

JOINT BASE LEWIS-McCHORD DESIGN STANDARDS
DIVISION 26 - ELECTRICAL

SECTION 26 32 15.00

ENGINE-GENERATOR SET STATIONARY 15-2500 KW, WITH AUXILIARIES

04/2025

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

AMERICAN NATIONAL STANDARDS INSTITUTE (ANSI)

ANSI C39.1 (1981; R 1992) Requirements for Electrical Analog Indicating Instruments

ASME INTERNATIONAL (ASME)

ASME B16.11 (2016) Forged Fittings, Socket-Welding and Threaded

ASME B16.3 (2011) Malleable Iron Threaded Fittings, Classes 150 and 300

ASME B16.5 (2017) Pipe Flanges and Flanged Fittings NPS ½ Through NPS 24 Metric/Inch Standard

ASME B31.1 (2016; Errata 2016) Power Piping

ASME BPVC SEC IX (2010) BPVC Section IX-Welding and Brazing Qualifications

ASME BPVC SEC VIII D1 (2015) BPVC Section VIII-Rules for Construction of Pressure Vessels Division 1

ASSOCIATION OF EDISON ILLUMINATING COMPANIES (AEIC)

AEIC CS8 (2013) Specification for Extruded Dielectric Shielded Power Cables Rated 5 Through 46 kV

ASTM INTERNATIONAL (ASTM)

ASTM A106/A106M (2014) Standard Specification for Seamless Carbon Steel Pipe for High-Temperature Service

ASTM A135/A135M (2009; R2014) Standard Specification for Electric-Resistance-Welded Steel Pipe

ASTM A181/A181M (2014) Standard Specification for Carbon Steel Forgings, for General-Purpose Piping

ASTM A234/A234M (2017) Standard Specification for Piping Fittings of Wrought Carbon Steel and Alloy Steel for Moderate and High Temperature Service

ASTM A53/A53M (2012) Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless

ASTM B395/B395M (2013) Standard Specification for U-Bend Seamless Copper and Copper Alloy Heat Exchanger and Condenser Tubes

ASTM D975 (2017a) Standard Specification for Diesel Fuel Oils

ELECTRICAL GENERATING SYSTEMS ASSOCIATION (EGSA)

EGSA 101P (1995) Performance Standard for Engine Driven Generator Sets

INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS (IEEE)

IEEE 1 (2000; R 2011) General Principles for Temperature Limits in the Rating of Electric Equipment and for the Evaluation of Electrical Insulation

IEEE 120 (1989; R 2007) Master Test Guide for Electrical Measurements in Power Circuits

IEEE 404 (2012) Standard for Extruded and Laminated Dielectric Shielded Cable Joints Rated 2500 V to 500,000 V

IEEE 48 (2009) Standard for Test Procedures and Requirements for Alternating-Current Cable Terminations Used on Shielded Cables Having Laminated Insulation Rated 2.5 kV through 765 kV or Extruded Insulation Rated 2.5 kV through 500 kV

IEEE 519 (2014) Recommended Practices and Requirements for Harmonic Control in Electrical Power Systems

IEEE 81 (2012) Guide for Measuring Earth Resistivity, Ground Impedance, and Earth Surface Potentials of a Ground System

IEEE C2 (2017; Errata 1-2 2017; INT 1 2017) National Electrical Safety Code

IEEE Stds Dictionary (2009) IEEE Standards Dictionary: Glossary of Terms & Definitions

MANUFACTURERS STANDARDIZATION SOCIETY OF THE VALVE AND FITTINGS INDUSTRY (MSS)

MSS SP-58 (1993; Reaffirmed 2010) Pipe Hangers and Supports - Materials, Design and Manufacture, Selection, Application, and Installation

MSS SP-80 (2013) Bronze Gate, Globe, Angle and Check Valves

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)

NEMA ICS 2 (2000; R 2005; Errata 2008) Industrial Control and systems Controllers, Contactors, and Overload Relays Rated 600 V

NEMA ICS 6 (1993; R 2016) Industrial Control and Systems: Enclosures

NEMA MG 1 (2016; SUPP 2016) Motors and Generators

NEMA PB 1 (2011) Panelboards

NEMA WC 74/ICEA S-93-639 (2012) 5-46 kV Shielded Power Cable for Use in the Transmission and Distribution of Electric Energy

NEMA/ANSI C12.11 (2007) Instrument Transformers for Revenue Metering, 10 kV BIL through 350 kV BIL (0.6 kV NSV through 69 kV NSV)

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 110 (2016) Standard for Emergency and Standby Power Systems

NFPA 30 (2015; ERTA 1 2016) Flammable and Combustible Liquids Code

NFPA 37 (2018) Standard for the Installation and Use of Stationary Combustion Engines and Gas Turbines

NFPA 70 (2017; ERTA 1-2 2017; TIA 17-1; TIA 17-2; TIA 17-3; TIA 17-4; TIA 17-5; TIA 17-6; TIA 17-7; TIA 17-8; TIA 17-9; TIA 17-10; TIA 17-11; TIA 17-12; TIA 17-13; TIA 17-14) National Electrical Code

NFPA 99 (2018; TIA 18-1) Health Care Facilities Code

SOCIETY OF AUTOMOTIVE ENGINEERS INTERNATIONAL (SAE)

SAE ARP892 (1965; R 1994) DC Starter-Generator, Engine

SAE J537 (2016) Storage Batteries

U.S. DEPARTMENT OF DEFENSE (DOD)

UFC 3-310-04 (2013; with Change 1) Seismic Design for Buildings

UNDERWRITERS LAB ORATORIES (UL)

UL 1236 (2015; Reprint Mar 2016) UL Standard for Safety Battery Chargers for Charging Engine-Starter Batteries

UL 489 (2016) UL Standard for Safety Molded-Case Circuit Breakers, Molded-Case Switches and Circuit-Breaker Enclosures

UL 891 (2005; Reprint Oct 2012) Switchboards

1.2 SYSTEM DESCRIPTION

a. Provide and install each engine-generator set complete and totally functional, with all necessary ancillary equipment to include air filtration; starting system; generator controls, protection, and isolation; instrumentation; lubrication; fuel system; cooling system; and engine exhaust system. Each engine generator set shall satisfy the requirements specified in the Engine Generator Parameter Schedule. Submit certification that the engine-generator set and cooling system function properly in the ambient temperatures specified.

b. Provide each engine-generator set consisting of one engine, one generator, and one exciter, mounted, assembled, and aligned on one base; and all other necessary ancillary equipment which may be mounted separately. Sets shall be

assembled and attached to the base prior to shipping. Set components shall be environmentally suitable for the locations shown and shall be the manufacturer's standard product offered in catalogs for commercial or industrial use. Provide a generator strip heater for moisture control when the generator is not operating.

1.2.1 Engine-Generator Parameter Schedule

ENGINE GENERATOR PARAMETER SCHEDULE

Service Load	[_____] [kVA] [kW]
Power Factor	[0.8] [_____] lagging
Motor Starting kVA (maximum)	[_____] kVA
Maximum Speed	1800 rpm
Engine-Generator Application	stand-alone
Engine Cooling Type	water/ethylene glycol
Heat Exchanger Type	[fin-tube] [shell-tube]
[Governor Type]	[Isochronous]
Frequency Bandwidth percent steady state	+/- [_____] [0.4] [0.25]
[Governor Type]	[Droop]
Frequency Regulation (droop) (No load to full load)	[[3] [_____] percent max.))

ENGINE GENERATOR PARAMETER SCHEDULE

Frequency Bandwidth percent (steady state)	+/- [_____] [0.4] [0.25]
Voltage Regulation (No load to full load)	+/- 2 percent (max.)
Voltage Bandwidth (steady state)	+/- [0.5] [1] [2] percent
Frequency	[50] [60] Hz
Voltage	[_____] volts
Phases	[3 Phase, Wye] [3 Phase, Delta] [1 Phase]
Minimum Generator Reactance	[_____] percent Subtransient
Nonlinear Loads	[_____] kVA
Max Step Load Increase	[_____] [100] percent of service Load at [_____] PF
Max Step Load Decrease (w/o shutdown)	[_____] [100] percent of Service

Load at [_____] PF

Max Time to Start and be Ready to Assume Load [10] [_____] seconds

Max Summer Indoor Temp (Prior to Genset Operation) [_____] degrees CF

Min Winter Indoor Temp (Prior to Genset Operation) [_____] degrees CF

Min Winter Indoor Temp [_____] degrees CF

Max Allowable Heat Transferred To Engine Generator Space at Rated Output Capacity [_____] kWMBTUH/hrMax

Summer Outdoor Temp (Ambient) [_____] degrees CFMin

Winter Outdoor Temp (Ambient) [_____] degrees CF

Installation Elevation [_____] above sea level

1.2.2 Output Capacity

Provide each generator set with power equal to the sum of service load plus the machine's efficiency loss and associated ancillary equipment loads. Rated output capacity shall also consider engine and/or generator oversizing required to meet requirements in paragraph Engine-Generator Parameter Schedule.

1.2.3 Power Rating

Standby ratings shall be in accordance with EGSA 101P.

1.2.4 Engine Generator Set Enclosure

The engine generator set enclosure shall be corrosion resistant, fully weather resistant, contain all set components, and provide ventilation to permit operation at rated load under secured conditions. Provide doors for access to all controls and equipment requiring periodic maintenance or adjustment. Provide removable panels for access to components requiring periodic replacement. The enclosure shall be capable of being removed without disassembly of the engine-generator set or removal of components other than exhaust system. The enclosure shall reduce the noise of the generator set to within the limits specified in the paragraph SOUND LIMITATIONS.

1.2.5 Vibration Isolation

1.2.5.1 Vibration Limitations

The maximum engine-generator set vibration in the horizontal, vertical and axial directions shall be limited to 0.15 mm 6 mils (peak-peak RMS), with an overall velocity limit of 24 mm/seconds 0.95 inches/seconds RMS, for all speeds through 110 percent of rated speed. The engine-generator set shall be provided with vibration-isolation in accordance with the manufacturer's standard recommendation. Where the vibration-isolation system does not secure the base to the structure floor or unit foundation, provide seismic restraints in accordance with the seismic parameters specified.

1.2.5.2 Torsional Analysis

Submit torsional analysis including prototype testing or calculations which certify and demonstrate that no damaging or dangerous torsional vibrations will occur when the prime mover is connected to the generator, at synchronous speeds, plus/minus 10 percent.

1.2.5.3 Performance Data

Submit vibration isolation system performance data for the range of frequencies generated by the engine-generator set during operation from no load to full load and the maximum vibration transmitted to the floor. Also submit a description of seismic qualification of the engine-generator mounting, base, and vibration isolation.

1.2.6 Reliability and Durability

Submit documentation which cites engines and generators in similar service to demonstrate compliance with the requirements of this specification. Certification does not exclude annual technological improvements made by a manufacturer in the basic standard model set on which experience was obtained, provided parts interchangeability has not been substantially affected and the current standard model meets all the performance requirements of this specification. For each different set, 2 like sets shall have performed satisfactorily in a stationary power application, independent and separate from the physical location of the manufacturer's and assembler's facilities, for a minimum of 2 consecutive years without any failure to start, including periodic exercise. The certification shall state that for the set proposed to meet this specification, there were no failures resulting in downtime for repairs in excess of 72 hours or any failure due to overheating during 2 consecutive years of service. Like sets are of the same model, speed, bore, stroke, number and configuration of cylinders, and output power rating. Like generators are of the same model, speed, pitch, cooling, exciter, voltage regulator and output power rating. A list shall be provided with the name of the installations, completion dates, and name and telephone number of a point of contact.

1.3 SUBMITTALS

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for Contractor Quality Control approval. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-02 Shop Drawings

Detailed Drawings; G
Acceptance; G

SD-03 Product Data

Manufacturer's Catalog
Instructions; G
Experience
Field Engineer
Site Welding
General Installation
Site Visit

SD-05 Design Data

Sound Limitations; G
Generator

Integral Main Fuel Storage Tank
Day Tank
Power Factor
Heat Exchanger
Time-Delay on Alarms
Cooling System
Vibration Isolation

SD-06 Test Reports

Performance Tests
Onsite Inspection and Tests; G

SD-07 Certificates

Vibration Isolation
Prototype Tests
Reliability and
Durability
Emissions
Sound limitations
Current Balance
Materials and Equipment
Factory Inspection and Tests
Inspections
Cooling System

SD-10 Operation and Maintenance Data

Operation Manual; G
Maintenance Manual; G
Extra Materials

1.4 QUALITY ASSURANCE

1.4.1 Conformance to Codes and Standards

Where equipment is specified to conform to requirements of any code or standard such as UL, the design, fabrication and installation shall conform to the code.

1.4.2 Site Welding

Weld structural members in accordance with Section 05 05 23.16 STRUCTURAL WELDING. For all other welding, qualify procedures and welders in accordance with ASME BPVC SEC IX.

a. Welding procedures qualified by others, and welders and welding operators qualified by a previously qualified employer may be accepted as permitted by ASME B31.1.

b. Welder qualification tests shall be performed for each welder whose qualifications are not in compliance with the referenced standards. Notify the Contracting Officer 24 hours in advance of qualification tests. The qualification tests shall be performed at the work site if practical.

c. The welder or welding operator shall apply the assigned personal symbol near each weld made as a permanent record

d. Submit a letter listing the welder qualifying procedures for each welder, complete with supporting data such as test procedures used, what was tested to, and a list of the names of all welders and their qualifications symbols.

1.4.3 Experience

Each component manufacturer shall have a minimum of 3 years' experience in the manufacture, assembly and sale of components used with stationary diesel engine-generator sets for commercial and industrial use. The engine-generator set manufacturer/assembler shall have a minimum of 3 years' experience in the manufacture, assembly and sale of stationary diesel engine-generator sets for commercial and industrial use. Submit a statement showing and verifying these requirements.

1.4.4 Field Engineer

The engine-generator set manufacturer or assembler shall furnish a qualified field engineer to supervise the complete installation of the engine-generator set, assist in the performance of the onsite tests, and instruct personnel as to the operational and maintenance features of the equipment. The field engineer shall have attended the engine-generator manufacturer's training courses on installation and operation and maintenance for engine generator sets. Submit a letter listing the qualifications, schools, formal training, and experience of the field engineer.

1.4.5 Seismic Requirements

Seismic requirements shall be in accordance with UFC 3-310-04 and Sections 13 48 00 [SEISMIC] BRACING FOR MISCELLANEOUS EQUIPMENT, 23 05 48.19 [SEISMIC] BRACING FOR HVAC and 26 05 48.00 10 SEISMIC PROTECTION FOR ELECTRICAL EQUIPMENT.

1.4.6 Detailed Drawings

Submit detailed drawings showing the following:

- a. Base-mounted equipment, complete with base and attachments including anchor bolt template and recommended clearances for maintenance and operation.
- b. Starting system.
- c. Fuel system.
- d. Cooling system.
- e. Exhaust system.
- f. Electric wiring of relays, breakers, programmable controllers, and switches including single line and wiring diagrams.
- g. Lubrication system, including piping, pumps, strainers, filters, heat exchangers for lube oil and turbocharger cooling, electric heater, controls and wiring.
- h. Location, type, and description of vibration isolation devices.
- i. The safety system, including wiring schematics.
- j. One-line schematic and wiring diagrams of the generator, exciter, regulator, governor, and all instrumentation.
- k. Panel layouts.
- l. Mounting and support for each panel and major piece of electrical equipment.
- m. Engine-generator set rigging points and lifting instructions

1.5 DELIVERY, STORAGE AND HANDLING

Properly protect materials and equipment in accordance with the manufacturers recommended storage procedures, before, during, and after installation. Protect stored items from the weather and contamination. During installation,

pipings and similar openings shall be capped to keep out dirt and other foreign matter.

1.6 MAINTENANCE SERVICE

Submit the operation and maintenance manuals and have them approved prior to commencing on site tests.

1.6.1 Operation Manual

Provide three copies of the manufacturer's standard operation Manual. Sections shall be separated by heavy plastic dividers with tabs which identify the material in the section. Drawings shall be folded blue lines, with the title block visible, and placed in 216 by 279 mm 8-1/2 by 11 inch plastic pockets with reinforced holes. The manual shall include:

- a. Step-by-step procedures for system startup, operation, and shutdown;
- b. Drawings, diagrams, and single-line schematics to illustrate and define the electrical, mechanical, and hydraulic systems with their controls, alarms, and safety systems;
- c. Procedures for interface and interaction with related systems to include automatic transfer switches [fire alarm/suppression systems] [load shedding systems] [uninterruptible power supplies] [___].

1.6.2 Maintenance Manual

Provide three copies of the manufacturer's standard maintenance Manual. Each section shall be separated by a heavy plastic divider with tabs. Drawings shall be folded, with the title block visible, and placed in plastic pockets with reinforced holes. The manual shall include:

- a. Procedures for each routine maintenance item. Procedures for troubleshooting. Factory-service, take-down overhaul, and repair service manuals, with parts lists.
- b. The manufacturer's recommended maintenance schedule.
- c. A component list which includes the manufacturer's name, address, type or style, model or serial number, rating, and catalog number for the major components listed in paragraph GENERAL REQUIREMENTS.
- d. A list of spare parts for each piece of equipment and a complete list of materials and supplies needed for operation.

1.6.3 Extra Materials

Provide two sets of special tools and two sets of filters required for maintenance. Special tools are those that only the manufacturer provides, for special purposes, or to reach otherwise inaccessible parts. One handset shall be provided for each electronic governor when required to indicate and/or change governor response settings. Supply two complete sets of filters in a suitable storage box in addition to filters replaced after testing.

PART 2 PRODUCTS

2.1 NAMEPLATES

Each major component of this specification shall have the manufacturer's name, type or style, model or serial number, and rating number on a plate secured to the equipment. As a minimum, nameplates shall be provided for: Engines; Relays; Generators; Day tanks; Transformers (CT & PT); Regulators; Pumps and pump motors; Governors; Generator Breaker; Economizers; Heat exchangers (other than base-mounted). Where the following equipment is provided as a standard component by the diesel-engine generator set manufacturer, the name plate information may be provided in the maintenance manual in lieu of name plates.

Battery charger	Heaters
Exhaust mufflers	Exciters
Switchgear	Silencers
Battery	

2.2 SAFETY DEVICES

Exposed moving parts, parts that produce high operating temperatures, parts which may be electrically energized, and parts that may be a hazard to operating personnel during normal operation shall be insulated, fully enclosed, guarded, or fitted with other types of safety devices. The safety devices shall be installed so that proper operation of the equipment is not impaired.

2.3 MATERIALS AND EQUIPMENT

Materials and equipment shall be as specified. Submit a letter certifying that where materials or equipment are specified to comply with requirements of UL, or other standards, written proof of such compliance has been obtained. The label or listing of the specified agency, or a written certificate from an approved, nationally recognized testing organization equipped to perform such services, stating that the items have been tested and conform to the requirements and testing methods of the specified agency are acceptable as proof.

2.3.1 Circuit Breakers, Low Voltage

UL 489 and UL 489.

2.3.2 Filter Elements (Fuel-oil, Lubricating-oil, and Combustion-air)

Manufacturer's standard.

2.3.3 Instrument Transformers

NEMA/ANSI C12.11.

2.3.4 Pipe (Fuel/Lube-oil, Compressed-Air, Coolant and Exhaust)

ASTM A53/A53M, ASTM A106/A106M or ASTM A135/A135M, steel pipe. Pipe smaller than 50 mm 2 inches shall be Schedule 80. Pipe 50 mm 2 inches and larger shall be Schedule 40.

2.3.5 Pipe Flanges and Fittings

2.3.5.1 Pipe Flanges and Flanged Fittings

ASTM A181/A181M, Class 60, or ASME B16.5, Grade 1, Class 150.

2.3.5.2 Pipe Welding Fittings

ASTM A234/A234M, Grade WPB or WPC, Class 150, or ASME B16.11, 1360.7 kg 3000 lb.

2.3.5.3 Threaded Fittings

ASME B16.3, Class 150.

2.3.5.4 Valves
MSS SP-80, Class 150.

2.3.5.5 Gaskets
Manufacturers Standard.

2.3.6 Pipe Hangers
MSS SP-58.

2.3.7 Electrical Enclosures

2.3.7.1 General
NEMA ICS 6.

2.3.7.2 Panelboards
NEMA PB.

2.3.8 Electric Motors
Electric motors shall conform to the requirements of NEMA MG 1. Motors shall have sealed ball bearings, a maximum speed of 1800 rpm and integral automatic or manual reset thermal overload protectors. Motors used indoors shall have drip proof frames; those used outside shall be totally enclosed. AC motors larger than 373 W 1/2 Hp shall be of the squirrel cage induction type for standard voltage of [[200][230][460][560] volts, 60 Hz][[240][380] volts, 50 Hz] three phase power. AC motors 373 W 1/2 Hp or smaller, shall be for standard voltage [[115][230] volts, 60 Hz,] [[110][220][240] volts, 50 Hz,] single phase power.

2.3.9 Motor Controllers
Motor controllers and starters shall conform to the requirements of NFPA 70 and NEMA ICS 2.

2.4 ENGINE

Each engine shall operate on No. 2-D diesel conforming to ASTM D975, shall be designed for stationary applications and shall be complete with ancillaries. The engine shall be a standard production model described in the manufacturer's catalog data, which describes and depicts each engine-generator set and all ancillary equipment in sufficient detail to demonstrate specification compliance. The engine shall be naturally aspirated, scavenged, supercharged or turbocharged. The engine shall be two- or four-stroke-cycle and compression-ignition type. The engine shall be vertical inline, V-, or oppose d-piston type, with a solid cast block or individually cast cylinders. The engine shall have a minimum of two cylinders. Opposed-piston type engines shall have no less than four cylinders. Each block shall have a coolant drain port. Each engine shall be equipped with an overspeed sensor.

2.5 FUEL SYSTEM

The fuel system for each engine generator set shall conform to the requirements of NFPA 30 and NFPA 37 and contain the following elements.

2.5.1 Pumps

2.5.1.1 Main Pump

Each engine shall be provided with an engine driven pump. The pump shall supply fuel at a minimum rate sufficient to provide the amount of fuel required to meet the performance indicated within the parameter schedule. The fuel flow

rate shall be based on meeting the load requirements and all necessary recirculation.

2.5.1.2 Auxiliary Fuel Pump

Auxiliary fuel pumps shall be provided to maintain the required engine fuel pressure, either required by the installation or indicated on the drawings. The auxiliary pump shall be driven by a dc electric motor powered by the starting/station batteries. The auxiliary pump shall be automatically actuated by a pressure detecting device.

2.5.2 Filter

A minimum of one full flow fuel filter shall be provided for each engine. The filter shall be readily accessible and capable of being changed without disconnecting the piping or disturbing other components. The filter shall have inlet and outlet connections plainly marked.

2.5.3 Relief/Bypass Valve

A relief/bypass valve shall be provided to regulate pressure in the fuel supply line, return excess fuel to a return line, and prevent the build-up of excessive pressure in the fuel system.

2.5.4 Integral Main Fuel Storage Tank

Each engine shall be provided with an integral main fuel tank. Each tank shall be factory installed and provided as an integral part of the diesel generator manufacturer's product.

Each tank shall be provided with connections for fuel supply line, fuel return line, local fuel fill port, gauge, vent line, and float switch assembly. A fuel return line cooler shall be provided as recommended by the manufacturer and assembler. The temperature of the fuel returning to the tank shall be below the flash point of the fuel. Each engine-generator set provided with weather proof enclosures shall have its tank mounted within the enclosure. The fuel fill line shall be accessible without opening the enclosure.

2.5.4.1 Capacity

Each tank shall have capacity to supply fuel to the engine for an uninterrupted 4-hour period at 100 percent rated load without being refilled.

2.5.4.2 Local Fuel Fill

Each local fuel fill port on the day tank shall be provided with a screw-on cap.

2.5.4.3 Fuel Level Controls

Each tank shall have a float-switch assembly to perform the following functions:

- a. Activate the "Low Fuel Level" alarm at 70 percent of the rated tank capacity.
- b. Activate the "Overfill Fuel Level" alarm at 95 percent of the rated tank capacity.

2.5.4.4 Arrangement

Integral tanks may allow gravity flow into the engine. Gravity flow tanks and any tank that allows a fuel level above the fuel injectors shall be provided with an internal or external factory installed valve located as near as possible to the shell of the tank. The valve shall close when the engine is not operating. Integral day tanks shall be provided with any necessary pumps to

supply fuel to the engine as recommended by the generator set manufacturer. The fuel supply line from the tank to the manufacturer's standard engine connection shall be welded pipe.

2.5.5 Day Tank

Provide each engine with integral day tank.

Provide each day tank with connections for fuel supply line, fuel return line, fuel overflow line, local fuel fill port, gauge, vent line, drain line, and float switch assembly for control. Provide a fuel return line cooler as recommended by the manufacturer and assembler. The temperature of the fuel returning to the day tank shall be below the flash point of the fuel. Install a temperature sensing device in the fuel supply line.

Each engine-generator set provided with weatherproof enclosures shall have its day tank mounted within the enclosure. The fuel fill line shall be accessible without opening the enclosure.

2.5.5.1 Capacity, Standby

Each day tank shall have capacity to supply fuel to the engine for an uninterrupted 4-hour [_____] period at 100 percent rated load without being refilled, plus any fuel which may be returned to the main fuel storage tank. Submit calculations for the capacity of each day tank, including allowances for recirculated fuel, usable tank capacity, and duration of fuel supply. 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 percent of the ultimate volume of the tank.

2.5.5.2 Drain Line

Each day tank drain line shall be accessible and equipped with a shutoff valve. Self supporting day tanks shall be arranged to allow drainage into a 305 mm 12 inch tall bucket.

2.5.5.3 Local Fuel Fill

Provide each local fuel fill port on the day tank with a screw-on cap.

2.5.5.4 Fuel Level Controls

Each day tank shall have a float-switch-assembly to perform the following functions:

- a. Start the supply of fuel into the day tank when the fuel level is at the "Low" level mark, 75 of the rated tank capacity.
- b. Stop the supply of fuel into the day tank when the fuel level is at 90 percent of the rated tank capacity.
- c. Activate the "Overfill Fuel Level" alarm at 95 percent of the rated tank volume.
- d. Activate the "Low Fuel Level" alarm at 70 percent of the rated tank Capacity.
- e. Activate the automatic fuel supply shut-off valve located on the fill line of the day tank and shut down the fuel pump which supplies fuel to the day tank at 95 percent of the rated tank volume. The flow of fuel shall be stopped before any fuel can be forced into the fuel overflow line.

2.5.5.5 Arrangement

Integral day tanks may allow gravity flow into the engine. Gravity flow tanks shall be provided with an internal or external valve located as near as possible to the shell of the tank. The valve shall close when the engine is not operating. Integral day tanks shall be provided with any necessary pumps to supply fuel to the engine as recommended by the generator set manufacturer. The overflow connection and the fuel supply line for integral day tanks which do not rely upon gravity flow shall be arranged so that the highest possible fuel level is below the fuel injectors. When the main fuel storage tanks are located below the day tank, a check valve shall be provided in the fuel supply line entering the day tank. When the main fuel storage tanks are located above the day tank, a solenoid valve shall be installed in the fuel supply line entering the day tank. The solenoid valve shall be in addition to the automatic fuel shut off valve. The fuel supply line from the day tank to the manufacturer's standard engine connection shall be welded pipe.

2.5.6 Fuel Supply System

The fuel supply from the main storage of fuel to the day tank shall be as specified in Section 33 56 10 FACTORY-FABRICATED FUEL STORAGE TANKS.

2.6 LUBRICATION

Each engine shall have a separate lube-oil system conforming to NFPA 30 and NFPA 37. Each system shall be pressurized by engine-driven oil pumps. Each system shall be furnished with a relief valve for oil pressure regulation (for closed systems) and a dip-stick for oil level indications. The crankcase shall be vented in accordance with the manufacturer's recommendation except that it shall not be vented to the engine exhaust system. Crankcase breathers, if provided on engines installed in buildings or enclosures, shall be piped to vent to the outside. The system shall be readily accessible for service such as draining, refilling, etc. Each system shall permit addition of oil and have oil-level indication with the set operating. The system shall utilize an oil cooler as recommended by the engine manufacturer.

2.6.1 Filter

One full-flow filter shall be provided for each pump. The filter shall be readily accessible and capable of being changed without disconnecting the piping or disturbing other components. The filter shall have inlet and outlet connections plainly marked.

2.6.2 Lube-Oil Sensors

Each engine shall be equipped with lube-oil pressure sensors. Pressure sensors shall be located downstream of the filters and provide signals for required indication and alarms.

2.7 COOLING SYSTEM

Each engine cooling system shall operate automatically while the engine is running. Each cooling system shall be sized for the maximum summer outdoor design temperature and site elevation. Water-cooled system coolant shall use a combination of water and ethylene-glycol sufficient for freeze protection at the minimum winter outdoor temperature specified. The maximum temperature rise of the coolant across the engine shall be no more than that recommended and submitted.

a. The maximum and minimum allowable inlet temperatures of the coolant fluid.

b. The maximum allowable temperature rise in the coolant fluid through the engine.

c. The minimum allowable inlet fuel temperature.

2.7.1 Coolant Pumps

Coolant pumps shall be the centrifugal type. Each engine shall have an engine-driven primary pump. Secondary pumps shall be electric motor driven and have automatic controllers.

2.7.2 Heat Exchanger

Each heat exchanger shall be of a size and capacity to limit the maximum allowable temperature rise in the coolant across the engine to that recommended and submitted in accordance with paragraph SUBMITTALS for the maximum summer outdoor design temperature and site elevation. Each heat exchanger shall be corrosion resistant, suitable for service in ambient conditions of application. Submit manufacturer's data to quantify heat rejected to the space with the engine generator set at rated capacity.

2.7.2.1 Fin-Tube-Type Heat Exchanger (Radiator)

Heat exchanger may be factory coated with corrosive resistant film providing that corrosion measures are taken to restore the heat rejection capability of the radiator to the initial design requirement via oversizing, or other compensating methods. Internal surfaces shall be compatible with liquid fluid coolant used. Materials and coolant are subject to approval by the Contracting Officer. Heat exchangers shall be pressure type incorporating a pressure valve, vacuum valve and a cap. Caps shall be designed for pressure relief prior to removal. Each heat exchanger and the entire cooling system shall be capable of withstanding a minimum pressure of 48 kPa gauge 7 psi. Each heat exchanger shall be protected with a strong grille or screen guard. Each heat exchanger shall have at least two tapped holes. One tapped hole in the heat exchanger shall be equipped with a drain cock, the rest shall be plugged.

2.7.2.2 Shell and U-Tube Type Heat Exchanger

Heat exchanger shall be multiple pass shell and U-tube type. Exchanger shall operate with low temperature water in the shell and high temperature water in the tubes. Exchangers shall be constructed in accordance with ASME BPVC SEC VIII D1 and certified ASME stamp secured to the unit. U-tube bundles shall be completely removable for cleaning and tube replacement and shall be free to expand with the shell. Shells shall be constructed of seamless steel pipe or welded steel. Tubes shall be cupronickel or inhibited admiralty, constructed in accordance with ASTM B395/B395M, suitable for the temperature and pressure specified. Tubes shall be not less than 19 mm 3/4 inch unless otherwise indicated. Shell side and tube side shall be designed for 1.03 kPa 150 psi working pressure and factory tested at 2.06 kPa 300 psi. High and low temperature water and pressure relief connections shall be located in accordance with the manufacturer's standard practice. Water connections larger than 76 mm 3 inches shall be ASME Class 150 flanged. Water pressure loss through clean tubes shall be as recommended by the engine manufacturer. Minimum water velocity through tubes shall be 300 mm 1 foot per second and assure turbulent flow. One or more pressure relief valves shall be provided for each heat exchanger in accordance with ASME BPVC SEC VIII D1. The aggregate relieving capacity of the relief valves shall be not less than that required by the above code. Discharge from the valves shall be installed as indicated. The relief valves shall be installed on the heat exchanger shell. A drain connection with 19 mm 3/4 inch hose bib shall be installed at the lowest point in the system near the heat exchanger. Additional drain connection with threaded cap or plug shall be installed wherever required for thorough draining of the system.

2.7.3 Expansion Tank

The cooling system shall include an air expansion tank which will accommodate the expanded water of the system generated within the normal operating temperature range, limiting the pressure increase at all components in the system to the maximum allowable pressure at those components. The tank shall be suitable for an operating temperature of 121 degrees C 250 degrees F and a working pressure of 0.86 MPa 125 psi. The tank shall be constructed of welded steel, tested and stamped in accordance with ASME BPVC SEC VIII D1 for the stated working pressure. A bladder type tank shall not be used. The tank shall be supported by steel legs or bases for vertical installation or steel saddles for horizontal installation.

2.7.4 Ductwork

Ductwork shall be as specified in Section 23 00 00 AIR SUPPLY, DISTRIBUTION, VENTILATION, AND EXHAUST SYSTEMS except that a flexible connection shall be used to connect the duct to the diesel engine radiator. Material for the connection shall be wire-reinforced glass. The connection shall be rendered practically airtight.

2.7.5 Temperature Sensors

Each engine shall be equipped with coolant temperature sensors. Temperature sensors shall provide signals for pre-high and high indication and alarms.

2.8 SOUND LIMITATIONS

The noise generated by the diesel generator set operating at 100 percent load shall not exceed the following sound pressure levels in any of the indicated frequencies when measured in a free field at a radial distance of 7 meters 22.9 feet at 45 degrees apart in all directions. Submit data to demonstrate compliance with these sound limitation requirements. Also submit certification from the manufacturer stating that the sound emissions meet the specification.

Frequency Band (Hz)	Maximum Acceptable Pressure Level (Decibels)
31	[_____]
63	[_____]
125	[_____]
250	[_____]
500	[_____]

Frequency Band (Hz)	Maximum Acceptable Pressure Level (Decibels)
1000	[_____]
2000	[_____]
4000	[_____]
8000	[_____]

The noise generated by the installed diesel generator set operating at 100 percent load shall not exceed the following sound pressure levels in any of the indicated frequencies when measured at a distance of 22.9 m 75 feet from the end of the exhaust and air intake piping directly along the path of intake and discharge for horizontal piping; or at a radius of 22.9 m 75 feet from the engine at 45 degrees apart in all directions for vertical piping. Submit data to demonstrate compliance with these sound limitation requirements. Also submit certification from the manufacturer stating that the sound emissions meet the specification.

Frequency Band (Hz)	Maximum Acceptable Pressure Level (Decibels)
31	[_____]
63	[_____]
125	[_____]
250	[_____]
500	[_____]
1000	[_____]
2000	[_____]
4000	[_____]
8000	[_____]

2.9 AIR INTAKE EQUIPMENT

Filters and silencers shall be provided in locations that are convenient for servicing. The silencer shall be of the high-frequency filter type, located in the air intake system as recommended by the engine manufacturer. Silencer shall be capable of reducing the noise level at the air intake to a point below the maximum acceptable levels specified in paragraph SOUND LIMITATIONS. A combined filter-silencer unit meeting requirements for the separate filter and silencer items may be provided. Expansion elements in air-intake lines shall be copper.

2.10 EXHAUST SYSTEM

The system shall be separate and complete for each engine. Piping shall be supported so as to minimize vibration. Where a V-type engine is provided, a V-type connect or with necessary flexible sections and hardware shall connect the engine exhaust outlets.

2.10.1 Flexible Sections and Expansion Joints

A flexible section at each engine and an expansion joint at each muffler shall be provided. Flexible sections and expansion joints shall have flanged connections. Flexible sections shall be made of convoluted seamless tube without joints or packing. Expansion joints shall be the bellows type. Expansion and flexible elements shall be stainless steel suitable for diesel-engine exhaust gas at the maximum exhaust temperature that is specified by the engine manufacturer. Expansion and flexible elements shall be capable of

absorbing vibration from the engine and compensation for thermal expansion and contraction.

2.10.2 Exhaust Muffler

A chamber type exhaust muffler shall be provided. The muffler shall be constructed of welded steel and designed for outside vertical or horizontal mounting. Eyebolts, lugs, flanges, or other items shall be provided as necessary for support in the location and position indicated. Pressure drop through the muffler shall not exceed the recommendations of the engine manufacturer. Outside mufflers shall be zinc coated or painted with high temperature 204 degrees C 400 degrees F resisting paint. The muffler and exhaust piping together shall reduce the noise level to less than the maximum acceptable level listed for sound limitations in paragraph SOUND LIMITATIONS. The muffler shall have a drain valve, nipple, and cap at the low-point of the muffler.

2.10.3 Exhaust Piping

Horizontal sections of exhaust piping shall be sloped downward away from the engine to a condensate trap and drain valve. Changes in direction shall be long-radius. Exhaust piping, mufflers and silencers installed inside any building shall be insulated in accordance with paragraph THERMAL INSULATION and covered to protect personnel. Vertical exhaust piping shall be provided with a hinged, gravity operated, self-closing, rain cover.

2.11 EMISSIONS

The finished installation shall comply with Federal, state, and local regulations and restrictions regarding the limits of emissions, as listed herein: [_____]

Submit a certification from the engine manufacturer stating that the engine exhaust emissions meet 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 for hazardous air pollutants (HAPs).

2.12 STARTING SYSTEM

The starting system for standby engine generator sets used in emergency applications shall be in accordance with NFPA 99 and NFPA 110 and as follows.

2.12.1 Controls

An engine control switch shall be provided with functions including: run/start (manual), off/reset, and automatic mode. Start-stop logic shall be provided for adjustable cycle cranking and cool down operation. The logic shall be arranged for fully automatic starting in accordance with paragraph AUTOMATIC ENGINE-GENERATOR SET SYSTEM OPERATION. Electrical starting systems shall be provided with an adjustable cranking limit device to limit cranking periods from 1 second up to the maximum duration.

2.12.2 Capacity

The starting system shall be of sufficient capacity, at the maximum outdoor summer temperature specified to crank the engine without damage or overheating. The system shall be capable of providing a minimum of three cranking periods with 15-second intervals between cranks. Each cranking period shall have a maximum duration of 15 seconds.

2.12.3 Functional Requirements

Starting system shall be manufacturers recommended dc system utilizing a negative circuit ground. Starting motors shall be in accordance with SAE ARP892.

2.12.4 Battery

A starting battery system shall be provided and shall include the battery, battery rack, intercell connectors, and spacers.

The battery shall be in accordance with SAE J537. Critical system components (rack, protection, etc.) shall be sized to withstand the seismic acceleration forces specified. The battery shall be nickel-cadmium type, with sufficient capacity, at the minimum outdoor winter temperature specified to provide the specified cranking periods.

2.12.5 Battery Charger

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 float charge rate for maintaining the batteries in prime starting condition. An ammeter shall be provided to indicate charging rate. A timer shall be provided for the equalizer charging rate setting. A battery is considered to be fully depleted when the output voltage falls to a value which will not operate the engine generator set and its components.

2.12.6 Starting Aids

The manufacturer shall provide one or more of the following methods to assist engine starting.

2.12.6.1 Glow Plugs

Glow plugs shall be designed to provide sufficient heat for combustion of fuel within the cylinders to guarantee starting at an ambient temperature of -32 degrees C -25 degrees F.

2.12.6.2 Jacket-Coolant Heaters

A thermostatically controlled electric heater shall be mounted in the engine coolant jacketing to automatically maintain the coolant within plus or minus 3 degrees of the control temperature. The heater shall operate independently of engine operation so that starting times are minimized. The control temperature shall be the temperature recommended by the engine manufacturer to meet the starting time specified.

2.13 GOVERNOR

Each engine shall be provided with a governor which maintains the frequency within a bandwidth of the rated frequency, over a steady-state load range of zero to 100 percent of rated output capacity. The governor shall be configured for safe manual adjustment of the speed/frequency during operation of the engine generator set, without special tools, from 90 to 110 percent of the rated speed/frequency, over a steady state load range of zero to 100 percent of rated capacity. Isochronous governors shall maintain the midpoint of the frequency bandwidth at the same value for steady-state loads over the range of zero to 100 percent of rated output capacity.

2.14 GENERATOR

Each generator shall be of the synchronous type, one or two bearing, conforming to NEMA MG 1, equipped with winding terminal housings in accordance with NEMA MG 1, equipped with an amortisseur winding, and directly connected to the engine. Insulation shall be Class H. Generator design shall protect against mechanical, electrical and thermal damage due to vibration, 25 percent

overspeeds, or voltages and temperatures at a rated output capacity of 100 percent. Generator ancillary equipment shall meet the short circuit requirements of NEMA MG 1. Frames shall be the drip-proof type. Submit each generator KW rating and short circuit capacity (both symmetric and asymmetric).

2.14.1 Current Balance

At 100 percent rated load, and load impedance equal for each of the three phases, the permissible current difference between any two phases shall not exceed 2 percent of the largest current on either of the two phases. Submit manufacturer's certification that the flywheel has been statically and dynamically balanced and is capable of being rotated at 125 percent of rated speed without vibration or damage.

2.14.2 Voltage Balance

At any balanced load between 75 and 100 percent of rated load, the difference in line-to-neutral voltage among the three phases shall not exceed 1 percent of the average line-to-neutral voltage. For a single-phase load condition, consisting of 25 percent load at unity power factor placed between any phase and neutral with no load on the other two phases, the maximum simultaneous difference in line-to-neutral voltage between the phases shall not exceed 3 percent of rated line to neutral voltage. The single-phase load requirement shall be valid utilizing normal exciter and regulator control. The interpretation of the 25 percent load for single phase load conditions means 25 percent of rated current at rated phase voltage and unity power factor.

2.14.3 Waveform

The deviation factor of the line-to-line voltage at zero load and at balanced full rated load at 0.8 power factor shall not exceed 10 percent. The RMS of all harmonics shall be less than 5.0 percent and that of any one harmonic less than 3.0 percent at full rated load. Each engine-generator shall be designed and configured to meet the total harmonic distortion limits of IEEE 519.

2.15 EXCITER

The generator exciter shall be of the brushless type. Semiconductor rectifiers shall have a minimum safety factor of 300 percent for peak inverse voltage and forward current ratings for all operating conditions, including 110 percent generator output at 40 degrees C 104 degrees F ambient. The exciter and regulator in combination shall maintain generator-output voltage within the limits specified.

2.16 VOLTAGE REGULATOR

Each generator shall be provided with a solid-state voltage regulator, separate from the exciter. The regulator shall maintain the voltage within a bandwidth of the rated voltage, over a steady-state load range of zero to 100 percent of rated output capacity. Regulator shall be configured for safe manual adjustment of the engine generator voltage output without special tools, during operation from 90 to 110 percent of the rated voltage over the steady state load range of zero to 100 percent of rated output capacity. Regulation drift shall not exceed plus or minus 0.5 percent for an ambient temperature change of 20 degrees C 36 degrees F. The voltage regulator shall have a maximum droop of 2 percent of rated voltage over a load range from 0 to 100 percent of rated output capacity and automatically maintain the generator output voltage within the specified operational bandwidth.

2.17 GENERATOR PROTECTION

Short circuit and overload protection for the generator shall be provided. The generator circuit breaker (IEEE Device 52) ratings shall be consistent with the generator rated voltage and frequency, with continuous, short circuit and interrupting current ratings to match the generator capacity. The manufacturer shall determine the short circuit current interrupting rating of the breaker. The breaker shall be engine generator base mounted by the engine-generator set manufacturer. Molded case breakers shall be provided with shunt trip. Surge protection shall be provided for each phase of the generator, to be mounted at the generator terminals.

2.17.1 Panelboards

Panelboards shall be metal-enclosed, general purpose, [3-phase, 4-wire], [1-phase, 3-wire], 600 volt rated, with neutral bus and continuous ground bus, conforming to NEMA PB 1 and UL 891. Neutral bus and ground bus capacity shall be full capacity. Enclosure designs, construction, materials and coatings shall be suitable for the application and environment. Bus continuous current rating shall be at least equal to the generator rating and correspond to UL listed current ratings specified for panelboards and switchboards. Current withstand rating (short circuit rating) shall match the generator capacity. Buses shall be copper.

2.17.2 Devices

Switches, circuit breakers, switchgear, fuses, relays, and other protective devices shall be as specified in Section 26 28 01.00 10 COORDINATED POWER SYSTEM PROTECTION.

2.18 SAFETY SYSTEM

Devices, wiring, remote panels, local panels, etc., shall be provided and installed as a complete system to automatically activate the appropriate signals and initiate the appropriate actions. The safety system shall be provided with a self-test method to verify its operability. Alarm signals shall have manual acknowledgement and reset devices. The alarm signal systems shall reactivate for new signals after acknowledgment is given to any signal. The systems shall be configured so that loss of any monitoring device shall be dealt with as an alarm on that system element.

2.18.1 Audible Signal

The audible alarm signal shall sound at a frequency of 70 Hz at a volume of 75 dB at 3.1 m 10 feet. The sound shall be continuously activated upon alarm and silenced upon acknowledgment. Signal devices shall be located as shown.

2.18.2 Visual Alarm Signal

The visual alarm signal shall be a panel light. The light shall be normally off, activated to be blinking upon alarm. The light shall change to continuously light upon acknowledgement. If automatic shutdown occurs, the display shall maintain activated status to indicate the cause of failure and shall not be reset until cause of alarm has been cleared and/or restored to normal condition. Shutdown alarms shall be red; all other alarms shall be amber.

2.18.3 Alarms and Action Logic

2.18.3.1 Shutdown

Simultaneous activation of the audible signal, activation of the visual signal, stopping the engine, and opening the generator main circuit breakers shall be accomplished.

2.18.3.2 Problem

Activation of the visual signal shall be accomplished.

2.18.4 Local Alarm Panel

Provide a local alarm panel with the following shutdown and alarm functions in accordance with NFPA 99 and NFPA 110 level 1, 2 and including the listed Corps of Engineers requirements, mounted either on or adjacent to the engine generator set.

Device/ Condition/ Function	What/Where/ Sizes	NFPA 99	NFPA 110 Level 1	NFPA 110 Level 2	Corps of Engineers Required
Shutdowns W/Alarms					
High engine temperature	Automatic/ jacket water/ cylinder	SD/CP VA	SD/CP VA	SD/CP VA	SD VA
Low lube-oil pressure	Automatic/ pressure/ level	SD/CP VA	SD/CP VA	SD/CP VA	SD VA
Overspeed shutdown & alarm	(110 percent (+ 2 percent) of rated speed	SD/CP VA	SD/CP VA	SD/CP VA	SD VA
Overcrank failure to start	Automatic/ Failure to start	SD/CP VA	SD/CP VA	SD/CP VA	
Air shutdown damper (200-600 kW)	When used		SD/CP VA	SD/CP VA	
Day tank overfill limit indication & transfer pump shutdown (95 percent volume)	Automatic/ Day Tank/ Level				SD/OPA (Pump)

Red emergency stop switch	Manual switch		SD/CP VA	SD/CP VA	SD VA
Failure to crank	Corps of Engineers Required				
[Day tank][Integral Main Fuel Tank] low fuel limit Device/ Condition/ indication (70 percent volume remaining)	Corps of Engineers Required				
Alarms					
Low lube-oil pressure	Pressure/ level	CP VA	CP VA	CP VAO	CP VA
Low fuel level	Main tank, 3 hours remaining	VA/AA	CP VA	CP VAO	
High fuel level	Integral Main Fuel Storage Tank 95 percent Volume				CP VA
Low coolant	Jacket water	CP/VA	CP/VA	CP/VA	
Pre-high temperature	Jacket water/ cylinder	CP/VA	CP/VA	CP VAO	CP/VA
Pre-low lube-oil pressure		CP/VA			CP/VA
High battery voltage			CP/VA	CP VAO	
Low battery voltage			CP/VA	CP VAO	
Battery charger AC failure	AC supply not available		CP/VA	CP VAO	
Control switch not in AUTO			CP/VA	CP VAO	

Low starting air pressure			CP/VA	CP VAO	
Low starting hydraulic pressure			CP/VA	CP VAO	
Symbol Key					
SD	Shut Down				
CP	On Control Panel				
VA	Visual Alarm				
AA	Audible Alarm				
O	Optional				

2.18.5 Time-Delay on Alarms

For startup of the engine-generator set, time-delay devices shall be installed bypassing the low lubricating oil pressure alarm during cranking, and the coolant-fluid outlet temperature alarm. The lube-oil time-delay device shall return its alarm to normal status after the engine starts. The coolant time-delay device shall return its alarm to normal status 5 minutes after the engine starts. Submit the magnitude of monitored values which define alarm or action set points, and the tolerance (plus and/or minus) at which the device activates the alarm or action.

2.18.6 Remote Alarm Panel

A remote alarm panel shall be provided in accordance with NFPA 99/NFPA 110 and as follows:

Device/ Condition/ Function	What/Where/Size	NFPA 99	NFPA 110 Level 1	NFPA 110 Level 2
Remote annunciator panel	Battery powered		Alarms	
Loads on genset		VA		
Battery charger malfunction		VA		
Low lube-oil	Pressure/level	VA/AA	AA	AAO
Low Temperature	Jacket water	VA/AA	AA	AAO
High Temperature	Jacket water/cylinder	VA/AA	AA	AAO
Low fuel level	Main tank, 3 hr remaining	VA/AA	AA	AAO
Overcrank	Failure to start	VA/AA	AA	AAO
Overspeed		VA/AA	AA	AAO
Pre-high temperature	Jacket water/cylinder		AA	
Control switch not in			AA	
AUTO				
Common alarm contacts for local & remote common alarm			X	X
Audible alarm silencing switch			X	O
Air shutdown damper	When used		AA	AAO
Common fault alarm			AA	
Symbology Key				

Device/ Condition/ Function	What/Where/Size	NFPA 99	NFPA 110 Level 1	NFPA 110 Level 2
X	Required			
SD	Shut Down			
CP	On Control Panel			
VA	Visual Alarm			
AA	Audible Alarm			
O	Optional			

2.19 ENGINE GENERATOR SET CONTROLS AND INSTRUMENTATION

Devices, wiring, remote panels, local panels, etc., shall be provided and installed as a complete system to automatically activate the appropriate signals and initiate the appropriate actions.

2.19.1 Controls

A local control panel shall be provided with controls in accordance with NFPA 110 level 1 or 2 and as follows mounted either on or adjacent to the engine generator set. A remote control panel shall be provided fully redundant to the local control panel.

Device/ Condition/ Function	Corps Requirement	NFPA 110 Level 1	NFPA 110 Level 2	MFG Offering
Controls				
Switch: run/start - off/set - auto	CP			CP/STD
Emergency stop switch & alarm	CP			CP/STD
Lamp test/indicator test	CP	CP VA	CP VA	CP/STD
Common alarm contacts/ fault relay		X	X	CP/O
Panel lighting	CP			CP/STD
Audible alarm & silencing/reset switch	CP			
Voltage adjust for voltage regulator	CP			CP/STD
Pyrometer display w/selector switch	CP			
Remote emergency stop switch		CP VA	CP VA	
Remote fuel shutoff switch				
Remote lube-oil shutoff switch				

2.19.2 Engine Generator Set Metering and Status Indication

A local panel shall be provided with devices in accordance with NFPA 110 level 1, 2 and as follows mounted either on or adjacent to the engine generator set. A remote control panel shall be provided fully redundant to the local control panel.

Device/ Condition/ Function	Corps Requirement	NFPA 110 Level 1	NFPA 110 Level 2	MFG Offering
Genset Status & Metering				
Genset supplying load		CP VA	CP VA	CP VAO
System ready				CP/STD
Engine oil pressure	CP			CP/STD
Engine coolant temperature	CP			CP/STD
Engine RPM (Tachometer)	CP			CP/STD
Engine run hours	CP			CP/STD
Pyrometer display w/selector switch	CP			
AC volts (generator), 3-phase	CP			CP/STD

Device/ Condition/ Function	Corps Requirement	NFPA 110 Level 1	NFPA 110 Level 2	MFG Offering
AC amps (generator), 3-phase	CP			CP/STD
Generator frequency	CP			CP/STD
Phase selector switches (amps & volts)	CP			CP/STD
Watts/kW				CP/VA-O
Voltage Regulator Adjustment	CP			

Symbology Key:	
CP	On Control Panel
VA	Visual Alarm
AA	Audible Alarm
O	Optional
STD	Manufacturers Standard Offering

2.20 PANELS

Each panel shall be of the type necessary to provide specified functions. Panels shall be mounted on the engine generator set base by vibration/shock absorbing type mountings. Instruments shall be mounted flush or semiflush. Convenient access to the back of instruments shall be provided to facilitate maintenance. Instruments shall be calibrated using recognized industry

calibration standards. Each panel shall be provided with a panel identification plate which clearly identifies the panel function as indicated. Each instrument and device on the panel shall be provided with a plate which clearly identifies the device and its function as indicated. Panels except the remote alarm panel can be combined into a single panel.

2.20.1 Enclosures

Enclosures shall be designed for the application and environment, conforming to NEMA ICS 6, and provided with locking mechanisms which are keyed alike.

2.20.2 Analog

Analog electrical indicating instruments shall be in accordance with ANSI C39.1 with semiflush mounting. Switchgear, and control-room panel-mounted instruments shall have 250 degree scales with an accuracy of not less than 1 percent. Unit-mounted instruments shall be the manufacturer's standard with an accuracy of not less than 2 percent. The instrument's operating temperature range shall be minus 20 to plus 65 degrees C minus 4 to plus 130 degrees F. Distorted generator output voltage waveform of a crest factor less than 5 shall not affect metering accuracy for phase voltages, hertz and amps.

2.20.3 Electronic

Electronic indicating instruments shall be true RMS indicating, 100 percent solid state, microprocessor controlled to provide all specified functions. Control, logic, and function devices shall be compatible as a system, sealed, dust and water tight, and shall utilize modular components with metal housings and digital instrumentation. An interface module shall be provided to decode serial link data from the electronic panel and translate alarm, fault and status conditions to set of relay contacts. Instrument accuracy shall be not less than 2 percent for unit mounted devices and 1 percent for control room, panel mounted devices, throughout a temperature range of minus 20 to plus 65 degrees C minus 4 to plus 130 degrees F. Data display shall utilize LED or back lit LCD. Additionally, the display shall provide indication of cycle programming and diagnostic codes for troubleshooting. Numeral height shall be [13 mm 1/2 inch][_____].

2.20.4 Parameter Display

Indication or readouts of the lubricating-oil pressure, ac voltmeter, ac ammeter, frequency meter, and coolant temperature.

2.20.5 Exerciser

The exerciser shall be in accordance with Section 26 36 00.00 10 AUTOMATIC TRANSFER SWITCH AND BY-PASS/ISOLATION SWITCH.

2.21 SURGE PROTECTION

Electrical and electronic components shall be protected from, or designed to withstand the effects of surges from switching and lightning.

2.22 AUTOMATIC ENGINE-GENERATOR-SET SYSTEM OPERATION

Fully automatic operation shall be provided for the following operations: engine-generator set starting and source transfer upon loss of normal source; retransfer upon restoration of the normal source; sequential starting; and stopping of each engine-generator set after cool down. Devices shall automatically reset after termination of their function.

2.22.1 Automatic Transfer Switch

Automatic transfer switches shall be in accordance with Section

26 36 00.00 10 AUTOMATIC TRANSFER SWITCH AND BY-PASS/ISOLATION SWITCH.

2.22.2 Monitoring and Transfer

Devices shall be provided to monitor voltage and frequency for the normal power source and each engine generator set, and control transfer from the normal source and retransfer upon restoration of the normal source. Functions, actuation, and time delays shall be as described in Section 26 36 00.00 10 AUTOMATIC TRANSFER SWITCH AND BY-PASS/ISOLATION SWITCH.

2.22.3 Remote Monitoring of Generator and Transfer Switch

Devices that communicate via serial Modbus RTU shall be provided to monitor at rest as well as running parameters of the generator set.

a. The following parameters are to be monitored:

- 1) Engine coolant temperature, both at rest and while running.
- 2) Generator fuel level, both at rest and while running, shall be displayed as percent remaining.
- 3) Generator engine oil pressure, while running.
- 4) Generator engine RPM, while running.
- 5) Generator set voltage output, each individual phase.
- 6) Generator set output amperage, each individual phase.
- 7) Generator set output frequency.

b. The same devices shall report the following parameters of the transfer switch.

- 1) Position of transfer switch, i.e. commercial power, off, generator.

c. Raceway will be installed from generator set to the facilities EEDRS JACE cabinet. Raceway shall contain a communications cable that is 24 gauge, shielded twisted pair, capable of RS485 data transfer.

2.23 MANUAL ENGINE-GENERATOR SET SYSTEM OPERATION

Complete facilities shall be provided for manual starting and testing of each set without load, loading and unloading of each set.

2.24 BASE

The base shall be constructed of steel. The base shall be designed to rigidly support the engine-generator set, ensure permanent alignment of all rotating parts, be arranged to provide easy access to allow changing of lube-oil, and ensure that alignment will be maintained during shipping and normal operation. The base shall permit skidding in any direction during installation and shall be provided with suitable holes for foundation bolts. The base shall also withstand and mitigate the effects of synchronous vibration of the engine and generator, and shall be provided with suitable holes for anchor bolts and jacking screws for leveling.

2.25 THERMAL INSULATION

Thermal insulation shall be as specified in Section 23 07 00 THERMAL INSULATION FOR MECHANICAL SYSTEMS.

2.26 PAINTING AND FINISHING

The engine-generator set shall be cleaned, primed and painted in accordance with the manufacturer's standard color and practice.

2.27 FACTORY INSPECTION AND TESTS

Perform factory inspection and tests on each engine-generator set proposed to meet this specification section. Inspections shall be completed and necessary repairs made prior to testing. Inspectors shall look for leaks, looseness, defects in components, and proper assembly. Factory tests shall be NEMA MG 1

routine tests and the manufacturer's routine tests. Submit a certification that each engine generator set passed the factory tests and inspections and a list of the test and inspections.

PART 3 EXECUTION

3.1 EXAMINATION

After becoming familiar with all details of the work, perform a Site Visit to verify details of the work. Submit a site visit letter stating the date the site was visited and listing discrepancies found and advise the Contracting Officer in writing of any discrepancies before performing any work.

3.2 GENERAL INSTALLATION

Submit a complete copy of the manufacturer's installation procedures. A detailed description of the manufacturer's recommended break-in procedure. Provide clear space for operation and maintenance in accordance with NFPA 70 and IEEE C2. Configure installation of pipe, duct, conduit, and ancillary equipment to facilitate easy removal and replacement of major components and parts of the engine-generator set.

3.3 PIPING INSTALLATION

3.3.1 General

Piping shall be welded. Connections at valves shall be flanged. Connections at equipment shall be flanged except that connections to the diesel engine may be threaded if the diesel-engine manufacturer's standard connection is threaded. Except as otherwise specified, flanged fittings shall be utilized to allow for complete dismantling and removal of each piping system from the facility without disconnecting or removing any portion of any other system's equipment or piping. Connections to all equipment shall be made with flexible connectors. Pipes extending through the roof shall be properly flashed. Piping shall be installed clear of windows, doors, and openings to permit thermal expansion and contraction without damage to joints or hangers, and with a 13 mm 1/2 inch drain valve at each low point.

3.3.2 Supports

Hangers, inserts, and supports shall be of sufficient size to accommodate any insulation and shall conform to MSS SP-58. Supports shall be spaced not more than 2.1 m 7 feet on center for pipes 50 mm 2 inches in diameter or less, not more than 3.6 m 12 feet on center for pipes larger than 50 mm 2 inches but no larger than 100 mm 4 inches, and not more than 5.2 m 17 feet on center for pipes larger than 100 mm 4 inches in diameter. Supports shall be provided at pipe bends or change of direction.

3.3.2.1 Ceiling and Roof

Exhaust piping shall be supported with appropriately sized type 41 single pipe roll and threaded rods; all other piping shall be supported with appropriately sized type 1 clevis and threaded rods.

3.3.2.2 Wall

Wall supports for pipe shall be made by suspending the pipe from appropriately sized type 33 brackets with the appropriate ceiling and roof pipe supports.

3.3.3 Flanged Joints

Flanges shall be Class 125 125 pound type, drilled, and of the proper size and configuration to match equipment and diesel-engine connections. Gaskets shall

be factory cut in one piece 1.6 mm 1/16 inch thick.

3.3.4 Cleaning

After fabrication and before assembly, piping interiors shall be manually wiped clean of all debris.

3.3.5 Pipe Sleeves

Pipes passing through construction such as ceilings, floors, or walls shall be fitted with sleeves. Each sleeve shall extend through and be securely fastened in its respective structure and shall be cut flush with each surface. The structure shall be built tightly to the sleeve. The inside diameter of each sleeve shall be 13 mm 1/2 inch, and where pipes pass through combustible materials, 25 mm 1 inch larger than the outside diameter of the passing pipe or pipe covering.

3.4 ELECTRICAL INSTALLATION

Electrical installation shall comply with NFPA 70, IEEE C2, and Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM. For vibration isolation, flexible fittings shall be provided for all conduit, cable trays, and raceways attached to engine-generator sets; metallic conductor cables installed on the engine generator set and from the engine generator set to equipment not mounted on the engine generator set shall be flexible stranded conductor; and terminations of conductors on the engine generator set shall be crimp-type terminals or lugs. Submit manufacturer's standard certification that prototype tests were performed for the generator model proposed.

3.5 FIELD PAINTING

Field painting shall be as specified in Section 09 90 00 PAINTS AND COATINGS.

3.6 ONSITE INSPECTION AND TESTS

3.6.1 Submittal Requirements

a. A letter giving notice of the proposed dates of all onsite inspections and tests at least 14 days prior to beginning tests.

b. A detailed description of the Contractor's proposed procedures for onsite tests including the test including the test plan and a listing of equipment necessary to perform the tests. Submission shall be at least 14 days prior to beginning tests.

c. Six copies of the onsite test data described below in 216 by 279 mm 8-1/2 by 11 inch 3-ring binders with a separate section for each test. Sections shall be separated by dividers with tabs. Data plots shall be full size 216 by 279 mm 8-1/2 by 11 inches minimum), showing all grid lines, with full resolution.

- (1) A description of the procedures for onsite tests.
- (2) A list of equipment used, with calibration certifications.
- (3) A copy of measurements taken, with required plots and graphs.
- (4) The date of testing.
- (5) The parameters verified.
- (6) The condition specified for the parameter.
- (7) The test results, signed and dated.
- (8) A description of all adjustments made.

3.6.2 Test Conditions

3.6.2.1 Data

Measurements shall be made and recorded of parameters necessary to verify that each set meets specified parameters. If the results of any test step are not satisfactory, adjustments or replacements shall be made and the step repeated until satisfactory results are obtained. Unless otherwise indicated, data shall be taken during engine-generator set operation and recorded in 15 minute intervals and shall include: readings of engine-generator set meters and gauges for electrical and power parameters; oil pressure; ambient temperature; and engine temperatures available from meters and gauges supplied as permanent equipment on the engine-generator set. In the following tests where measurements are to be recorded after stabilization of an engine-generator set parameter (voltage, frequency, current, temperature, etc.), stabilization is considered to have occurred when measurements are maintained within the specified bandwidths or tolerances, for a minimum of four consecutive readings. Electrical measurements shall be performed in accordance with IEEE 120. Definitions and terms are in accordance with IEEE Stds Dictionary. Temperature limits in the rating of electrical equipment and for the evaluation of electrical insulation shall be in accordance with IEEE 1.

3.6.2.2 Power Factor

Engine-generator set operating tests shall be made utilizing a load with the power factor specified in the engine generator set parameter schedule. Submit generator capability curve showing generator kVA output (kW vs. kvar) for both leading and lagging power factors ranging from 0 to 1.0.

3.6.2.3 Contractor Supplied Items

Provide all equipment and supplies required for inspections and tests including fuel, test instruments, and loadbanks at the specified power factors.

3.6.2.4 Instruments

Readings of panel gauges, meters, displays, and instruments, provided under this specification shall be verified during test runs by test instruments of precision and accuracy greater than the tested items. Test instrument accuracy shall be at least as follows: current, 1.5 percent; voltage, 1.5 percent; real power, 1.5 percent; reactive power, 1.5 percent; power factor, 3 percent; frequency, 0.5 percent. Test instruments shall be calibrated by a recognized standards laboratory within 30 days prior to testing.

3.6.2.5 Sequence

The sequence of testing shall be as specified in the approved testing plan unless variance is authorized by the Contracting Officer. Field testing shall be performed in the presence of the Contracting Officer. Tests may be scheduled and sequenced in order to optimize run-time periods; however the following general order of testing shall be followed: Construction Tests; Inspections; Safety run Tests; and Performance Tests and Final Inspection.

3.6.3 Construction Tests

Individual component and equipment functional tests for fuel piping, coolant piping, and lubricating-oil piping, electrical circuit continuity, insulation resistance, circuit protective devices, and equipment not provided by the engine-generator set manufacturer shall be performed prior to connection to the engine-generator set.

3.6.3.1 Piping Test

a. Lube-oil and fuel-oil piping shall be flushed with the same type of fluid intended to flow through the piping, until the outflowing fluid has no obvious sediment or emulsion.

b. Fuel piping which is external to the engine-generator set shall be tested in accordance with NFPA 30. All remaining piping which is external to the engine generator set shall be pressure tested with air pressure at 150 percent of the maximum anticipated working pressure, but in no case less than 1 MPa 150 psig, for a period of 2 hours to prove the piping has no leaks. If piping is to be insulated, the test shall be performed before the insulation is applied.

3.6.3.2 Electrical Equipment Tests

a. Low-voltage cable insulation integrity tests shall be performed for cables connecting the generator breaker to the automatic transfer switch, [panelboard] [main disconnect switch], Low-voltage cable, complete with splices, shall be tested for insulation resistance after the cables are installed, in their final configuration, ready for connection to the equipment, and prior to energization. The test voltage shall be 500 volts dc, applied for one minute between each conductor and ground and between all possible combinations conductors in the same trench, duct, or cable, with all other conductors in the same trench, duct, or conduit. The minimum value of insulation shall be:

(1) $R \text{ in megohms} = (\text{rated voltage in kV} + 1) \times 304,800 / (\text{length of cable in meters})$.

(2) $(R \text{ in megohms} = (\text{rated voltage in kV} + 1) \times 1000 / (\text{length of cable in feet}))$

(3) Each cable failing this test shall be repaired or replaced. The repaired cable shall be retested until failures have been eliminated.

b. Medium-voltage cable insulation integrity tests shall be performed for cables connecting the generator breaker to the generator switchgear or main disconnect switch. After insulation and before the operating test or connection to an existing system, the medium-voltage cable system shall be given a high potential test. Direct-current voltage shall be applied on each phase conductor of the system by connecting conductors as one terminal and connecting grounds or metallic shieldings or sheaths of the cable as the other terminal for each test. Prior to making the test, the cables shall be isolated by opening applicable protective devices and disconnecting equipment. The test shall be conducted with all splices, connectors, and terminations in place. The method, voltage, length of time, and other characteristics of the test for initial installation shall be in accordance with NEMA WC 74/ICEA S-93-639 for the particular type of cable installed, except that 28kV and 35kV insulation test voltages shall be in accordance with either AEIC CS8 or AEIC CS8 as applicable, and shall not exceed the recommendations of IEEE 404 for cable joints and IEEE 48 for cable terminations unless the cable and accessory manufacturers indicate higher voltages are acceptable for testing. Should any cable fail due to a weakness of conductor insulation or due to defects or injuries incidental to the installation or because of improper installation of cable, cable joints, terminations, or other connections, make necessary repairs or replace cables as directed. Repaired or replaced cables shall be retested.

c. Ground-Resistance Tests. The resistance of each grounding electrode

system, the ground ring shall be measured using the fall-of-potential method defined in IEEE 81. Ground resistance measurements shall be made before the electrical distribution system is energized and shall be made in normally dry conditions not less than 48 hours after the last rainfall. Resistance measurements of separate grounding electrode systems shall be made before the systems are bonded together below grade. The combined resistance of separate systems may be used to meet the required resistance, but the specified number of electrodes must still be provided.

- (1) Single rod electrode - 25 ohms.
- (2) Multiple rod electrodes - 25 ohms.
- (3) Ground mat - 25 ohms.

d. Circuit breakers and switchgear shall be examined and tested in accordance with manufacturer's published instructions for functional testing.

3.6.4 Inspections

The following inspections shall be performed jointly by the Contracting Officer and the Contractor, after complete installation of each engine-generator set and its associated equipment, and prior to startup of the engine-generator set. Checks applicable to the installation shall be performed. The results of those which are physical inspections (I) shall be documented and submitted as a letter certifying that all facilities are complete and functional, that each system is fully functional, and that each item of equipment is complete, free from damage, adjusted, and ready for beneficial use. Present manufacturer's data for the inspections designated (D) at the time of inspection. Inspections shall verify that equipment type, features, accessibility, installation and condition are in accordance with the contract specification. Manufacturer's statements shall certify provision of features which cannot be verified visually.

1. Drive belts. (I)
2. Governor type and features. (I)
3. Engine timing mark. (I)
4. Starting motor. (I)
5. Starting aids. (I)
6. Coolant type and concentration. (D)
7. Radiator drains. (I)
8. Block coolant drains. (I)
9. Coolant fill level. (I)
10. Coolant line connections. (I)
11. Coolant hoses. (I)
12. Combustion air filter. (I)
13. Intake air silencer. (I)
14. Lube oil type. (D)
15. Lube oil drain. (I)
16. Lube-oil filter. (I)
17. Lube-oil-fill level. (I)
18. Lube-oil line connections. (I)
19. Lube-oil lines. (I)
20. Fuel type. (D)
21. Fuel-level. (I)
22. Fuel-line connections. (I)
23. Fuel lines. (I)
24. Fuel filter. (I)
25. Access for maintenance. (I)
26. Voltage regulator. (I)
27. Battery-charger connections. (I)

- 28. Wiring & terminations. (I)
- 29. Instrumentation. (I)
- 30. Hazards to personnel. (I)
- 31. Base. (I)
- 32. Nameplates. (I)
- 33. Paint. (I)
- 34. Exhaust system. (I)
- 35. Access provided to controls. (I)
- 36. Enclosure. (I)
- 37. Engine & generator mounting bolts (proper application). (I)

3.6.5 Safety Run Tests

- a. Perform and record engine manufacturer's recommended prestarting checks and inspections.
- b. Start the engine, record the starting time, make and record engine manufacturer's after-starting checks and inspections during a reasonable warm-up period.
- c. Activate the manual emergency stop switch and verify that the engine stops.
- d. Remove the high and pre-high lubricating oil temperature sensing elements from the engine and temporarily install temperature gauge in their normal locations on the engine (required for safety, not for recorded data). Where necessary, provide temporary wiring harness to connect the sensing elements to their permanent electrical leads.
- e. Start the engine, record the starting time, make and record engine manufacturer's after-starting checks and inspections and operate the engine generator-set at no load until the output voltage and frequency stabilize. Monitor the temporarily installed temperature gauges. If temperature reading exceeds the value for an alarm condition, activate the manual emergency stop switch.
- f. Immerse the elements in a vessel containing controlled-temperature hot oil and record the temperature at which the pre-high alarm activates and the temperature at which the engine shuts down. Remove the temporary temperature gauges and reinstall the temperature sensors on the engine.
- g. Remove the high and pre-high coolant temperature sensing elements from the engine and temporarily seal their normal location on the engine and temporarily install temperature gauges in their normal locations on the engine (required for safety, not for recorded data). Where necessary provide temporary wiring harness to connect the sensing elements to their permanent electrical leads.
- h. Start the engine, record the starting time, make and record engine manufacturer's after-starting checks and inspections and operate the engine generator-set at no load until the output voltage and frequency stabilize.
- i. Immerse the elements in a vessel containing controlled-temperature hot oil and record the temperature at which the pre-high alarm activates and the temperature at which the engine shuts down. Remove the temporary temperature gauges and reinstall the temperature sensors on the engine.
- j. Start the engine, record the starting time, make and record engine manufacturer's after-starting checks and inspections during a reasonable warm-

up period.

k. Operate the engine generator-set for at least 30 minutes at 100 percent of service load.

l. Verify proper operation of the governor and voltage regulator.

m. Verify proper operation and setpoints of gauges and instruments.

n. Verify proper operation of ancillary equipment.

o. Manually adjust the governor to increase engine speed past the overspeed limit. Record the RPM at which the engine shuts down.

p. Start the engine, record the starting time, make and record engine manufacturer's after-starting checks and inspections and operate the engine generator-set for at least 15 minutes at 75 percent of rated load.

q. Manually fill the day tank to a level above the overfill limit.

Record the level at which the overfill alarm sounds. Verify shutdown of the fuel transfer pump. Drain the day tank down below the overfill limit.

r. Shut down the engine. Remove the time-delay low lube oil pressure alarm bypass and try to start the engine. Record the results.

s. Attach a manifold to the engine oil system (at the oil sensor pressure port) that contains a shutoff valve in series with a connection for the engine's oil pressure sensor followed by an oil pressure gauge ending with a bleed valve. The engine's oil pressure sensor shall be moved from the engine to the manifold and its normal location on the engine temporarily sealed. The manifold shutoff valve shall be open and bleed valve closed.

t. Start the engine, record the starting time, make and record all engine manufacturer's after-starting checks and inspections and operate the engine generator-set for at least 15 minutes at 75 percent of service load.

u. Close the manifold shutoff valve. Slowly allow the pressure in the manifold to bleed off through the bleed valve while watching the pressure gauge. Record the pressure at which the engine shuts down. Catch oil spillage from the bleed valve in a container. Add the oil from the container back to the engine, remove the manifold, and reinstall the engine's oil pressure sensor on the engine.

v. Start the engine, record the starting time, make and record all engine manufacturer's after-starting checks and inspections and operate the engine generator-set for at least 15 minutes at 100 percent of service load. Record the maximum sound level in each frequency band at a distance of [_____] [22.9] m [_____] [75] feet from the end of the exhaust and air intake piping directly along the path of intake and discharge horizontal piping; or at a radius of [22.9] [10.7] m [75][35] feet from the engine at 45 degrees apart in all directions for vertical piping. The measurements should comply with the paragraph SOUND LIMITATIONS. If a sound limiting enclosure is provided, the enclosure, the muffler, and intake silencer shall be modified or replaced as required to meet the sound requirements contained within this specification. If a sound limiting enclosure is not provided, the muffler and air intake silencer shall be modified or replaced as required to meet the sound limitations of this specification. If the sound limitations can not be obtained by modifying or replacing the muffler and air intact silencer, notify

the Contracting Officer and provide a recommendation for meeting the sound limitations.

w. Manually drain off fuel slowly from the day tank to empty it to below the low fuel level limit and record the level at which the audible alarm sounds. Add fuel back to the day tank to fill it above low level alarm limits.

3.6.6 Performance Tests

Submit calculations of the engine and generator output power capability, including efficiency and parasitic load data.

3.6.6.1 Continuous Engine Load Run Test

The engine-generator set and ancillary systems shall be tested at service load to: demonstrate reliability and durability (see paragraph RELIABILITY AND DURABILITY for submittal requirements); verify that heat of extended operation does not adversely affect or cause failure in any part of the system; and check all parts of the system. If the engine load run test is interrupted for any reason, the entire test shall be repeated. The engine load run test shall be accomplished principally during daylight hours, with an average ambient temperature of [_____] degrees C degrees F, during the month of [_____]. After each change in load in the following test, measure the vibration at the end bearings (front and back of engine, outboard end of generator) in the horizontal, vertical, and axial directions. Verify that the vibration is within the allowable range. Measurements are to be recorded after stabilization of an engine-generator set parameter (voltage, frequency, current, temperature, etc.). Stabilization is considered to have occurred when measurements are maintained within the specified bandwidths or tolerances, for a minimum of four consecutive readings. Data taken at 15 minutes intervals shall include the following:

a. Electrical: Output amperes, voltage, real and reactive power, power factor, frequency.

b. Pressure: Lube-oil.

c. Temperature: Coolant, Lube-oil, Ambient.

(1) Perform and record engine manufacturer's recommended prestarting checks and inspections. Include as a minimum checking of coolant fluid, fuel, and lube-oil levels.

(2) Start the engine; make and record engine manufacturer's after-starting checks and inspections during a reasonable warm-up period.

(3) Operate the engine generator-set for at least 2 hours at 75 percent of service load.

(4) Increase load to 100 percent of service load and operate the engine generator-set for at least 2 hours.

(5) Remove load from the engine-generator set.

3.6.6.2 Load Acceptance Test

Engine manufacturer's recommended prestarting checks and inspections shall be performed and recorded. The engine shall be started, and engine manufacturer's after-starting checks and inspections made and recorded during a reasonable warm-up period. For the following steps, the output line-line and line-neutral

voltages and frequency shall be recorded after performing each step instruction (after stabilization of voltage and frequency). Stabilization is considered to have occurred when measurements are maintained within the specified bandwidths or tolerances, for a minimum of four consecutive readings.

- a. Apply load in steps no larger than the Maximum Step Load Increase to load the engine-generator set to 100 of Service Load.
- b. Verify that the engine-generator set responds to the load addition and that the output voltage returns to and stabilizes within the rated bandwidths.

3.6.7 Automatic Operation Tests for Stand-Alone Operation

The automatic loading system shall be tested to demonstrate automatic starting, and loading and unloading of each engine-generator set. The loads for this test shall utilize the actual loads to be served, and the loading sequence shall be the indicated sequence. Perform this test for a minimum of two successive, successful tests. Data taken shall include the following:

- a. Ambient temperature (at 15 minute intervals).
 - b. Generator output current (before and after load changes).
 - c. Generator output voltage (before and after load changes).
 - d. Generator output frequency (before and after load changes.)
- (1) Initiate loss of the primary power source and verify automatic sequence of operation.
 - (2) Restore the primary power source and verify sequence of operation.
 - (3) Verify resetting of controls to normal.

3.7 ONSITE TRAINING

Conduct training course for operating staff as designated by the Contracting Officer. The training period shall consist of a total 4 hours of normal working time and shall start after the system is functionally completed but prior to final acceptance. The course instructions shall cover pertinent points involved in operating, starting, stopping, servicing the equipment, as well as all major elements of the operation and maintenance manuals. Additionally, the course instructions shall demonstrate all routine maintenance operations such as oil change, oil filter change, and air filter change.

3.8 FINAL INSPECTION AND TESTING

- a. Start the engine, record the starting time, make and record all engine manufacturer's after-starting checks and inspections during a reasonable warm-up period.
- b. Increase the load in steps no greater than the maximum step load increase to 100 percent of service load, and operate the engine-generator set for at least 30 minutes. Measure the vibration at the end bearings (front and back of engine, outboard end of generator) in the horizontal, vertical, and axial directions. Verify that the vibration is within the same range as previous measurements and is within the required range.

- c. Remove load and shut down the engine-generator set after the recommended cool down period. Perform the pre-test inspections and take necessary corrective actions.
- d. Remove the lube oil filter and have the oil and filter examined by the engine manufacturer for excessive metal, abrasive foreign particles, etc. Any corrective action shall be verified for effectiveness by running the engine for 4 hours at service load, then re-examining the oil and filter.
- e. Remove the fuel filter and examine the filter for trash, abrasive foreign particles, etc.
- f. Visually inspect and check engine and generator mounting bolts for tightness and visible damage.
- g. Replace air, oil, and fuel filters with new filters.

3.9 MANUFACTURER'S FIELD SERVICE

The engine generator-set manufacturer shall furnish a qualified representative to supervise the installation of the engine generator-set, assist in the performance of the onsite tests, and instruct personnel as to the operational and maintenance features of the equipment.

3.10 INSTRUCTIONS

Two sets of instructions shall be typed and framed under weatherproof laminated plastic, and posted side-by-side where directed before acceptance. First set of instructions shall include a one-line diagram, wiring and control diagrams and a complete layout of the system. Second set of instructions shall include the condensed operating instructions describing manufacturer's pre-start checklist and precautions; start procedures for test-mode, manual-start mode, and automatic-start mode (as applicable); running checks, procedures, and precautions; and shutdown procedures, checks, and precautions. Instructions shall include procedures for interrelated equipment (such as heat recovery systems, co-generation, load-shedding, and automatic transfer switches).

3.11 ACCEPTANCE

Final acceptance of the engine-generator set will not be given until the Contractor has successfully completed all tests and after all defects in installation material or operation have been corrected. Submit drawings which accurately depict the as-built configuration of the installation, upon acceptance of the diesel-generator set installation. Revise layout drawings to reflect the as-built conditions and submit them with the as-built drawings.

-- End of Section --