilated room which will have average ambient air temperatures ranging from a minimum of -15 degrees C (-5 degrees F) in winter to maximum of 49 degrees C (120 degrees F) in summer.

1.7 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
- C. American Society of Testing Materials (ASTM):
- A53/A53M-04.....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)
- D. Institute of Electrical and Electronic Engineers (IEEE):
- C37.13-95.....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):
- AB 1-02.....Molded Case Circuit Breakers and Molded Case Switches and Circuit Breaker Enclosures
- ICS 6-01.....Industrial Control and Systems: Enclosures
- ICS 4-05.....Terminal Blocks,
- MG 1-04.....Motor and Generators
- MG 2-01.....Safety Standard and Guide for Selection, Installation and use of Electric Motors and Generators

- PB 2-01.....Dead-Front Distribution Switchboards
- SG 3-95.....Low Voltage Power Circuit Breakers-Power
Switching Equipment
- SG 5-95.....Power Switchgear Assemblies
- 250-03.....Enclosures for Electrical Equipment (1000 Volts
Maximum)
- F. National Electrical Testing Association (NETA):
 - ATS-95.....Electrical Power Distribution Equipment and
Systems
- G. National Fire Protection Association (NFPA):
 - 30-03.....Flammable and Combustible Liquids Code.
 - 37-02.....Installations and Use of Stationary Combustion
Engine and Gas Turbines
 - 70-05.....National Electrical Code (NEC)
 - 99-05.....Health Care Facilities
 - 110-05.....Standard for Emergency and Standby Power
Systems.
- H. Underwriters Laboratories, Inc. (UL):
 - 50-03.....Enclosures for Electrical Equipment
 - 142-02.....Steel Aboveground Tanks for Flammable and
Combustible liquids
 - 2085-95.....Insulated Aboveground Tanks for Flammable and
Combustible Liquids
 - 2200-04.....Stationary Engine Generator Assemblies
 - 1236-02.....Battery Charges for Charging Engine-Starter
Batteries
 - 467-04.....Grounding and Bonding Equipment.
 - 489-04.....Molded-Case Circuit Breakers, Molded-Case
Switches and Circuit-Breaker Enclosures
 - 508-05.....Industrial Control Equipment
 - 891-03.....Dead-Front Switchboards

PART 2 - PRODUCTS

2.1 DIESEL ENGINE-GENERATOR SET

- A. The engine generator system shall be in accordance with NFPA, UL, NEMA and ANSI, and as specified and as shown on the drawings.
- B. Provide a factory-assembled, wired, (except for the field connections), complete, fully automatic diesel engine-generator system.
- C. Published Rating:
 - 1. Shall be not less than the KW/KVA rating and voltage indicated on the drawings, Standby 3-phase, 4-wire, 60 Hz and 0.80 power factor.

- 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. Coordinate the components of the system and their arrangements, electrically and mechanically.
- G. Connections between components of the system shall conform to the recommendations of the manufacturer of the diesel engine-generator set.
- H. 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.
- I. Generator set and cooling system shall be furnished with extended life antifreeze solution to protect the system from freezing at all times.
- J. Generator set shall have the following features:
 - 1. Factory-mounted on a common, rigid, welded, structural steel base.
 - 2. The maximum engine-generator set vibration in the horizontal, vertical, and axial directions shall be limited to 0.15mm with an overall velocity limit of 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. Automatic start, accelerate to the specified RPM and deliver the specified KW/KVA output at 60 Hz within 10 seconds after a single pole contact closes in a remote device.
 - 5. Recover rapidly from instantaneous changes between no load and the specified KW/KVA rating, and the reverse changes of load, without damage.
 - 6. Shall be capable of operating satisfactorily as specified for not less than 10,000 hours between major overhauls.
 - 7. Engine-generator set shall be statically and dynamically balanced at the factory in order to comply with the maximum vibration velocity specified in paragraph 3.1.D.

2.2 DIESEL ENGINE

- A. Coupled directly to a generator.
- B. Minimum 4-cylinders.
- C. Operating speed shall be 1800 RPM.
- D. BMEP for the diesel engine, while the engine-generator set is delivering 100 percent of its specified output, shall not exceed the following maximum limits:

2100 kPa (305 psi)

- E. The minimum cubic inch displacement of the engine shall not be less than the value calculated from the following equation:

$$\text{Displacement} = \frac{\text{BHP} \times \text{K}}{\text{BMEP} \times \text{RPM}}$$

$$\text{Where BHP} = \frac{\text{Specified KW} + \text{R}}{0.746 \times \text{G}}$$

K = 396,000 for 2-cycle engines

K = 792,000 for 4-cycle engines

BMEP = Values specified above

RPM = 1800

G = generator efficiency expressed as a decimal

R = horsepower of radiator fan

R = 0, when electric motor driven radiator fan is herein specified

- F. The engine shall be able to start in a 4.5 degrees C (40 degrees F) ambient temperature while using No. 2 diesel fuel oil without the use of starting aids such as glow plugs and ether injections.
- G. Fuel oil consumption of the engine rate shall not exceed 0.44, for generator sets rated 500 KW or less and 0.40 for sets rated greater than 500 kW, pounds of fuel oil per BHP per hour when it delivers 100 percent of its specified KW/KVA rating.
- H. Equipped with electric heaters for maintaining the engine's coolant temperature in the range of 32-38 degrees C (90-100 degrees F) 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 1/3 of one percent.
- C. At 60 Hz, when load changes equal to 25 percent of the specified KW/KVA rating, frequency change shall not exceed two percent and it shall recover to 60 Hz within three seconds.
- D. At 60 Hz, when load changes equal to 100 percent of the specified KW/KVA rating, frequency change shall not exceed eight percent and it shall recover to 60 Hz within five seconds.
- E. 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 passing out through the skid base and terminate it with a drain valve and plug.
- F. Provide a 120-volt oil heater for exterior generator set.

2.5 FUEL OIL 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, which require cleaning or replacement, will 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 so 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. Provide redundant primary and secondary filters with three-way valve and air purge system to allow fuel filter change and filler transfer while engine is running at full load.
- B. Integral Sub-Base Fuel Tank:
 - 1. Capacity of the integral sub-base fuel tank shall be not less than: 72 hours fuel consumption based on 100% load.
 - 2. Shall be welded steel, UL approved.
 - 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.

5. Incorporate a float switch on the integral sub-base fuel tank to actuate an alarm in the engine generator control cubicle when the oil level in the tank drops below the level at which maintenance should refill the tank.
 - a. The float switch contacts, which control the low fuel main tank alarm, shall be set to activate the alarm when the liquid level in the tank reaches 1/3 of the total volume of the tank.
6. Engine supply line elevations shall be below the elevation of the injector return outlet on the engine.

2.6 ENGINE COOLING SYSTEM

- A. Liquid-cooled, closed loop, with radiator mounted on the engine generator set, as shown on the drawings.
- B. Cooling capacity shall not be less than the cooling requirements of the engine-generator set and its lubricating oil while operating continuously at 110 percent of its specified rating.
- C. Coolant shall be extended life antifreeze solution, 50 percent ethylene and 50 percent soft water, with corrosion inhibitor additive as recommended by the manufacturer
- D. Radiator core tubes material shall be as recommended by the engine manufacturer.
- E. Fan shall be driven by multiple belts from engine shaft.
- 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 by the manufacturer of the generator set, 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 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. Where turbo-charges are required, they shall be engine-mounted, driven by the engine gases, securely braced against vibration and adequately lubricated by the engine's filtered lubrication system.
 2. Exhaust Muffler:

- a. 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 set while it is delivering 110 percent 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.
- D. Exhaust Piping and Supports: Black steel pipe, ASTM A-53 standard weight with welded fittings. Spring type hangers shall support the pipe.
- E. Insulation for Exhaust Pipe and Muffler:
1. Calcium silicate minimum 75 mm (3 inches) thick.
 2. The installed insulation shall be covered with aluminum jacket 0.4 mm (0.016 inch) thick. The jacket is to be held in place by bands of (0.38 mm) (0.015 inch) thick by 15 mm (0.5 inch) wide aluminum.
 3. Insulation and jacket are not required on flexible exhaust sections.

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.

C. Batteries: 24 volt electric with the following features:

1. Batteries shall be nickel-cadmium high discharge rate type.
2. Each battery cell shall have minimum and maximum electrolyte level indicators, and flip top flame arrestor vent cap.
3. Batteries shall have connector covers for protection against external short circuits.
4. With the charger disconnected, the batteries shall have sufficient capacity so that the total system voltage does not fall below 85 percent of the nominal system voltage with the following demands:
 - a. 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).
5. Battery racks shall be metal with an alkali resistant finish and thermal insulation, and secured to the floor.
6. Battery shall operate continuously for 12 hours and be able to provide the cranking power described in 2.8.B.3 without charging.

D. Battery Charger:

1. The charger shall maintain one percent voltage regulation from no load to full load for line voltage variation of 10 percent and frequency variation of ± 3 Hz from 60 Hz.
2. The charger shall maintain a nominal float voltage of 1.4 vdc and a nominal equalizing voltage of 1.6 vdc.
3. The charger shall be capable of continuous operation in an ambient temperature of -20 to 60 degrees C (-30 to 104 degrees F) without derating. The charger shall be convection cooled and housed in a NEMA 250, Type 1 enclosure. The charger shall have a hinged front door and all components shall be accessible from the front.
4. Provide both AC and DC transient protection. Charger shall be able to recharge a fully discharged battery without tripping AC protective devices. AC circuit breaker shall not trip under any DC load condition including short circuit on output terminals.
5. The charger shall be capable of recharging the fully discharged battery in 12 hours and simultaneously power the Supervisory and Control panel.
6. The charger shall have fused AC input and DC output protection, and shall not discharge the batteries when AC power fails.
7. The charger shall have the following accessories:

- a. On-Off control switch with pilot light.
- b. Hand adjustable 0 to 24 hour equalize charge timer.
- c. AC power failure alarm light.
- d. High DC voltage alarm light.
- e. DC voltmeter - 5 percent accuracy.
- f. DC Ammeter - 5 percent accuracy.

2.9 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 at the construction site.
- C. Integral poles and spider, or individual poles dove-tailed to the spider.
- D. Insulation shall be as required for the ambient temperature and other requirements designated in the paragraph, DIESEL ENGINE-GENERATOR SET, in this section.
- E. Designed for sustained short circuit currents in conformance with NEMA Standards.
- F. Designed for sustained operation at 125 percent of the RPM specified for the generator set without damage.
- G. Telephone influence factor shall conform to NEMA Standards.
- H. Furnished with brushless excitation system or static-exciter-regulator assembly.
- I. 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.
- J. At full load, the efficiency shall be not less than:
 - 1. 89 percent for sets specified from 60 KW to 175 KW.
 - 2. 92 percent for sets specified over 175 KW.
- K. The neutral shall be electrically isolated from equipment ground and terminated in same junction box as the phase conductors.
- L. Provide a thermostatically controlled strip heater arranged to maintain starter windings above the dew point.

2.10 EQUIPMENT FOR CONTROLS, SUPERVISION AND DISTRIBUTION

- A. Shall include Engine Generator Control Cubicle(s) Remote Annunciator Panel Remote Derangement Panel, Remote Monitoring Panel, and Exercising Control Panel
 - 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. Incorporate all of the items required to fulfill the requirements in the specifications and on the drawings.
4. Components:
 - a. Shall be heavy duty, industrial type.
 - b. Electrical contacts shall be precious metal surfaced.
 - c. Only heavy duty solid-state components will be accepted.
5. Coordinate controls with the automatic transfer devices shown on the drawings, so that the systems will operate as specified.
6. Panels:
 - a. Code gauge steel; manufacturer's recommended heavy gauge steel with factory primer and light gray finish.
 - b. Doors shall be gasketed and be attached with concealed or semi-concealed hinges, and shall have a permanent means of latching in closed position.
 - c. Panels shall be wall mounted or incorporated in other equipment as indicated on the drawings or as specified.
 - d. Door locks for panels and cubicles shall have identical keying to operate from a single key.
 - e. Panel installation shall be suitable for convenient maintenance and operation. Overall heights of the cubicles shall not exceed 2.5 meters (90 inches).
7. Wiring: Insulated, rated at 600 volts, UL approved.
 - a. Install the wiring in vertical and horizontal runs, neatly harnessed.
 - b. Terminate all external wiring at heavy duty, pressure type, terminal blocks.
8. Clearly and permanently label the equipment, wiring terminals and wires.
9. Laminate or mount under plexiglas appropriate wiring diagrams and mount them within the frame on the inside of the cubicles and panels.
10. The system shall be designed and manufactured employing the most modern technology to insure maximum reliability and longevity. It shall be arranged for automatic and manual starting, and stopping.
11. All indicating lamps and switches shall be accessible and mounted on the cubicle doors.
12. The repetitive accuracy of the monitors shall be as stated over an environmental temperature range of 0 to 45 degrees C (32 to 113 degrees F) and voltage range of 70 to 110 percent of nominal. The accuracy shall not exceed the following limits:

Voltage Monitors	+ 2 percent of set point
Current Monitors	+ 3 percent of set point
Frequency Monitors	+ 0.2 Hz.
Power Monitors	+ 3 percent of set point

13. The manufacturer shall coordinate the interfacing of the control systems with all related equipment supplied in accordance with other sections of the project specification.

B. 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 pushbutton 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 percent 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, 0 to 15 minute range, shall cause the engine generator set 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 set shall stop.
- d. Selector switch in "OFF" position shall prevent the engine from starting either automatically or manually. Selector switch in "MANUAL" position shall cause the engine to start when the manual start pushbutton is also depressed momentarily.
- e. With selector switch in "MANUAL" position, depressing the "MANUAL STOP" pushbutton momentarily shall stop the engine after a cool down period.
- f. A maintained contact, red mushroom head pushbutton switch marked "EMERGENCY STOP" will cause the engine to stop without a cool down period independent of the position of the selector switch.

2. Engine Cranking Controls:

- a. The cranking cycles shall be controlled by timer that will be independent of the battery voltage fluctuations.

- b. 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 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) Difference between the first and second stage temperature settings shall be approximately -12 degrees C (10 degrees F).
 - 4) Permanently indicate the temperature settings near the associated signal light.
 - 5) When the coolant temperature drops to below 21 degrees C (70 degrees F), 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) Difference between the first and second stage pressure settings shall be approximately 15 percent of the oil pressure.
- 4) Permanently indicate the pressure settings near the associated signal light.

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 - Main Storage Tank:

- 1) When the fuel oil level in the storage tank decreases to less than 1/3 of total tank capacity, the "LOW FUEL-MAIN STORAGE TANK" signal light and audible alarm shall be energized.

g. 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 pushbutton 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 Resident Engineer. The audible alarm shall be rated for 85 dB at 3 meter (10 feet).

h. Generator Breaker Signal Light:

- 1) Molded case circuit breaker and contactor: A flashing green light shall be energized when the generator circuit breaker is in either 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 less than a 9,999 hour, heavy duty and an electric type tachometer.
 - c. Voltmeter, ammeter, and their selector switches, 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 - MAIN STORAGE TANK
 - f. Lamp Test: "Lamp Test" momentary contact switch shall momentarily actuate the alarm buzzer and all the indicating lamps.
5. Power switching and overcurrent protection shall be accomplished with molded case circuit breakers.
- a. Molded Case Circuit Breakers shall have the following features:
 - 1) Solid state adjustable trip type circuit breakers.
 - 2) Shall be in accordance with UL 489 and NEMA AB-1.
 - 3) Trip units shall have field adjustable tripping characteristics as follows:
 - a) Ampere setting (continuous).
 - b) Long time band.
 - c) Short time trip point.
 - d) Short time delay.
 - e) Instantaneous trip point.
 - f) Ground fault system for circuit breakers rated 480 volt, equal to or greater than 1000 amperes. The system shall alarm but not trip the circuit breaker.
 - 4) Trip setting shall be as shown on the electrical system protective device study.

- 5) Shall be 100 percent rated.
 - 6) Electrically and mechanically trip free.
 - 7) Manual operating handle with lock-open padlocking provisions, and position indicators on the front of the breaker.
 - 8) Rear stud connection for both line and load sides.
 - 9) Shall include type "a" and "b" auxiliary contacts for interfacing with controls.
6. Automatic Voltage Regulator:
- a. Shall maintain the generator's output voltage within plus or minus one percent for load variations between no load and full load.
 - b. Shall correct voltage fluctuations rapidly and restore the output voltage to the predetermined level with a minimum amount of hunting.
 - c. Shall include voltage level rheostat located inside the control cubicle.
 - d. Provide a 3-phase automatic voltage regulator immune to waveform distortion.
7. Governor: Specified herein before in Article 2.3 "GOVERNOR".
8. The voltage regulator and other components of the auxiliary electrical power system shall be protected during operation of the diesel engine-generator set at speeds other than the rated RPM while performing maintenance by a power monitoring system which monitors single phase and three phase faults. A time-delay relay shall shut down the engine when the alternator thermal capacity is exceeded.

2.11 REMOTE ANNUNCIATOR PANEL

- A. Remote annunciator panel shall be installed in the essential system electrical room for each building served by the generator and other locations as indicated on the drawings.
- B. The annunciator shall indicate alarm conditions of the emergency or auxiliary power source as follows:
1. Individual visual signals shall indicate:
 - a. Which generator is operating to supply power to load.
 - b. Which battery charger is malfunctioning.
 - c. When main storage tank is low.
 2. Individual visual signals plus a common audible alarm shall warn of the following:
 - a. "LOW LUBRICATING OIL PRESSURE - FIRST STAGE."
 - b. "LOW COOLANT."
 - c. "EXCESSIVE COOLANT TEMPERATURE - FIRST STAGE."
 - d. LOW FUEL - MAIN TANK."

- e. "OVERCRANK" (failure to start).
 - f. "OVERSPEED."
 - g. All other remote indicating devices and controls required by NFPA 99 and NFPA 110 for a Level 1 system.
- C. The annunciator shall also have the following features:
- 1. One pushbutton momentary contact switch. Label switch "LAMP - TEST". Initiating this switch shall momentarily actuate the alarm buzzer and all the indicating lamps.
 - 2. Audible Alarm: There shall be an audible alarm, rated for 85 dB at 10 feet, which shall become actuated whenever an alarm condition occurs. A momentary-contact acknowledge pushbutton shall silence the audible alarm, but not clear the alarm lamp. Elimination of the alarm condition shall automatically release the seal-in circuit for the audible alarm and extinguish the alarm lamp.

2.12 REMOTE DERANGEMENT PANEL

- A. Incorporate an engine running light (red), trouble light (amber), generator breaker open or tripped (green flashing) and buzzer with a momentary-contact silencing switch or pushbutton on a suitable NEMA Standard metal enclosure.
- B. Install circuits between this remote panel and the Local Engine-Generator Control Cubicle.
- C. The light and buzzer shall be energized whenever a trouble light and audible alarm is energized at the Engine-Generator Control cubicle.
- D. Install two panels, one each in the twenty-four hour a day manned locations in the boiler plant (Building 16) and the chiller plant (Building 107). Provide new conductors and extend conduits as necessary for a fully functioning alarm. Existing conductors for the demolished generator may be re-used if they are suitable for the application and in good condition.
- E. Permanently attach an identification sign to the enclosure. The sign "AUXILIARY ELECTRICAL POWER SYSTEM" shall be laminated black phenolic resin with a white core and engraved lettering not less than 4.7 mm (3/16 in high).

2.13 REMOTE MONITORING PANEL

- A. Shall have duplicates of the voltmeter, ammeter, and voltmeter and ammeter selector switches, engine running light (red) and shall be located at the Engineering Control Center. Install circuits between the Remote Monitoring panel and the Engine-Generator Control Cubicle. Provide in the essential system electrical room served by the generator or as directed by the COTR.

2.14 EXERCISING CONTROL PANEL

- A. Incorporate exercising controls so as to allow testing of each remotely located transfer switch from the Engine-Generator Enclosure.
 - 1. For each transfer switch, incorporate red and green lamps, indicating the position of the transfer switch.
 - 2. For each transfer switch, incorporate a two position contact switch. Label switch position: "Test and "Automatic". The "Test" position shall simulate an outage of normal power at the transfer switch. The "Automatic" position shall place the transfer switch in normal operation.

2.15 REMOTE EMERGENCY STOP

- A. Provide remote manual stop station with break glass or approved equal means to prevent inadvertent operation in accordance with NFPA 110 5.6.5.6. Locate in nearest mechanical or electrical room inside the building adjacent to the generator set as or as indicated on the drawings. Locate nearest to entrance of the room from the building's exterior. Provide permanent sign in accordance with section 260511 EQUIPMENT IDENTIFICATION indicating "GENERATOR EMERGENCY STOP" at remote stop location.

2.16 SOUND ATTENUATED ENCLOSURE

- A. The emergency generator set and related equipment shall be housed in an outdoor weatherproof enclosure. The generator will function properly without overheating in the ambient conditions specified. Enclosure shall be walk-in type and sound attenuated (maximum 85 dBA at 1.525 m (5 feet) from any side, top and bottom to no more than 75 dBA when measured at 15 meters (50 feet) horizontally from any part of the enclosure or appendage on the enclosure). Sound ratings shall be based on full load condition of engine/generator in a single unit operation condition. Airflow configuration of the unit will be intake through rear of unit and discharge air vertically up. Enclosure shall be suitable for winds up to 193 kmh (120 mph); roof load shall be equal to or greater than 200 kg/sq m (40 lbs per sq. ft). Non-distributed loading as required.
- B. The enclosure shall meet the following requirements:
 - 1. The exterior finish shall be guaranteed for a period of 10 years to be free from any defects when properly maintained.
 - 2. Enclosure shall be of sufficient size allowing for code clearances and proper servicing isles without removal or opening of enclosure panels.

3. Radiator exhaust outlet shall be ducted through the end of the enclosure.
4. All exterior surfaces shall be factory painted with industrial enamel. Finish shall be dark bronze.
5. Unit shall have sufficient guards to prevent entrance by small animals.
6. Batteries to fit inside enclosure and along side the engine provide protective shield. (Batteries under the generator are not acceptable.)
7. Exhaust System: The silencer shall be critical grade, mounted and thermally insulated inside the enclosure. Insulation shall be provided for the silencer, flex and all discharge piping. The weight of the silencer shall not be supported by engine. The exhaust pipe size shall be sufficient to insure that exhaust backpressure does not exceed the maximum limitations specified by the engine manufacturer. The exhaust silencer outlet roof penetration shall be sealed to prevent the entrance of rain, snow and sleet. A stainless steel bellowed flex shall be provided.
8. The weather protected enclosure shall be of formed steel construction, and modular in that the side panels and doors shall not exceed 36" in width and shall be a minimum thickness of 14 gauge for all component parts. The roof of the enclosure shall meet or exceed the minimum gauge requirements specified but, in addition, shall be strengthened in such a manner as to support the largest commercially available exhaust silencer recommended by the engine manufacturer for this application.
9. All doors on the enclosure shall be strategically located in areas as to allow ease of maintenance on the generator set and allow access to and visibility of instruments, controls and engine gauges. The doors shall be fitted with bolt-on, stainless steel constructed strap type hinges. Each door shall be fitted with padlock cable latches.
10. All louvers shall have sufficient free area to allow for 120% of the total engine/generator cooling air requirements. Louvers shall be of all galvanized construction and shall have motorized dampers as specified herein before in Article 2.6 "Engine Cooling System".
11. The entire enclosure, except for the louvered opening, shall have sound attenuation material mechanically attached to the interior surfaces of the unit. Sound absorbing material shall be held in place by a perforated mill finish galvanized liner to form a removable section easily inspected by maintenance personnel. The sound attenuation material and fastening system shall apply to the

enclosure roof as well as side panels and doors as required to achieve sound ratings specified herein.

12. All wiring within the enclosure shall be in conduits made from Rigid Metal, EMT, IMC, or liquid-tight, flexible metal conduit as specified in Section 26 05 33 RACEWAYS AND BOXES FOR ELECTRICAL SYSTEMS. All connections at the generator set shall be flexible, and shall be furnished and installed by the enclosure manufacturer. The lights and receptacles shall be circuited to the Life Safety branch of the emergency system with a homerun in a dedicated 230 mm (3/4 in.) conduit from the generator enclosure to the Life Safety branch panel inside the building.
13. Provide two, forty-eight inch, dual 32W T8 lamped fluorescent luminaires with wet location enclosure within the enclosure located on either side of the generator set. They shall be ceiling mounted and perpendicular to the length of the unit. Provide a minimum of two self-contained emergency luminaires that provide ninety (90) minutes of illumination when the power is interrupted with an initial output of 1400 lumens. One luminaire shall be provided on each side of the long axis of the engine-generator. The AC lighting shall have three-way switching installed at entrances on either end of the enclosure. Provide an unswitched GFCI receptacle adjacent to each switch. The lights and receptacles shall be circuited to the Life Safety branch of the emergency system with a homerun in a dedicated 230 mm (3/4 in.) conduit from the generator enclosure to the Life Safety branch panel inside the building. These luminaires and receptacles shall not be circuited to the enclosure's panel which is not circuited to the life safety. branch.
14. The enclosure shall be equipped with a panelboard as a single entry point for supply conduits and wiring for the battery charger, jacket water heater(s), and all other generator accessories, as specified herein in 26 24 16 PANELBOARDS and as shown on the drawings. A load center will not be accepted as a substitute for a panelboard in compliance with 26 24 16. The panelboard shall be mounted within the enclosure and allow for site condition conduit entry. The placement of this load center shall be shown on the submittal drawings. All internal wiring and conduit runs to the ancillary equipment supplied with the package shall be pre-wired at the factory in accordance with NFPA 70.
15. All necessary fittings, hoses, shut-off valves, etc., shall be provided by the enclosure manufacturer to facilitate lube oil and water drain at the exterior of the enclosure. In addition,

- engines equipped with crankcase breather tubes shall have this tube terminate at the exterior of the enclosure.
16. The floor of the enclosure shall be designed and constructed in such a manner as to prevent the entrance of rodents. This shall be accomplished with solid metal or "diamond plate", capable of fully supporting any ancillary equipment specified with will be secured to it plus the anticipated weight of maintenance personnel and their tools. Under no circumstances shall the floor area or any of its parts be utilized for cooling air intake or discharge for the generator set or its associated equipment, nor shall its properties as a "heat sink" or heat dissipating medium be utilized in any manner whatsoever in this application.
 17. Base & Mounting: The generator set and enclosure shall be mounted and shipped to the engine dealer on the structural steel sub-base. Provisions for crane unloading of the complete package shall be designed into the base of the unit.
 18. The base and enclosure assembly shall allow room within the package to mount and maintain the specified battery charger, engine starting batteries, racks and cables, generator circuit breaker, engine-generator control panel, and other items as specified herein or as shown on the drawings.
 19. The weight of the entire unit consisting of generator set, base, enclosure, and other specified items including all liquids (i.e. fuel oil, lube oil and cooling solutions) shall be calculated by the engine dealer utilizing manufacturer's data. The base of the unit shall be designed and manufactured as a heavy duty, structural steel construction with four point lifting provisions to support the calculated weight. Details and manufacturer's certification of the base construction shall be included with the drawings submitted for approval as well as all dealer weight calculations supported by manufacturer's data.
 20. Fuel Tank: The unit shall be equipped with a UL142 labeled in-base fuel tank of capacity specified herein before in Article 2.5 "Fuel Oil System" and shall be supplied with a low fuel level alarm float switch, a high fuel level alarm switch and a lockable fill cap. The normal fuel tank vents shall be extended through the roof of the enclosure and terminate with a vent cap at a point that measures at least 12-feet above grade. The emergency vent shall be located inside the enclosure at terminated with a spring load pressure release vent cap. All necessary fuel lines for proper engine performance shall be provided as well as a means to readily detect

the fuel level in the tank without the use of a measuring stick. The unit shall be equipped with a fuel containment basin with a normal capacity of 120% of the fuel tank and shall be supplied with a leakage detector float switch in the basin.

21. An interior mounted low profile, internally insulated exhaust silencer and flexible, stainless steel exhaust bellows properly sized shall be furnished and installed according to the manufacturer's recommendations by the enclosure manufacturer. The silencer shall be mounted such that its weight is not supported by the engine nor will exhaust system growth due to thermal expansion be imposed on the engine. Exhaust pipe sizes shall be sufficient to ensure that exhaust back pressure does not exceed the maximum limitations specified by the engine manufacturer. Insulation blankets shall be provided for the stainless steel flex and exhaust elbow assemblies located inside the enclosure. At the point where the exhaust pipe penetrates the roof of the enclosure, a suitable "rain skirt" and collar shall be provided by the enclosure manufacturer. It shall be designed to prevent the entrance of rain while allowing for expansion and vibration of the exhaust piping without chafing or stress to the exhaust system.
22. A battery tray shall be provided for the engine starting batteries and shall conform to NFPA 70 (NEC) 480.8(B). It shall be constructed and so treated as to be resistant to deterioration by battery electrolyte. Construction shall be such that any spillage or boil-over of battery electrolyte shall be contained within the tray to prevent a direct path to ground.
23. Provide thermostatically controlled electric heat for the enclosure that maintains a minimum temperature of 16°C (60°F) inside the enclosure when the temperature outside the enclosure is minus 21°C (minus 5°F). Heat shall be disabled whenever the engine is running.
24. Provide thermostatically controlled exhaust fan with CFM sufficient to limit the temperature rise inside the enclosure to 5.5 degrees C (10 degrees F) above ambient. Thermostat shall close contacts at 30 degrees C (86 degrees F). Provide motor starter with H-O-A switch adjacent to the wall-mounted thermostat for three phase fans. Fan shall be circuited to the accessory load center. Fan shall be disabled whenever the engine is running.
25. There shall be a minimum 900 mm (3'-0") clear floor space around the three sides other than the radiator of the engine-generator in accordance with NFPA 110 7.2.5. Electrical components shall have minimum clearances in accordance with NFPA 70 (NEC) 110.26 for

generators less than 600 V and 110.34(A) for generators greater than 600 V. The minimum clearances shall be 1.2 m (4'-0") for all major electrical components and 1.5 m (5'-0") for all components greater than 600 V, or the code minimum clearance, whichever is greater. All required clearances shall be provided within the enclosure with the doors shut and shall not utilize space to the exterior of the enclosure that is only available with panels removed or doors opened.

2.16 SPARE PARTS

- A. For each engine-generator set:
 - 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:
 - 1. Three complete sets of fuses.
 - 2. One complete set of indicating lamps.
- C. For each control and supervisory panel:
 - 1. Three complete sets of fuses.
 - 2. One complete set of indicating lamps.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Install concrete bases of dimensions shown on the drawings for packaged engine-generator sets.
- B. Installation of the engine generator set shall comply with manufacturer's written instructions and with NFPA 110.
- C. Mounting
 - 1. Support the base of engine-generator set on vibration isolators, each isolator bolted to the floor (pad), generator base bolted to isolator.
 - 2. Install sufficient number of 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 set's base.
 - 4. Locate isolators for approximately equal load distribution and deflection per isolator. Base of the engine-generator set shall be drilled at the factory for the isolator bolts.
 - 5. Isolators shall be shipped loose with the engine-generator set.

6. All connections between the engine-generator set and exterior systems, such as fuel lines, electrical connections, and engine exhaust system and air exhaust shroud, shall be flexible.

D. Balance:

1. The vibration velocity in the horizontal, vertical, and axial directions shall not exceed 16.25 mm (0.65 inch) 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.
2. Balance the engine-generator set statically and dynamically at the factory in order to comply with the maximum specified vibration velocity.

- E. Connect all components of the essential electrical power system so that they will continue to be energized by the auxiliary electrical power system during failures of the normal electrical power supply system.

3.2 START UP AND TESTING

- A. Provide the services of a factory-authorized, factory-trained representative of the diesel engine-generator set manufacturer to inspect field-assembled components, and equipment installation and supervise the field tests
- B. When the complete auxiliary electrical power system has been installed and prior to the final inspection, tests all components of the system in the presence of the Resident Engineer 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 diesel engine-generator set.
- D. Field Tests for the Diesel Engine-Generator Set:
 1. Test the engine generator set for eight hours of continuous operation as follows:
 - a. First six hours while the set is delivering 100 percent of its specified KW rating.
 - b. Last two hours while the set is delivering 110 percent 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 until the satisfactory results are attained at no additional cost to the government.
 2. Record the following test data at 30-minute intervals:

- a. Time of day, also 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 diesel engine.
 - l. Average ambient temperature in the vicinity of the starting batteries.
3. Demonstrate that the generator set will attain proper voltage, frequency and will accept 100 percent block load within 10 seconds from a cold start after the closing of a single contact.
 4. Furnish a resistance type load for the testing of the generator:
 - a. When approved in writing by the Resident Engineer prior to the testing, the Contractor may use connected loads in the building (resistant plus other types) as part of the test load provided the Contractor assumes complete responsibility for the use of the connected loads, including personnel injuries and property damage.
 - b. 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:
 - 1) Shall not be less than 110 percent of the specified KW rating of the largest generator set.
 - 2) Shall not be less than 35 percent of the sum of the specified KW ratings of the all generator sets in a paralleling system.
- E. Battery and Starting System Test:
1. Demonstrate that the batteries and cranking motor are capable of 5 starting attempts of 10 second cranking each at 10 second intervals with the battery charger turned off.
- F. Test local and remote panels: Simulate engine failures while checking for proper operation of each indicating lamp, alarm device and reset button. (It is recommended that one VA inspector be located in the generator room and another at the site of remote panels. By means of telephone or walkie-talkies, the inspectors should be assured of proper operation and coordination of these panels.)

- G. At the completion of the field tests, fill the underground storage tank with fuel of grade and quality as recommended by the manufacturer of the engine.
- H. 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 Resident Engineer, at no additional cost to the Government.
- I. Provide test and inspection results in writing to the Resident Engineer.

3.3 INSTRUCTIONS AND FINAL INSPECTIONS

- A. Laminate or mount under Plexiglas a set of operating instructions for the system and install instructions within a frame mounted on the wall near the diesel engine-generator set as requested by the Resident Engineer.
- B. At the final inspection in the presence of a VA representative, demonstrate that the complete auxiliary electrical power system operates properly in every respect.
- C. Furnish the services of a competent, factory-trained engineer or technician for five, 4-hour periods for instructions to VA personnel in operation and maintenance of the equipment, on the dates requested by the Resident Engineer.

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