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USACE / NAVFAC / AFCESA / NASA **UFGS-26 32 14.00 10 (February 2010)**

Preparing Activity: USACE **Superseding**
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UNIFIED FACILITIES GUIDE SPECIFICATIONS

References are in agreement with UMRL dated January 2012
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DIVISION 26 - ELECTRICAL

SECTION 26 32 14.00 10

DIESEL-GENERATOR SET, STATIONARY 15-300 KW, STANDBY APPLICATIONS

02/10

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SECTION 26 32 14.00 10

DIESEL-GENERATOR SET, STATIONARY 15-300 KW, STANDBY APPLICATIONS
02/10

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NOTE: This guide specification covers the requirements for stationary diesel driven generator sets in the 15 to 300 kilowatt capacity for standby applications.

Adhere to UFC 1-300-02 Unified Facilities Guide Specifications (UFGS) Format Standard when editing this guide specification or preparing new project specification sections. Edit this guide specification for project specific requirements by adding, deleting, or revising text. For bracketed items, choose applicable items(s) or insert appropriate information.

Remove information and requirements not required in respective project, whether or not brackets are present.

Comments, suggestions and recommended changes for this guide specification are welcome and should be submitted as a Criteria Change Request (CCR).
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PART 1 GENERAL

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NOTE: This specification is for procurement of engine-generator sets which are suitable for serving general purpose and commercial-grade loads (loads which may be served by an electric utility). These are loads which can endure or recover quickly from transient voltage and frequency changes (as much as 30 percent transient voltage drop, and plus or minus 5 percent frequency deviation, with recovery time of 2 seconds). For applications where strict control of voltage, frequency, and transient response is required, provide uninterruptible power supplies or utilize Section 26 32 15.00 10 DIESEL-GENERATOR SET STATIONARY 100-2500 KW, WITH AUXILIARIES. This specification is for procurement of engine-generator

sets for standby, stand-alone applications. For prime or parallel applications, incorporate the appropriate paragraphs from Section 26 32 15.00 10. Select the features and fill in blanks with values appropriate for the design condition. This specification does not apply to 400 Hz applications.
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1.1 REFERENCES

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NOTE: This paragraph is used to list the publications cited in the text of the guide specification. The publications are referred to in the text by basic designation only and listed in this paragraph by organization, designation, date, and title.

Use the Reference Wizard's Check Reference feature when you add a RID outside of the Section's Reference Article to automatically place the reference in the Reference Article. Also use the Reference Wizard's Check Reference feature to update the issue dates.

References not used in the text will automatically be deleted from this section of the project specification when you choose to reconcile references in the publish print process.
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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	(2009) Forged Fittings, Socket-Welding and Threaded
ASME B16.3	(2011) Malleable Iron Threaded Fittings, Classes 150 and 300
ASME B16.5	(2009) Pipe Flanges and Flanged Fittings: NPS 1/2 Through NPS 24 Metric/Inch Standard
ASME B31.1	(2010) Power Piping
ASME BPVC SEC IX	(2010) BPVC Section IX-Welding and Brazing Qualifications
ASME BPVC SEC VIII D1	(2010) BPVC Section VIII-Rules for Construction of Pressure Vessels Division 1

ASSOCIATION OF EDISON ILLUMINATING COMPANIES (AEIC)

AEIC CS8 (2000) Extruded Dielectric Shielded Power Cables Rated 5 Through 46 kV

ASTM INTERNATIONAL (ASTM)

ASTM A106/A106M (2010) Standard Specification for Seamless Carbon Steel Pipe for High-Temperature Service

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

ASTM A181/A181M (2006) Standard Specification for Carbon Steel Forgings, for General-Purpose Piping

ASTM A234/A234M (2011) Standard Specification for Piping Fittings of Wrought Carbon Steel and Alloy Steel for Moderate and High Temperature Service

ASTM A53/A53M (2010) Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless

ASTM B395/B395M (2008) Standard Specification for U-Bend Seamless Copper and Copper Alloy Heat Exchanger and Condenser Tubes

ASTM D975 (2011) Standard Specification for Diesel Fuel Oils

ELECTRICAL GENERATING SYSTEMS ASSOCIATION (EGSA)

EGSA 101P (1995) Engine Driven Generator Sets

INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS (IEEE)

IEEE 1 (2000; R 2005) 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 (2006) 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 (1992; R 1993; Errata 2004) Recommended

Practices and Requirements for Harmonic Control in Electrical Power Systems

IEEE 81 (1983) Guide for Measuring Earth Resistivity, Ground Impedance, and Earth Surface Potentials of a Ground System

IEEE C2 (2012) 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 (2009) Pipe Hangers and Supports - Materials, Design and Manufacture, Selection, Application, and Installation

MSS SP-69 (2003) Pipe Hangers and Supports - Selection and Application (ANSI Approved American National Standard)

MSS SP-80 (2008) Bronze Gate, Globe, Angle and Check Valves

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)

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

NEMA ICS 6 (1993; R 2011) Enclosures

NEMA MG 1 (2009) Motors and Generators

NEMA PB 1 (2006; Errata 2008) Panelboards

NEMA WC 74/ICEA S-93-639 (2006) 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 (2010; TIA 10-1) Standard for Emergency and Standby Power Systems

NFPA 30 (2012; Errata 2011; Errata 2011) Flammable and Combustible Liquids Code

NFPA 37 (2010; TIA 10-1) Standard for the Installation and Use of Stationary Combustion Engines and Gas Turbines

NFPA 70 (2011; TIA 11-1; Errata 2011; TIA 11-2;

	TIA 11-3; TIA 11-4) National Electrical Code
NFPA 99	(2012) Health Care Facilities Code

SOCIETY OF AUTOMOTIVE ENGINEERS INTERNATIONAL (SAE)

SAE ARP892	(1965; R 1994) DC Starter-Generator, Engine
SAE J537	(2011) Storage Batteries

U.S. DEPARTMENT OF DEFENSE (DOD)

UFC 3-310-04	(2007; Change 1) Seismic Design for Buildings

UNDERWRITERS LABORATORIES (UL)

UL 1236	(2006; Reprint Jul 2011) Standard for Battery Chargers for Charging Engine-Starter Batteries
UL 489	(2009; Reprint Jun 2011) Molded-Case Circuit Breakers, Molded-Case Switches, and Circuit-Breaker Enclosures
UL 891	(2005) 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

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NOTE: Where multiple engine-generator sets of different sizes or applications are to be provided, a Parameter Schedule should be shown on the contract drawings (one for each engine-generator set to be installed). If only one engine-generator set is provided (or multiples of the same type, size, etc.), the schedule may be in the body of the

specification. Note that the specifications refer to the Engine Generator parameter Schedule and the designer must provide one each by that name.

Power Ratings and Industry Terminology. The following definition is from the Electrical Generating Systems Association Standard 101P, Engine Driven Generating Sets. Stationary diesel-engine-driven electric generator sets are divided into the following four rating categories: EMERGENCY STANDBY, LIMITED RUNNING TIME, PRIME POWER, and INDUSTRIAL.

"EMERGENCY STANDBY RATING means the power that the generator set will deliver continuously under normal varying load factors for the duration of a power outage". It must be understood that this definition uses the term "normal varying load conditions". Most manufacturers use this terminology to indicate that their units typically are not rated for continuous operation at the nameplate rating, but rather that the units provided are rated for continuous operation at 70 to 80 percent of their nameplate rating, with periodic loading up to 100 percent of the nameplate rating for short (cyclical) periods during a power outage. Additionally, the designer must analyze the load characteristics and profiles of the load to be served to determine the peak demand, maximum step load increase and decrease, motor starting requirements represented as starting kVA, and the non-linear loads to be served. This information should be included in the engine-generator set parameter schedule or on the drawings for each different unit provided. For this application service load is the peak estimated loading to be placed on the engine generator set. Peak demand calculation provides a figure from which to determine the service load. When specifying a genset be sure to specify what the peak load is and how much is continuous.

Power Factor. Commercial genset power ratings are usually based on 0.8 power factor. Select 0.8 unless the application requires one more stringent.

Motor Starting Load. Motor starting requirements are important to properly size engine generator sets because the starting current for motors can be as much as six times the running current, and can cause generator output voltage and frequency to drop, even though the genset has been sized to carry the running load. The designer must analyze the motor loads to determine if the starting characteristics of a motor or a group of motors to be started simultaneously will cause objectionable genset performance. Provide a starting kVA value for the largest motor or combination of motors to be started simultaneously. An increase in the size rating of the genset may be necessary to compensate for the inrush current. This assists the genset supplier in properly sizing the engine generator set.

Maximum Speed. The maximum allowable speed is 1800 RPM. If there is no specific requirement or user requirement for slower speed machines, select 1800 RPM.

Heat Exchanger Type. Fin-tube exchangers (radiators) are the predominate method of cooling. Specify either a fin-tube or a shell-tube heater exchanger for each engine-generator set. Heat exchangers located remote from the engine-generator set (i.e., not mounted on the engine-generator set base) shall be shown on the project plans, including the power source for associated fans and pumps.

Governor. The type of governor to be used on each engine generator set should be identified as isochronous or droop on the engine-generator set parameter schedule. Isochronous governors hold frequency at the setpoint frequency (within bandwidth) for all steady state loads from 0 to 100 percent load and are required for applications where severe demands are made on voltage and frequency regulation. Droop governors allow frequency to droop to the specified percentage proportional to steady state loads from 0 to 100 percent load and are generally acceptable for general purpose and commercial applications.

Engine-generator sets in stand alone service (isolated bus) may utilize either droop or isochronous governors. The designer should analyze the application and loads to determine if the more expensive isochronous unit is actually required. Droop units provide added stability (less engine cycling) in single unit applications where constant speeds are not critical and are less expensive than isochronous governors.

Frequency Bandwidth. Governor frequency bandwidth defines the allowable steady state variation in frequency and is typically quite small for commercially available governors (typically less than ± 0.4 percent with ± 0.25 percent readily available). The predominant type of device loads which are susceptible to steady state frequency deviations less that ± 0.4 percent are those which employ switching power supplies (computers and variable frequency drives). The designer should select the least restrictive value for bandwidth for the application.

Voltage Regulators. Solid state regulators are easily available which maintain the voltage level (regulation or voltage droop) to ± 0.5 percent. Voltage regulator bandwidth is important relative primarily to transient response. EGSA Standard

100R-1992 defines three performance classes for voltage regulators: standard (2 percent bandwidth); high (1 percent bandwidth); and precision (0.5 percent bandwidth). Select the least restrictive bandwidth necessary to satisfy the application requirement.

Generator frequency, and voltage should be shown on the engine-generator set schedule. (For example: 60 Hz, 208Y/120 volts, 3-phase, 4-wire).

Subtransient Reactance. The subtransient reactance of a generator is the impedance characteristic which determines current during the first cycle after a system short circuit condition is presented to the generator. Therefore, it is used to determine the necessary interrupting capacity of the genset circuit interrupting device. It also is utilized to predict generator response to non-linear loads. Typical values for generator subtransient reactance are found in IEEE Std 141. Subtransient reactance is specified in per unit of the generator rated kVA. Also, see the following discussion on non-linear loads.

Non-linear Loads: Non-linear loads are addressed in IEEE 519. They are loads that draw a non-sinusoidal current wave form when supplied by a sinusoidal voltage source. Typical non-linear loads include solid state switching power supplies, computer power supplies (including those found in desktop PC's, uninterruptible power supplies, variable frequency drives, radar power supplies, and solid state ballasts in florescent light fixtures. They cause distortion of the source voltage and current waveforms that can have harmful effects on many types of electrical equipment and electronics, including generators. Non-linear loads are similar to short circuits in that they provide momentary, sub-cycle-duration, short-circuiting of two phases. Switching power supplies consist of SCR/thyristors-controlled rectifier bridges which act as three single-phase loads, each connected across two phases of the power system. When the SCR/thyristors are switched on and off a notch in the voltage waveform will occur as a result of an instantaneous phase-phase short-circuit during the commutation of current. A low generator subtransient reactance minimizes the voltage waveform distortion in the presence of such loads. For this reason, when the non-linear loads comprise 25 percent or more of the loads served, the generator subtransient reactance should be limited to more than 0.12.

Generators are particularly vulnerable to control problems and instability, excessive winding heating, neutral overheating, reduced efficiency, reduced torque, shaft fatigue, accelerated aging, and induced mechanical oscillations when non-linear loads are applied without careful consideration of the generator's capability to supply them. Measures which can be used to mitigate the effects of non-linear loads on generators include: procurement of low impedance generators with special windings to compensate for the additional heating; installation of harmonic filter traps; avoidance of self-excited generators; use of 2/3 pitch factor (rather than 5/6 pitch) generator windings; and generator derating with oversized neutrals.

For large non-linear loads, filter traps which are tuned to the dominant harmonic frequencies of the non-linear loads should be procured/provided with the load component. This approach is normally less costly than procurement of specially designed or derated generators.

For combinations of linear and non-linear loads where the percentage of non-linear loads is small relative to the capacity rating of the generator (25 percent or less), standard generator configurations are normally acceptable.

Provide a list of the non-linear loads in the parameter schedule either on the drawings (and denoted on the single-line diagram) or in tabular form in the specification section. The list should contain a description of the load including equipment type, whether the rectifier is 6-pulse or 12-pulse, kVA rating, and frequency. Provide a linear load value (kVA @ PF) which represents the maximum linear load demand when non-linear loads will also be in use. The generator manufacturer will be required to meet the total harmonic distortion limits established in IEEE 519. Delete the non-linear load paragraph when non-linear loads are not served from the engine-generator set.

Maximum Step Load Increase. Maximum step load increase is used to account for the addition of block loads. This affects engine-generator set frequency and voltage output and usually initiate governor and regulator response. The change in engine-generator set output and the response of the governor and regulator defines the transient loading response. In the size range covered by this specification (and for standby applications) acquisition of full load in one step is typical for major genset manufacturers (voltage deviation of 30 percent or less, frequency deviation of $\pm$ 5 percent, recovery time 3 to 5 seconds, typical). If the application requires a more stringent response, specify the actual maximum step load and add the allowable deviations and recovery times to the Engine Generator Set Parameter Schedule. If it is critical enough to add these requirements, also add the Transient Response Test from Section

26 32 15.00 10 DIESEL-GENERATOR SET STATIONARY 100-2500 KW, WITH AUXILIARIES, to verify the results in the field. It should be noted that this adds significant cost to the cost of a genset.

Transient Recovery Criteria (short time duration). Genset response and recovery times vary according to the size of the set, the block load, and the controls specified. Normal response to addition of a block load will include dips in either output voltage or frequency or both and possible "overshoot" as the governor and voltage regulator respond to bring the voltage and frequency back within bandwidth. Normal response to lose of a block load will include an upward spike in output voltage or frequency back within bandwidth. The Maximum Voltage and Frequency deviation apply to undervoltage/underfrequency ("dips") from the addition of block loads and any undershoot resulting from the recovery of an upward spike, as well as overvoltage/overfrequecy (upward spikes) from the loss of block loads and any overshoot resulting from the recovery of a dip.

Cost Impact. If stringent transient-response requirements are specified the manufacturer may select engine and generator models which have nominal rating much larger than the service load; may use an unnecessarily expensive governor; and may use a higher inertia flywheel. The designer should investigate what may actually be provided so that the cost estimate will be reasonably accurate and to confirm the selected transient requirements are not unnecessarily stringent. A maximum size for the engine-generator set may be needed to avoid the problems associated with a small load on a large capacity set.

The designer must determine the cost benefits of providing an uninterruptible power system for transient ride-through versus purchasing a generator with stringent transient response requirements. In determining the allowable voltage and frequency variation and recovery times, analyze the effects on equipment performance and recovery. Consult the NEMA utilization equipment standards to determine the maximum allowable voltage dips/overshoots (excursions).

Maximum Voltage Deviation. select 5 percent Maximum Voltage Deviation option only if communication equipment or other sensitive electronic equipment are a critical part of the load, and there is no UPS provided. Fluorescent lights can tolerate a maximum of 10 percent voltage variation. NEMA induction motors and control relays can tolerate a maximum of 10 percent variation, for 30 cycles and one cycle respectively. Solenoids (brakes, valves, clutches) and ac & dc starter coils can tolerate a maximum of minus 30 percent variation, for 1/2 cycle, 2 cycles (dropout), and 5 - 10 cycles (dropout) respectively. (The times listed in cycles are not given to define the recovery time back to bandwidth, but to assist the designer in defining the maximum allowable voltage deviation.) The designer should realistically assess the need for limiting the transient voltage dip to less than 30 percent.

Maximum Voltage Deviation with Step Load Increase	[5] [10] [30] [_____] percent of rated voltage.

Maximum Frequency Deviation. Computers can usually tolerate only ± 0.5 Hz variation, so an UPS is normally required where computer service should not be interrupted, or where system recovery times are critical. Inverters can tolerate ± 2 Hz variation. NEMA induction motors and control relays can tolerate a maximum of 5 percent frequency variation. (The times listed in cycles are not given to define the recovery time back to bandwidth, but to assist the designer in defining the maximum allowable frequency deviation.) The designer must be realistic in assessing the needs of the facility to be served so that unnecessarily stringent requirements are not specified.

Maximum Frequency Deviation with Step Load Increase	[2.5] [5] [_____] frequency.

Recovery Time Back to Bandwidth. The designer should determine the required recovery time for the loads served. The recovery time to bandwidth is not critical to operation of most equipment if the voltage and frequency do not deviate from the critical limits, or if momentary interruption is acceptable to the loads being served. The primary importance of this requirement is to ensure that the engine generator set recovers and stabilizes after load changes. Most engine generator sets can respond to 100 percent block loads ;and return to voltage and frequency bandwidths within 15 - 20 seconds, depending on the size of the machine (RPM, relative mass of the rotating elements, and ambient conditions).

Transient Recover Time with Step Load Increase (Voltage).	[_____] seconds
Transient Recovery Time with Step Load Increase (Frequency).	[_____] seconds

Maximum Step Load Decrease (without shutdown). An engine generator set should be capable of being unloaded in a single step without tripping offline. In these situations the voltage and frequency transients are of no concern because there is no load being served.

Nominal Step Load Decrease. Step load decrease is used to account for dropping of block loads. This affects engine-generator set frequency and voltage output and usually initiates governor and regulator response. The change in engine-generator set output and the response of the governor and regulator defines the transient loading response. Where the load served may be sensitive to voltage and frequency variation due to significant load decrease, included the items below in the Parameter Schedule. The Nominal Step Load Decrease provided the genset manufacturer with the information necessary to set the governor response for load decreases such that an overspeed (over-frequency) condition does not occur. The cost of engine-generator sets increase by large percentages for smaller frequency and voltage deviations from bandwidth and improved recovery times. Carefully analyze the user's need for restrictions on frequency, voltage, and waveform characteristics. If required add the following to the Engine Generator Set Parameter Schedule and also add the Transient Response Test from Section 26 32 15.00 10 DIESEL-GENERATOR SET STATIONARY 100-2500 KW, WITH AUXILIARIES to verify the results in the field.

Nominal Step Load Decrease at [_____] PF	[25] [50] [75] percent of Service Load
Transient Recovery Time with Step Load Decrease (Voltage)	[_____] seconds
Transient Recovery Time with Step Load Decrease (Frequency)	[_____] seconds
Maximum Voltage Deviation with Step Load Decrease	[5] [10] [30] [_____] percent of rated voltage
Maximum Frequency Deviation with Step load Decrease	[2.5] [5] [_____] percent of rated frequency

Maximum Time to Start and Assume Load. Choose 10 seconds for emergency-standby applications (critical for life safety), NFPA 70 requires that standby engine-generator sets used in emergency applications start and assume load in 10 seconds. Most commercially available engine generator sets are capable of starting and assuming load within 10 seconds, however, a default value of 20 seconds is non-restrictive and provides a reasonable maximum value for non-critical applications.

Temperature Management. The designer is responsible for temperature control in the space occupied by the engine generator set. However, because the genset supplier normally provides the engine cooling system (and block heaters where required), the designer must provide ambient conditions under which the engine generator must operate, so that the supplier can size the equipment. Typically, high temperature provides the most restrictive condition, therefore the designer must design air-flow of adequate temperature and sufficient quantity to maintain the temperature of the generator and engine space within acceptable limits. This requires the designer to consult manufacturers literature and/or representatives to determine the nominal heat rejection to the surroundings at rated capacity (from all heat sources) to determine the required cooling or air flow through the engine generator set room or enclosure. In turn the manufacturer must submit the specific operating data in order for the Contracting Officer and designers to verify that the proposed equipment meets the design parameters.

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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.)]
Frequency Bandwidth percent (steady state)	± [_____] [0.4] [0.25]
Voltage Regulation (No load to full load)	± 2 percent (max.)

ENGINE GENERATOR PARAMETER SCHEDULE	
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/hr
Max Summer Outdoor Temp (Ambient)	[_____] degrees CF
Min Winter Outdoor Temp (Ambient)	[_____] degrees CF
Installation Elevation	[_____] above sea level

1.2.2 Output Capacity

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NOTE: The service load for each genset should be shown on the Engine-Generator Parameter Schedule. The designer has control over the service load. The Contractor through the supplier's manufacturer/assembler has control of the efficiency and associated ancillary equipment loads.

****

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

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NOTE: If the engine-generator set is to be installed out-of-doors, include requirement for the weatherproof enclosure in the engine-generator set schedule. Define corrosion resistance and/or material required for the environment. Provide structural loading required for the geographic area (wind loads, snow loads, etc.). A generator set enclosure may also be needed to mitigate excessive noise caused by the engine generator set mechanical components. Delete the reference to mechanical noise limitations if an enclosure is not needed to mitigate sound emissions. If a sound enclosure is not provided, the designer must provide a design to prevent excessive noise (meet OSHA requirements. Delete this paragraph if no engine-generator set enclosure is needed.
****

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

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NOTE: See UFC 3-450-02, Power Plant Acoustics, and UFC 3-450-01, Noise and Vibration Control For Mechanical Equipment for vibration criteria. Choose between a vibration-isolation system and the manufacturer's standard mounting. Vibration isolation systems should be applied where vibration transmitted through the generator set support structure produces (either directly or by resonant frequencies of structural members) annoying or damaging vibration in the surrounding environment. Select the manufacturer's standard or provide the maximum allowable vibration force necessary to limit the maximum vibration. Delete the vibration isolation requirement for applications where vibration does not affect the floor or foundation.
****

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. [Install a vibration-isolation system between the floor and the base to limit the maximum vibration transmitted to the floor at all frequencies to a maximum of [_____] (peak force).] [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

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NOTE: Review submittal description (SD) definitions in Section 01 33 00 SUBMITTAL PROCEDURES and edit the following list to reflect only the submittals required for the project.

The Guide Specification technical editors have designated those items that require Government approval, due to their complexity or criticality, with a "G." Generally, other submittal items can be reviewed by the Contractor's Quality Control System. Only add a "G" to an item, if the submittal is sufficiently important or complex in context of the project.

For submittals requiring Government approval on Army projects, a code of up to three characters within the submittal tags may be used following the "G" designation to indicate the approving authority. Codes for Army projects using the Resident Management System (RMS) are: "AE" for Architect-Engineer; "DO" for District Office (Engineering Division or other organization in the District Office); "AO" for Area Office; "RO" for Resident Office; and "PO" for Project Office. Codes following the "G" typically are not used for Navy, Air Force, and NASA projects.

Choose the first bracketed item for Navy, Air Force and NASA projects, or choose the second bracketed item for Army projects.
****

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for [Contractor Quality Control approval.] [information only. When used, a designation following the "G" designation identifies the office that will review the submittal for the Government.] Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-02 Shop Drawings

Detailed Drawings[; G][; G, [_____]]
Acceptance[; G][; G, [_____]]

SD-03 Product Data

Manufacturer's Catalog
Instructions[; G][; G, [_____]]
Experience
Field Engineer
Site Welding
General Installation
Site Visit

SD-05 Design Data

Sound Limitations[; G][; 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][; 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
Maintenance Manual
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 WELDING, STRUCTURAL. 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 manufacture/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

****
NOTE: Provide seismic requirements, if a Government designer (either Corps office or A/E) is the Engineer of Record, and show on the drawings. Delete the bracketed phrase if no seismic details are provided. Pertinent portions of UFC 3-310-04 and Sections 13 48 00, 13 48 00.00 10, and 26 05 48.00 10, properly edited, must be included in the contract documents.
****

Seismic requirements shall be in accordance with UFC 3-310-04 and Sections 13 48 00 SEISMIC PROTECTION FOR MISCELLANEOUS EQUIPMENT, 13 48 00.00 10 SEISMIC PROTECTION FOR MECHANICAL EQUIPMENT and 26 05 48.00 10 SEISMIC PROTECTION FOR ELECTRICAL EQUIPMENT [as shown on the drawings].

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, piping 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 onsite tests.

1.6.1 Operation Manual

Provide [three] [_____] copies of the [manufacturers standard operation manual] [operation manual in 216 by 279 mm 8-1/2 by 11 inch three-ring binders]. 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 [manufacturers standard maintenance manual] [maintenance manual containing the information described below in 216 x 279 mm 8-1/2 x 11 inch three-ring binders]. 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

****

NOTE: Delete any equipment not applicable to the project.

****

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).

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 nameplate information may be provided in the maintenance manual in lieu of nameplates.

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

a. Pipe Flanges and Flanged Fittings: ASTM A181/A181M, Class 60, or ASME B16.5, Grade 1, Class 150.

b. Pipe Welding Fittings: ASTM A234/A234M, Grade WPB or WPC, Class 150, or ASME B16.11, 1360.7 kg 3000 lb.

c. Threaded Fittings: ASME B16.3, Class 150.

d. Valves: MSS SP-80, Class 150.

e. Gaskets: Manufacturers Standard.

2.3.6 Pipe Hangers

MSS SP-58 and MSS SP-69.

2.3.7 Electrical Enclosures

2.3.7.1 General

NEMA ICS 6.

2.3.7.2 Panelboards

NEMA PB 1.

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

****
NOTE: Specify fuel type if different from No. 2 diesel.
****

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 opposed-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

****

NOTE: The auxiliary fuel pump is required to support the main pump if the length of pipe from the day tank to the main pump is greater than the value recommended by the engine manufacturer. This value may be approximately 12m (40 feet); however, engine manufacturers should be consulted during design to verify the pumping requirements.

****

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

****

NOTE: Delete this paragraph if an integral main fuel storage tank is not desired.

An integral main fuel storage tank will be the only fuel source for the engine. These tanks may be useful for applications that require a minimal fuel storage capacity.

Due to the minimal storage capacity, integral main fuel storage tanks are not practical for prime power usage. They are also not practical for standby units that require large fuel quantities. The designer should consider the availability and anticipated frequency of fuel truck deliveries when deciding whether or not to use an integral main fuel storage tank. These tanks should also not be used in locations where a truck fueling hose can not reach the diesel generator set.

See NFPA 99 and NFPA 110 for guidance on fuel tank sizes.

See NFPA 37 restrictions on allowable tank sizes and enclosures. Integral tanks allow for 1 to 8 hours of operation depending on diesel generator size and configuration. Consult generator set manufacturer for the proper hours of operation for the application of integral tanks. Standby applications for use with fire pumps will have tanks sized for 8 hours duration. The tank can be sized by the designer or the Contractor. The size of the tank should be based on a fuel flow rate that is equal to the value of a typical engine manufacturer for the indicated engine generator size. A value of 200 percent of the expected fuel consumption of the engine is not unusual for the flow rate of the main fuel pump. Since the excess fuel will be returned to the tank, the designer should consider the impact of heat buildup when sizing the tank. If a fuel oil cooler is not used, the day tank size may need to be increased to properly dissipate the heat absorbed by the fuel.

****

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 weatherproof 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 [as shown] [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

****

NOTE: Delete this paragraph if an integral main fuel storage tank is used.

See NFPA 37 restrictions on allowable day tank sizes and enclosures. Select either self-supporting or integral day tank. Select the first option below for applications where fuel is returned to the day tank. Select the second option below for applications where fuel is returned to the main tank. Integral day tanks allow for 1 to 8 hours of operation. Consult generator set manufacturer for the proper hours of operation for the application of integral day tanks. Standby applications for use with fire pumps will have day tanks sized for 8 hours duration. Select day tank capacity for either prime or standby application. The day tank can be sized by the designer or the Contractor. The size of the day tank should be based on a fuel flow rate that is equal to the value of a typical engine manufacturer for the indicated engine generator size. A value of 200 percent of the expected fuel consumption of the engine is not unusual for the flow rate of the main fuel pump. The excess fuel may be returned to the day tank or main fuel tank. The designer should also consider the impact of heat build up when sizing the day tank. If a fuel oil cooler is not used or if fuel is returned to the day tank, the day tank size may need to be increased to properly dissipate the heat absorbed by the fuel.

****

Each engine shall be provided with [a separate self-supporting][integral] day tank. [Each day tank shall be provided 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. A fuel return line cooler shall be provided 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. A temperature sensing device shall be installed in the fuel supply line.] [Each day tank shall be provided with connections for fuel supply line, fuel overflow line, local fuel fill port, gauge, vent line, drain line, and float switch assembly for control.] 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 [as shown] [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

Each local fuel fill port on the day tank shall be provided 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. [When the main storage tank is located higher than the day tank, open the solenoid valve located on the fuel supply line entering the day tank and start the supply of fuel into the day tank] [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. [When the main storage tank is located higher than the day tank, stop the supply of fuel into the day tank and close the solenoid valve located on the fuel supply line entering the day tank] [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

****

NOTE: Select between integral and self supporting day tanks. Also, select between applications where the main fuel storage tank is located above the day tank and applications where the main fuel storage tank is located below the day tank. The location of

all tanks, piping, and valves should also be indicated on the drawings.
****

[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.] [Self-supporting day tank shall either be arranged so that the fuel level in the day tank remains above the suction port of the engine driven fuel pump or be provided with a transfer pump to provide fuel to the engine driven pump. The overflow connection and fuel supply line 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

****
NOTE: Delete this paragraph if an integral main fuel storage tank is used.
****

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

****
NOTE: Coordinate with paragraph SYSTEM DESCRIPTION.
****

Each engine cooling system shall operate automatically while the engine is running. Each cooling system shall be sized for the maximum summer [outdoor] [indoor] 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][cooling air].

b. The maximum allowable temperature rise in the [coolant fluid through the engine][cooling air across 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 manufacturers 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)

****
NOTE: Keep this paragraph and delete the next paragraph, if required by the project.
****

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

****
NOTE: Keep this paragraph and delete paragraph above, if required by the project.
****

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 manufacturers 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

****
NOTE: Delete this paragraph if a shell and U-tube type heat exchanger is not needed.
****

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 31 13.00 40 METAL DUCTS] [23 00 00 AIR SUPPLY, DISTRIBUTION, VENTILATION, AND EXHAUST SYSTEMS] [23 35 19.00 20 INDUSTRIAL VENTILATION AND EXHAUST] 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

****

NOTE: The designer must perform an analysis in accordance with UFC 3-450-01 NOISE AND VIBRATION CONTROL and UFC 3-450-02 POWER PLANT ACOUSTICS. The designer must consider air intake, exhaust, and diesel generator casing noise. The designer must also coordinate with the architect for proper material selections for the sound transmittance characteristics of the mechanical equipment room and adjacent areas. The designer should consider sound within the equipment room, adjacent areas and building exterior. Acceptable sound levels will vary depending on the function of the space. As a minimum the design should comply with the following OSHA safety requirements; however, more stringent sound restrictions may be required to met the functional requirements of the occupied spaces.

Frequency Band (Hz)	**Maximum Acceptable Sound Level (Decibels) Industrial**	**Residential**
20-75	**87**	**81**
75-150	**77**	**71**
150-300	**70**	**64**
300-600	**64**	**58**
600-1,200	**61**	**55**
1,200-2,400	**60**	**54**
2,400-4,800	**60**	**54**
4,800-10 kHz	**62**	**56**

Typically, the diesel generator manufacturer can

provide information concerning the noise generated by the diesel generator in a free field environment. The manufacturer does not have control over any other building parameters or additional mechanical equipment noise. Therefore the designer should indicate the required sound limits for each of the indicated octave bands for the sound pressure level of the diesel generator set operating at 100 percent load in a free field. The designer should develop these numbers based on the desired sound levels that should exist at various locations after the generator is installed. This information should be based on the values used in the acoustical analysis and verified by coordination with equipment manufacturers during design. In some cases, a sound attenuated enclosure may be needed to achieve the desired result.

The designer should also indicate the desired sound pressure levels that will be measured in the field. The pressure levels should be based on the acoustical analysis and should consider the specified operating conditions of the diesel generator operating in a free field, other mechanical equipment, the building's sound absorption characteristics, OSHA requirements, and the building's functional requirements. The location of the measurement points for the installed diesel generator should be coordinated with the SAFETY RUN TEST paragraph. Modify the radial distance requirement from the engine, air-intake, and exhaust to account for obstructions, variations in site conditions, building configurations or indicate points on the contract drawings at which measurements are to be made.

****

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	[_____]

Frequency Band (Hz)	Maximum Acceptable Pressure Level (Decibels)
500	[____]
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] [10.7] [_____] m [75] [35] [_____] 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][rubber].

2.10 EXHAUST SYSTEM

****
NOTE: Include on the drawings a detail of the exhaust piping that penetrates building construction such as walls or roof.
****

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 connector 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

****
NOTE: Muffler locations and mountings shall be shown on the drawings.
****

A chamber type exhaust muffler shall be provided. The muffler shall be constructed of welded steel and designed for [outside] [inside] [vertical] [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

****
NOTE: Exhaust piping shall be sized at a gas velocity of less than 25.4 m/second (5000 fpm). Piping should be shown on the drawings.
****

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

****
NOTE: The designer will coordinate emissions requirements with the installation (base/post) environmental office and provide a listing of the requirements. The identification of environmental requirements should be identified at the beginning of the project as a special study effort which requires funding separate from the normal design.
****

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

****
NOTE: Select the first option for emergency applications and delete subsequent paragraphs. Select second option for all other standby applications.
****

[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.] [The starting system for engine generator sets used in non-emergency applications shall be 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 [manual starting] [and] [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][indoor] 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

****

NOTE: Select nickel-cadmium when the battery temperature cannot be maintained above minus 6 degrees C (22 degrees F).

****

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 [lead-acid][nickel-cadmium] type, with sufficient capacity, at the minimum [outdoor][indoor] winter temperature specified to provide the specified cranking periods. Valve-regulated lead-acid batteries are not acceptable.

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 equalize 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

****

NOTE: Jacket coolant heaters are normally provided for most applications to aid starting. Some manufacturers may require glow plugs for combustion air temperatures significantly below 0 degrees C (32 degrees F); however, use if these alone do not ensure NFPA availability in the application size range. Consult manufacturers for availability in the application size range.

****

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

****
NOTE: Coordinate with paragraph Engine Generator Parameter Schedule.
****

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.] [Droop governors shall maintain the midpoint of the frequency bandwidth linearly for steady-state loads over the range of zero to 100 percent of rated output capacity, with 3 percent droop.]

2.14 GENERATOR

****
NOTE: Armature and field winding insulation classes are specified based on the allowable temperature rise (the temperature in the windings above the temperature of the air used to cool the windings). See NEMA MG 1 for a discussion of the classes with respect to size range, elevation, method of measurement, and ambient temperature. Select the class insulation for each application based on operating conditions. Class F is considered industry standard. If a different class is required for different machines, specify the one for each application in the parameter schedule for the respective generator set.
****

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][Class F]. 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

****

NOTE: Generator protection shall be based on the application and size of the generator and should comply with the recommendations of IEEE 242 and IEEE Std 446 for both generator breaker features and protection schemes. See AFMAN 32-1077 for recommended protection schemes for Air Force projects. The designer must perform a power system coordination study (reference UFC 3-520-01) to specify the breaker ratings, breaker trip unit features and settings, relay protection scheme, and relay settings for coordination for each generator set installed. The configuration should always include a disconnecting means for taking clearance on the generator for maintenance purposes. If the scope of protection is small the designer may elect to delete the paragraphs in this section and reference Section 26 28 01.00 10 COORDINATED POWER SYSTEM PROTECTION. Show panelboard ratings on the contract drawings for each generator set. Rating information should include voltage, phase, bus continuous capacity (amperes), bus withstand capacity (amperes) (see NEMA PB 1 for necessary rating information). Show breaker frame, trip, and interrupting ratings on the contract drawings.

Surge capacitors and surge arresters should be provided when the sets are to be connected to exposed overhead lines directly or through transformers, even though connection may be only for transfer of load without service interruption. Surge arrester protection is not required where sets serve single buildings isolated from overhead lines by automatic or manual transfer switches where provision has been made to prevent simultaneous connection to both sources. The designer will specify the surge arrester rating.

Fuse and circuit breaker ratings should be shown on the contract drawings. Show voltage, phase, continuous current (ampere), short circuit withstand, interrupting, neutral size, etc.

****

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 [as shown][full capacity]. Enclosure designs, construction, materials and coatings shall be [as indicated][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][as indicated]. 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

****

NOTE: High dB levels are required for alarms located near engine. Specify over 100 dB for engine room application and show alarm location.

****

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

****

NOTE: The designer must provide design features in accordance with the requirements of NFPA 70, NFPA 99 for medical facilities. The designer must provide design features in accordance with the requirements of NFPA 70 and NFPA 110 for emergency and standby applications. For emergency and standby applications select either Level 1 or Level 2. Level 1 defines the most stringent equipment performance requirements for applications where the failure of the equipment to perform could result in loss of human life or serious injury. Level 2 defines equipment performance where failure of the equipment to operate is less critical to human life. Edit the table to include all required shutdowns and alarms. Delete optional alarms which are not required. Delete all columns except the first column, the appropriate code reference column, and the column that shows Corps of Engineers required alarms/controls. Add necessary parameters to define critical limits for alarms or shutdown.

The designer should remove all references to day tanks if integral main fuel tanks are used.

The designer should remove all references to integral main fuel storage tanks if day tanks are used.

The following alarms are standard offerings of one or more manufacturers (Kohler, Caterpillar, Cummins - Onan, Detroit Diesel). They are not required by NFPA, but may be added if there is a specific requirement. Please note that some are not typically offered by three or more manufacturers, and may constitute a sole-source requirement.

Device/Condition/ Function	Action/Location/ Function	No. of Manufacturers Offering
Low Coolant Level	SD/CP VA	3
Overvoltage Protection Shutdown	SD/CP VA O	3
Underfrequency	SD/CP VA	1
Undervoltage	SD/CP VA	1
Magnetic Pickup Failure	SD/CP VA	1
Overcurrent	SD/CP VA	1
Short Circuit	SD/CP VA	1
Auxiliary Fault Alarm	CP VA	1
Audible Alarm	CP AA	1
Overcurrent	CP VA	1
Oil Pressure Sender Fault	CP VA	1
Weak Battery	CP VA	1

****

Provide a local alarm panel with the following shutdown and alarm functions [as indicated] [in accordance with [NFPA 99] [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% (+ 2%) 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% 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% volume remaining)	Corps of Engineers Required				
Alarms					

Device/ Condition/ Function	What/Where/ Sizes	NFPA 99	NFPA 110 Level 1	NFPA 110 Level 2	Corps of Engineers Required
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% 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 setpoints, and the tolerance (plus and/or minus) at which the device activates the alarm or action.

2.18.6 Remote Alarm Panel

****
NOTE: The Remote Alarm Panel should be shown on the drawings. Delete remote alarm panel where not required. Select the first option if the application is a prime power plant. For prime power units provide panel elevations depicting desired configurations, together with a listing of alarms and instruments. Select the second option for engine generator sets utilized in emergency or standby applications. The designer must provide design features in accordance with the requirements of NFPA 70, and NFPA 99 for medical facilities. The designer must provide design features in accordance with the requirements of NFPA 70 and NFPA 110 for emergency and standby applications. A remote panel is required for NFPA 99 and for NFPA 110, Level 1 applications. A remote panel is not required for NFPA 110, Level 2 applications. Edit the table to include all required alarms. Delete optional alarms which are not required. Delete all columns except the first column and the appropriate code reference column. Add necessary parameters where required to define critical limits for alarms.
****

[A remote alarm panel shall be provided as indicated.] [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

Device/ Condition/ Function	What/Where/Size	NFPA 99	NFPA 110 Level 1	NFPA 110 Level 2
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				
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

****

NOTE: Delete the remote control (control room) panel if the application is not a prime power

application. Provide plan and elevation drawings of the remote control panels for prime power applications, depicting specific devices, instrument, and meters, including layouts. Generator circuit breaker controls with position indication may be added if required (Not available for standard molded-case breakers. Use only for power circuit breakers or switchgear).

Edit the table to include all required devices. Delete all columns except the first column and the appropriate reference columns (always delete "MFG Offering" column).

A remote stop switch is required by NFPA 37 for 100 hp and above engines, and by NFPA 110 for both Level 1 and Level 2 applications. A remote fuel shutoff switch, and a remote lube-oil shutoff switch are required by NFPA 37 for 100 hp and above engines. Delete the remote fuel shutoff switch, and a remote lube-oil shutoff switch where not required.

****

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

Device/ Condition/ Function	Corps Requiremen	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

Device/ Condition/ Function	Corps Requiremen	NFPA 110 Level 1	NFPA 110 Level 2	MFG Offering
Controls				
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

****

NOTE: Delete the remote (control room) panel if the application is not a prime power application. Provide plan and elevation drawings of the remote panels for prime power applications, depicting specific devices, instrument, and meters, including layouts. Edit the table to include all required devices. Delete optional devices that are not required for the application. Delete all columns except the first column and the appropriate reference column (always delete the "MFG Offering" column). Add any necessary parameters to define devices required. A fuel meter display should be added for prime rated applications. A fuel header pressure display should be added for prime rated applications. Delete the pyrometer devices for sets smaller than 200 kW, KWh, kVAR, power factor meters and reverse power indication may be added as required.

The following instruments may be added as required.

Indicating VAR meter. Power-factor meter, indicating. (Specify one of these. They are normally used only for prime applications, however can be specified for standby units as required.)

Indicating wattmeter. (Normally used only for prime applications, however can be specified for standby units as required.)

Totalizing Kilowatt-hour meter with 15 or 30 minute demand register. (Normally used only for prime applications, however can be specified for standby units as required.)

Recording Kilowatt-hour/demand meter. (Normally used only for prime applications, however can be specified for standby units as required.)

The 15-minute demand register is preferred to the 30-minute register in most cases, because it permits more accurate timing of facility peak load occurrence.

Delete Frequency and Volt meters if a Synchronizing Panel is provided.

****

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

****
NOTE: Panels, except the remote panel, can be combined into a single panel paragraph.

Provide a panel-mounting location and detail for panels not mounted on the generator set base. The designer may elect other locations such as adjacent to engine generator set; in the generator enclosure; or in or on the switchgear enclosure.

Provide panel nameplate and instrument nameplate unique identifiers or user preferred identifiers. Provide sizes, materials, and attachment preferences.

Delete either the "standard panel" or "electronic panel".
****

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] [as shown]. 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

****
NOTE: Delete locking mechanism when not required.
****

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

****

NOTE: Delete the exerciser when it is not required. Ensure that the exerciser is compatible with the automatic transfer scheme. It is highly desirable to utilize system loads for generator set exercise loads and to exercise the complete standby system periodically. Coordinate requirements with the user. The designer shall ensure that the design provides warning signs in areas where the engine generator can start automatically.

****

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

****

NOTE: Adapt to fit application and provide desired actuation sequence.

****

Fully automatic operation shall be provided for the following operations: engine-generator set starting and source transfer upon loss of [normal] [preferred] source; retransfer upon restoration of the [normal] [preferred] 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] [preferred] power source and each engine generator set, and control transfer from the [normal] [preferred] source and retransfer upon restoration of the [normal] [preferred] 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.

2.23 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] [[_____] diameter 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 manufacturers 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

****

NOTE: Provide an equipment layout on the plans which provides the clear space for operation and maintenance in accordance with NFPA 70 and IEEE C2. Include requirements for a staging/laydown area for disassembly or removal and replacement of major parts of the generator set. Additionally, it is advisable to provide access to remove the unit and/or major parts of equipment from the room and building either through doors/passageways or

equipment hatches.
****

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 and MSS SP-69. 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

****

NOTE: For Air Force work add that the exterior of all equipment shall be finished in the base standard color.

****

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

3.6 ONSITE INSPECTION AND TESTS

****

NOTE: Delete tests not necessary.

****

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 [_____] 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] [a [_____] power factor]. 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] [90] days prior to testing.

3.6.2.5 Sequence

The sequence of testing shall be as specified in the approved testing plan unless variance in 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

****
NOTE: Coordinate the construction test requirements with the other specification sections to eliminate redundant tests and provide additional reference to necessary 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

****
NOTE: Delete ground resistance test where covered by other project specifications, or where no grounds are installed.
****

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] [distribution bus] [_____]. 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 in megohms = (rated voltage in kV + 1) x 304,800/(length of cable in meters).

(2) (R in megohms = (rated voltage in kV + 1) x 1000/(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] [main disconnect switch] [distribution bus]. 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] [each grounding electrode system] [the ground mat] [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 - [_____] ohms.
(3) Ground mat - [_____] 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

****

NOTE: For the sound level tests, modify the radial distance requirement from the engine intake and exhaust to account for obstructions, variations in site conditions, building configurations; or indicate points on the contract drawings at which measurements are to be made.

Delete item w if a day tank is not used.

Add the following test under item x below when over/under frequency alarms are provided. Coordinate the requirement with paragraph Alarm Panels.

x. Manually adjust the governor to speed up the engine to a level beyond the over frequency alarm setpoint and record the frequency when the audible alarm sounds. Manually adjust the governor to slow down the engine to a level below the under frequency alarm setpoint and record the frequency when the audible alarm sounds. Return the speed to the rated value. Shut down the engine-generator set.

****

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

****
NOTE: If contractually possible, specify an ambient temperature for the load run test which is typical for the average maximum temperature. This is the most strenuous operating condition. Specify a month which typically provides the most restrictive operating condition.
****

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

****

NOTE: Substitute manual operation and transfer for automatic operation where automatic operation is not required by the project. Delete automatic loading system where not required. The designer will provide the sequence of operation (load sequences for load acquisition and load shedding) in the design documents.

****

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

****
NOTE: Delete onsite training if not required.
****

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

****

NOTE: The designer should check with the customer to determine if framed instructions can be placed in the project area (requires wall space), and where they are to be placed. Select the 216 x 279 mm (8 1/2 x 11 inches) notebook option where instructions will have to be placed in the genset enclosure or a switchgear cubicle (or other suitable enclosure).

****

[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).] [Two sets of instructions shall be typed in 216 x 279 mm 8 1/2 x 11 inches format, laminated in weatherproof plastic, and placed in three-ring vinyl binders. The binders shall be placed as directed by the Contracting Officer. The instructions shall be in place prior to acceptance of the engine generator set installation. 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; startup 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 --