SECTION 263213.16 - GAS-ENGINE-DRIVEN GENERATOR SETS

Revise this Section by deleting and inserting text to meet Project-specific requirements.

This Section uses the term "Architect." Change this term to match that used to identify the design professional as defined in the General and Supplementary Conditions.

Verify that Section titles referenced in this Section are correct for this Project's Specifications; Section titles may have changed.

1. GENERAL
	* + 1. RELATED DOCUMENTS

Retain or delete this article in all Sections of Project Manual.

* + - * 1. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.
			1. SUMMARY
				1. Section Includes:

Engine.

Gas fuel system.

Control and monitoring.

Generator overcurrent and fault protection.

Generator, exciter, and voltage regulator.

Load bank.

Outdoor generator-set enclosure.

Remote radiator motors.

Vibration isolation devices.

* + - 1. DEFINITIONS

Retain terms that remain after this Section has been edited for a project.

* + - * 1. EPS: Emergency power supply.
				2. EPSS: Emergency power supply system.
				3. LP: Liquefied petroleum.
				4. Operational Bandwidth: The total variation from the lowest to highest value of a parameter over the range of conditions indicated, expressed as a percentage of the nominal value of the parameter.
			1. SUBMITTALS
				1. Submittals for this section are subject to the re-evaluation fee identified in Article 4 of the General Conditions.
				2. Manufacturer’s installation instructions shall be provided along with product data.
				3. Submittals shall be provided in the order in which they are specified and tabbed (for combined submittals).
				4. Product Data: For each type of product.

Include rated capacities, operating characteristics, electrical characteristics, and furnished specialties and accessories.

Include thermal damage curve for generator.

Include time-current characteristic curves for generator protective device.

Include fuel consumption in cubic feet per hour (cubic meters per hour) at 0.8 power factor at 0.5, 0.75 and 1.0 times generator capacity.

Include generator efficiency at 0.8 power factor at 0.5, 0.75, and 1.0 times generator capacity.

Include air flow requirements for cooling and combustion air in cfm at 0.8 power factor, with air supply temperature of 95 deg F, 80 deg F, 70 deg F, and 50 deg F. Provide drawings showing requirements and limitations for location of air intake and exhausts.

Include generator characteristics, including, but not limited to, kilowatt rating, efficiency, reactances, and short-circuit current capability.

* + - * 1. Shop Drawings:

Include plans and elevations for engine generator and other components specified.

Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.

Identify fluid drain ports and clearance requirements for proper fluid drain.

Design calculations for selecting vibration isolators and seismic restraints and for designing vibration isolation bases.

Vibration Isolation Base Details: Detail fabrication including anchorages and attachments to structure and to supported equipment. Include base weights.

Include diagrams for power, signal, and control wiring. Complete schematic, wiring, and interconnection diagrams showing terminal markings for EPS equipment and functional relationship between all electrical components.

* + - * 1. Submittals for this section are subject to the re-evaluation fee identified in Article 4 of the General Conditions.

Coordinate "Qualification Data" paragraph below and as may be supplemented in "Quality Assurance" Article.

* + - * 1. Qualification Data: For [**Installer**] [**manufacturer**] [**and**] [**testing agency**].

Retain "Seismic Qualification Data" paragraph below if required by seismic criteria applicable to Project. Coordinate with Section 260548.16 "Seismic Controls for Electrical Systems." See ASCE/SEI 7 for certification requirements for equipment and components.

* + - * 1. Seismic Qualification Data: Certificates, for engine generator, accessories, and components, from manufacturer.

Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.

Dimensioned Outline Drawings of Equipment Unit: With engine and generator mounted on rails, identify center of gravity and total weight, [**supplied enclosure,**] [**external silencer,**] [**subbase-mounted fuel tank,**] [**skid-mounted load bank,**] and each piece of equipment not integral to the engine generator, and locate and describe mounting and anchorage provisions.

Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.

Coordinate paragraph below with "Source Quality Control" Article.

* + - * 1. Source Quality-Control Reports: Including, but not limited to, the following:

Certified summary of prototype-unit test report.

Certified Test Reports: For components and accessories that are equivalent, but not identical, to those tested on prototype unit.

Retain first subparagraph below for engine generators specified to meet performance requirements and for engine generators serving sensitive loads.

Certified Summary of Performance Tests: Certify compliance with specified requirement to meet performance criteria for sensitive loads.

Report of factory test on units to be shipped for this Project, showing evidence of compliance with specified requirements.

Report of sound generation.

Report of exhaust emissions showing compliance with applicable regulations.

Requirement in subparagraph below is from Section 5.6.10.2 of NPFA 110.

Certified Torsional Vibration Compatibility: Comply with NFPA 110.

Retain "Field quality-control reports" paragraph below if Contractor is responsible for field quality-control testing and inspecting.

* + - * 1. Field quality-control reports.
				2. Warranty: For special warranty.
			1. CLOSEOUT SUBMITTALS
				1. Operation and Maintenance Data: For engine generators to include in emergency, operation, and maintenance manuals.

Include the following:

List of tools and replacement items recommended to be stored at Project for ready access. Include part and drawing numbers, current unit prices, and source of supply.

Operating instructions laminated and mounted adjacent to generator location.

Training plan.

* + - 1. MAINTENANCE MATERIAL SUBMITTALS

Extra materials may not be allowed for publicly funded projects.

* + - * 1. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

Quantities below are examples only.

Fuses: One for every 10 of each type and rating, but no fewer than one of each.

Indicator Lamps: Two for every six of each type used, but no fewer than two of each.

Filters: One set each of lubricating oil, fuel, and combustion-air filters.

Tools: Each tool listed by part number in operations and maintenance manual.

* + - 1. QUALITY ASSURANCE
				1. Installer Qualifications: An authorized representative who is trained and approved by manufacturer.

Retain "Testing Agency Qualifications" paragraph below if Contractor selects testing agency or if Contractor is required to provide services of a qualified testing agency in "Field Quality Control" Article.

* + - * 1. Testing Agency Qualifications: Accredited by NETA.

Testing Agency's Field Supervisor: Certified by NETA to supervise on-site testing.

* + - 1. WARRANTY

When warranties are required, verify with Director’s Representative that special warranties stated in this article are not less than remedies available to Director’s Representative under prevailing local laws.

* + - * 1. Manufacturer's Warranty: Manufacturer agrees to repair or replace components of packaged engine generators and associated auxiliary components that fail in materials or workmanship within specified warranty period.

Verify available warranties and warranty periods for units and components.

Warranty Period: <**Insert number**> years from date of Substantial Completion.

1. PRODUCTS

Manufacturers and products listed in SpecAgent and MasterWorks Paragraph Builder are neither recommended nor endorsed by the AIA or Deltek. Before inserting names, verify that manufacturers and products listed there comply with requirements retained or revised in descriptions and are both available and suitable for the intended applications.

* + - 1. MANUFACTURERS

* + - * 1. [Manufacturers:](http://www.specagent.com/Lookup?ulid=13824) Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:

[Caterpillar, Inc.; Electric Power Division](http://www.specagent.com/Lookup?uid=123457164095).

[Cummins Power Generation](http://www.specagent.com/Lookup?uid=123457164096).

[Generac Power Systems, Inc](http://www.specagent.com/Lookup?uid=123457164098).

Or equal.

* + - * 1. Source Limitations: Obtain packaged engine generators and auxiliary components through one source from a single manufacturer.
			1. PERFORMANCE REQUIREMENTS

Retain "Seismic Performance" paragraph below with "Seismic Qualification Data" paragraph in "Informational Submittals" Article for projects requiring seismic design. Delete paragraph if performance requirements are indicated on Drawings. Model building codes and ASCE/SEI 7 establish criteria for buildings subject to earthquake motions. Coordinate requirements with structural engineer.

* + - * 1. Seismic Performance: Engine generator housing, engine generator, batteries, battery racks, silencers, [**load banks,**]and sound attenuating equipment, accessories, and components shall withstand the effects of earthquake motions determined according to [**ASCE/SEI 7**]<**Insert requirement**>.

Retain first subparagraph below to define the term "withstand" as it applies to this Project. Definition varies with type of building and occupancy and is critical to valid certification. Option is used for essential facilities where equipment must operate immediately after an earthquake.

The term "withstand" means "the unit will remain in place without separation of any parts when subjected to the seismic forces specified[**and the unit will be fully operational after the seismic event**]."

Shake-table testing shall comply with UNIFORM CODE-ES AC156. Testing shall be performed with all fluids at worst-case normal levels.

For life-safety components required to function after an earthquake (such as fire-sprinkler systems, components that contain hazardous content, and storage racks in structures open to the public), the Component Importance Factor is 1.5. For other components, the Component Importance Factor is 1.0 unless the structure is in Seismic Use Group III and component is necessary for continued operation of facility or failure of component could impair continued operation of facility, in which case the Component Importance Factor is 1.5.

Component Importance Factor: [**1.5**] [**1.0**].

* + - * 1. B11 Compliance: Comply with B11.19.
				2. NFPA Compliance:

Comply with NFPA 37.

Comply with NFPA 70.

Retain first subparagraph below for healthcare facilities.

Comply with NFPA 99.

Retain subparagraph below if generator is automatically started. See the Evaluations for discussion of emergency generator level requirements. Level 1 - systems shall be installed where failure of the equipment to perform could result in loss of human life or serious injury. Level 2 - systems shall be installed where failure of the EPSS to perform is less critical to human life and safety.

Comply with NFPA 110 requirements for Level [**1**] [**2**] EPSS.

Do not retain UL 2200 for marine generators, UPS equipment, hazardous or classified locations, or mobile engine generator packages that are covered by the applicable UL standards.

* + - * 1. UL Compliance: Comply with UL 2200.

Retaining Tier 2 or 3 in "Engine Exhaust Emissions" paragraph below is dependent on the size of the engine and generator use. Most emergency engine generators are exempt from Tier 4 requirements unless used to support load while normal power is available. See discussion in the Evaluations and see EPA and manufacturer's documentation.

* + - * 1. Engine Exhaust Emissions: Comply with EPA Tier [**2**] [**3**] [**4**] requirements and applicable state and local government requirements.

Retain "Noise Emission" paragraph below for installations with critical noise-abatement requirements, particularly outdoor engine generators. Coordinate with noise-reduction features in the design, including those relating to cooling-air intake and discharge arrangement and muffler specification and its location and orientation as shown on Drawings. See the Evaluations for discussion of noise generation and regulations.

* + - * 1. Noise Emission: Comply with [**applicable state and local government requirements**] <**Insert Project criteria**> for maximum noise level at [**adjacent property boundaries**] <**Insert critical locations**> due to sound emitted by engine generator including engine, engine exhaust, engine cooling-air intake and discharge, and other components of installation.
				2. Environmental Conditions: Engine generator system shall withstand the following environmental conditions without mechanical or electrical damage or degradation of performance capability:

Retain first option in "Ambient Temperature" subparagraph below if engine generator start time must be within NFPA 110 limits. This temperature range usually implies installation indoors in heated space. Coordinate with Drawings.

Ambient Temperature: [**41 to 104 deg F**] [**5 to 104 deg F**].

Delete "Relative Humidity" subparagraph below for outdoor units.

Relative Humidity: Zero to 95 percent.

Altitude: Sea level to [**1000 feet**] <**Insert altitude**>.

If unusual service conditions for equipment exist and cannot be eliminated, specify them in "Unusual Service Conditions" paragraph below. See the Evaluations for further discussion of service conditions.

* + - * 1. Unusual Service Conditions: Engine generator equipment and installation are required to operate under the following conditions:

Subparagraph below is an example only. Revise to list unusual conditions.

[**High salt-dust content in the air due to sea-spray evaporation**] <**Insert unusual condition**>.

* + - 1. ENGINE GENERATOR ASSEMBLY DESCRIPTION
				1. Factory-assembled and -tested, water-cooled engine, with brushless generator and accessories.
				2. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a testing agency acceptable to authorities having jurisdiction, and marked for intended location and use.

See Evaluations for discussion of prime and industrial ratings.

* + - * 1. Power Rating: [**Prime**] [**Industrial**] [**Standby**].

"Overload Capacity" paragraph below is only applicable if "prime" option is retained above.

* + - * 1. Overload Capacity: 110 percent of service load for 1 hour in 12 consecutive hours.

Retain "EPSS Class" paragraph below if retaining "standby" option in "Power Rating" paragraph above. "Class," as used in "EPSS Class" paragraph below, refers to the number of hours the EPSS is required to operate at full load without refueling. Coordinate with seismic design criteria. NFPA 110 requires seismic Categories C, D, E, and F to have a minimum 96-hour fuel supply for Level 1 engine generators.

* + - * 1. EPSS Class: Engine generator shall be classified as [**Class 2**] [**Class 6**] [**Class 48**] [**Class 96**] <**Insert Classification**> according to NFPA 110.
				2. Service Load: <**Insert number**> kVA.
				3. Power Factor: [**0.8**] <**Insert number**>, lagging.
				4. Frequency: 60 Hz.
				5. Voltage: [**208**] [**240**] [**480**] [**600**] [**4160**] V ac.
				6. Phase: Three-phase, [**three**] [**four**] wire, [**wye**] [**delta**].
				7. Induction Method: [**Naturally aspirated**] [**Turbocharged**].
				8. Governor: Adjustable isochronous, with speed sensing.
				9. Mounting Frame: Structural steel framework to maintain alignment of mounted components without depending on concrete foundation. Provide lifting attachments sized and spaced to prevent deflection of base during lifting and moving.

Retain "Rigging Diagram" subparagraph below if rigging is required.

Rigging Diagram: Inscribed on metal plate permanently attached to mounting frame to indicate location and lifting capacity of each lifting attachment and generator-set center of gravity.

Coordinate "Capacities and Characteristics" paragraph below with prototype test requirements in "Informational Submittals" Article and in "Source Quality Control" Article.

* + - * 1. Capacities and Characteristics:

Power Output Ratings: Nominal ratings as indicated at 0.8 power factor excluding power required for the continued and repeated operation of the unit and auxiliaries[**, with capacity as required to operate as a unit as evidenced by records of prototype testing**].

Nameplates: For each major system component to identify manufacturer's name and address, and model and serial number of component.

Retain "Engine Generator Performance" paragraph below for loads involving little or no sensitive electronic equipment or adjustable frequency drives. For loads that involve sensitive electronic equipment or significant nonlinear load elements, see "Generator-Set Performance for Sensitive Loads" paragraph below. For loads that involve UPS systems, consult manufacturers to determine the engine generator performance characteristics and revise one of two paragraphs below. See the Evaluations.

* + - * 1. Engine Generator Performance:

Steady-State Voltage Operational Bandwidth: 3 percent of rated output voltage from no load to full load.

Transient Voltage Performance: Not more than 20 percent variation for 50 percent step-load increase or decrease. Voltage shall recover and remain within the steady-state operating band within three seconds.

Steady-State Frequency Operational Bandwidth: 0.5 percent of rated frequency from no load to full load.

Steady-State Frequency Stability: When system is operating at any constant load within the rated load, there shall be no random speed variations outside the steady-state operational band and no hunting or surging of speed.

Transient Frequency Performance: Less than 5 percent variation for 50 percent step-load increase or decrease. Frequency shall recover and remain within the steady-state operating band within five seconds.

Output Waveform: At no load, harmonic content measured line to line or line to neutral shall not exceed 5 percent total and 3 percent for single harmonics. Telephone influence factor, determined according to NEMA MG 1, shall not exceed 50 percent.

Sustained Short-Circuit Current: For a three-phase, bolted short circuit at system output terminals, system shall supply a minimum of 250 percent of rated full-load current for not less than 10 seconds and then clear the fault automatically, without damage to generator system components.

Start Time:

Retain subparagraph below for standby generators. First option in subparagraph below requires generator to start immediately and function "basically (as an) uninterruptible power supply." Second option requires 10-second maximum start time under specific conditions and includes startup only, not load assumption. Other startup Types are also available.

Comply with NFPA 110, [**Type U**] [**Type 10**] system requirements.

Retain subparagraph below for prime or industrial generators.

[**10**] <**Insert time**> seconds.

Retain "Engine Generator Performance for Sensitive Loads" paragraph below for loads involving sensitive electronic equipment or significant nonlinear load elements. For loads that involve UPS systems, consult manufacturers to determine the engine generator performance characteristics and revise paragraph below. Coordinate with "Governor" paragraph in "Engine Generator Assembly Description" Article and with "Generator, Exciter, and Voltage Regulator" Article. See Section 263353 "Static Uninterruptible Power Supply" for coordination with UPS equipment.

* + - * 1. Engine Generator Performance for Sensitive Loads:

Oversizing generator compared with the rated power output of the engine is permissible to meet specified performance.

Nameplate Data for Oversized Generator: Show ratings required by the Contract Documents rather than ratings that would normally be applied to generator size installed.

Some manufacturers may be required to provide an oversized engine generator to meet parameters in "Steady-State Voltage Operational Bandwidth" subparagraph below. This could impact space, noise, ventilation, cooling, and other parameters. Permanent magnet excitation is an alternative method to meet the requirements in the subparagraphs below. Verify performance of products if specific manufacturers are listed. Revise requirements below to suit actual Project load characteristics. See the Evaluations.

Steady-State Voltage Operational Bandwidth: 1 percent of rated output voltage from no load to full load.

Transient Voltage Performance: Not more than 10 percent variation for 50 percent step-load increase or decrease. Voltage shall recover and remain within the steady-state operating band within 0.5 second.

Steady-State Frequency Operational Bandwidth: Plus or minus 0.25 percent of rated frequency from no load to full load.

Steady-State Frequency Stability: When system is operating at any constant load within the rated load, there shall be no random speed variations outside the steady-state operational band and no hunting or surging of speed.

Transient Frequency Performance: Less than 2-Hz variation for 50 percent step-load increase or decrease. Frequency shall recover and remain within the steady-state operating band within three seconds.

Output Waveform: At no load, harmonic content measured line to neutral shall not exceed 2 percent total with no slot ripple. Telephone influence factor, determined according to NEMA MG 1, shall not exceed 50 percent.

Sustained Short-Circuit Current: For a three-phase, bolted short circuit at system output terminals, system shall supply a minimum of 300 percent of rated full-load current for not less than 10 seconds and then clear the fault automatically, without damage to winding insulation or other generator system components.

Excitation System: Performance shall be unaffected by voltage distortion caused by nonlinear load.

Permanent magnet excitation in subparagraph below is a standard feature of some manufacturers' engine generators larger than 200 kW.

Provide permanent magnet excitation for power source to voltage regulator.

Start Time:

Retain subparagraph below for standby generators. First option in subparagraph below requires generator to start immediately and function "basically (as an) uninterruptible power supply." Second option requires 10-second maximum start time under specific conditions and includes startup only, not load assumption. Other startup Types are also available.

Comply with NFPA 110, [**Type U**] [**Type 10**] system requirements.

Retain subparagraph below for prime or industrial generators.

[**10**] <**Insert time**> seconds.

Retain "Parallel Engine Generators" paragraph below for paralleled generators; delete for single-unit generators. This paragraph is intended for the specification of dual-unit, smaller-sized parallel generators. For large or multiple parallel units. Generators may be paralleled to supply power to the required load with smaller, less-expensive units or to provide redundancy and higher reliability. Multiple sets allow the possibility of removing a unit from operation for maintenance or repair without adversely affecting the emergency load capability.

* + - * 1. Parallel Engine Generators:

Automatic reactive output power control and load sharing between engine generators operated in parallel.

Automatic regulation, automatic connection to a common bus, and automatic synchronization, with manual controls and instruments to monitor and control paralleling functions.

Protective relays required for equipment and personnel safety.

Paralleling suppressors to protect excitation systems.

Reverse power protection.

Loss of field protection.

* + - 1. GAS ENGINE
				1. Fuel: [**Natural gas**] [**and**] [**LP gas**] [**Natural gas with LP gas backup**].
				2. Rated Engine Speed: 1800 rpm.
				3. Lubrication System: Engine or skid-mounted.

Filter and Strainer: Rated to remove 90 percent of particles 5 micrometers and smaller while passing full flow.

Thermostatic Control Valve: Control flow in system to maintain optimum oil temperature. Unit shall be capable of full flow and is designed to be fail-safe.

Crankcase Drain: Arranged for complete gravity drainage to an easily removable container with no disassembly and without use of pumps, siphons, special tools, or appliances.

"Jacket Coolant Heater" paragraph below is an optional feature, often used on emergency generators, where required by NFPA 110 5.3.1, to keep engine jacket-water temperature within a certain range. Coordinate with Drawings for electrical supply.

* + - * 1. Jacket Coolant Heater: Electric-immersion type, factory installed in coolant jacket system. Comply with UL 499[**and with NFPA 110 requirements for Level 1 equipment for heater capacity**].

Retain "Integral Cooling System" or "Remote Cooling System" paragraph below. Coordinate with Drawings. See the Evaluations for further discussion of cooling cycle and effect of location on radiator effectiveness.

* + - * 1. Integral Cooling System: Closed loop, liquid cooled, with radiator factory mounted on engine generator mounting frame and integral engine-driven coolant pump.

Coolant: Solution of 50 percent ethylene-glycol-based antifreeze and 50 percent water, with anticorrosion additives as recommended by engine manufacturer.

Retain "Size of Radiator" or "Expansion Tank" subparagraph below. Retain "Expansion Tank" subparagraph if containment of coolant expansion by radiator is marginal or inadequate. Coordinate with Drawings.

Size of Radiator: Adequate to contain expansion of total system coolant from cold start to 110 percent load condition.

Expansion Tank: Constructed of welded steel plate and rated to withstand maximum closed-loop coolant system pressure for engine used. Equip with gage glass and petcock.

Temperature Control: Self-contained, thermostatic-control valve modulates coolant flow automatically to maintain optimum constant coolant temperature as recommended by engine manufacturer.

Coolant Hose: Flexible assembly with inside surface of nonporous rubber and outer covering of aging-, ultraviolet-, and abrasion-resistant fabric.

Rating: 50-psig maximum working pressure with coolant at 180 deg F, and noncollapsible under vacuum.

End Fittings: Flanges or steel pipe nipples with clamps to suit piping and equipment connections.

Retain first option in "Remote Cooling System" paragraph below for remote radiator cooling unless friction head is exceeded. If both static and friction heads are exceeded, a heat exchanger cooling system may be required. Coordinate with generator-set manufacturer for remote radiator or heat exchanger type cooling. Indicate remote radiator location on Drawings.

* + - * 1. Remote Cooling System: Closed loop, liquid cooled, with remote radiator and [**integral engine-driven**] [**auxiliary**] coolant pump.

Configuration: [**Vertical**] [**Horizontal**] air discharge.

Radiator Core Tubes: [**Aluminum**] [**Nonferrous-metal construction other than aluminum**].

Retain "Size of Radiator" or "Expansion Tank" subparagraph below. Retain "Expansion Tank" subparagraph if containment of coolant expansion by radiator is marginal or inadequate. Coordinate with Drawings. See Section 077200 "Roof Accessories" for the type and style of roof curbs and equipment supports for a remote radiator mounted on the roof.

Size of Radiator: Adequate to contain expansion of total system coolant from cold start to 110 percent load condition.

Expansion Tank: Constructed of welded steel plate and rated to withstand maximum closed-loop coolant system pressure for engine used. Equip with gage glass and petcock.

Fan: Driven by [**multiple belts from engine shaft**] [**totally enclosed electric motor with sealed bearings**].

Coolant: Solution of 50 percent ethylene-glycol-based antifreeze and 50 percent water, with anticorrosion additives as recommended by engine manufacturer.

Temperature Control: Self-contained, thermostatic-control valve modulates coolant flow automatically to maintain optimum constant coolant temperature as recommended by engine manufacturer.

* + - * 1. Muffler/Silencer:

Retain one of three subparagraphs below. Revise dBA requirements to accommodate environment in which engine generator is operating. If unit is specified with an enclosure, consider specifying sound level requirements at specified distance from enclosure on each of four sides. See the Evaluations for discussion of muffler types and noise criteria.

Critical type sized as recommended by engine manufacturer and selected with exhaust piping system to not exceed engine manufacturer's engine backpressure requirements.

Minimum sound attenuation of 25 dB at 500 Hz.

Sound level measured at a distance of 25 feet from exhaust discharge after installation is complete shall be [**78**] <**Insert number**> dBA or less.

Semicritical type, sized as recommended by engine manufacturer and selected with exhaust piping system to not exceed engine manufacturer's engine backpressure requirements.

Minimum sound attenuation of 18 dB at 500 Hz.

Sound level measured at a distance of 25 feet from exhaust discharge after installation is complete shall be [**85**] <**Insert number**> dBA or less.

Commercial type sized as recommended by engine manufacturer and selected with exhaust piping system to not exceed engine manufacturer's engine backpressure requirements.

Minimum sound attenuation of 12 dB at 500 Hz.

Sound level measured at a distance of 25 feet from exhaust discharge after installation is complete shall be [**90**] <**Insert number**> dBA or less.

Retain second option in "Air-Intake Filter" paragraph below if filters may not be serviced as often as recommended. If air contaminant level is excessive, consult manufacturers to determine if special filtration of combustion air is needed.

* + - * 1. Air-Intake Filter: [**Standard**] [**Heavy**]-duty, engine-mounted air cleaner with replaceable dry-filter element and "blocked filter" indicator.

Retain first option in "Starting System" paragraph below for smaller engine generators. Retain second option for units 175 kW and larger.

* + - * 1. Starting System: [**12**] [**24**]-V electric, with negative ground.

Components: Sized so they are not damaged during a full engine-cranking cycle with ambient temperature at maximum specified in "Performance Requirements" Article.

Cranking Motor: Heavy-duty unit that automatically engages and releases from engine flywheel without binding.

Retain first option in "Cranking Cycle" subparagraph below if "Performance Requirements" Article specifies NFPA 110, Level 1 or 2; otherwise, retain second. See the Evaluations for further discussion of cranking cycle.

Cranking Cycle: [**As required by NFPA 110 for system level specified**] [**60 seconds**].

First option in "Battery" subparagraph below complies with NFPA 110 requirements. Second is a more conservative rule used for some industrial applications. Lead-acid batteries are less expensive and perform as well as or better than nickel cadmium if temperatures are maintained between 0 deg F and 100 deg F. Note that valve-regulated, lead-acid batteries are even more subject to thermal stresses and are not recommended for engine generator starting service. Nickel cadmium batteries have better characteristics in more extreme temperature applications. Verify requirements for eyewash in the vicinity of the batteries with the authority having jurisdiction.

Battery: [**Lead acid**] [**Nickel cadmium**], with capacity within ambient temperature range specified in "Performance Requirements" Article to provide specified cranking cycle at least [**twice**] [**three times**] without recharging.

Coordinate "Battery Cable" subparagraph below with Drawings.

Battery Cable: Size as recommended by engine manufacturer for cable length indicated. Include required interconnecting conductors and connection accessories.

Retain "Battery Compartment" subparagraph below if compartment is required.

Battery Compartment: Factory fabricated of metal with acid-resistant finish and thermal insulation. Thermostatically controlled heater shall be arranged to maintain battery above 50 deg F regardless of external ambient temperature within range specified in "Performance Requirements" Article. Include accessories required to support and fasten batteries in place. Provide ventilation to exhaust battery gases.

Battery Stand: Factory-fabricated, two-tier metal with acid-resistant finish designed to hold the quantity of battery cells required and to maintain the arrangement to minimize lengths of battery interconnections.

Battery-Charging Alternator: Factory mounted on engine with solid-state voltage regulation and 35 A minimum continuous rating.

 Retain if battery charger is not specified to be integral with transfer switch.

Battery Charger: Current-limiting, automatic-equalizing and float-charging type designed for [**lead-acid**] [**nickel cadmium**] batteries. Unit shall comply with UL 1236 and include the following features:

Operation: Equalizing-charging rate of 10 A shall be initiated automatically after battery has lost charge until an adjustable equalizing voltage is achieved at battery terminals. Unit shall then be automatically switched to a lower float-charging mode and shall continue to operate in that mode until battery is discharged again.

Automatic Temperature Compensation: Adjust float and equalize voltages for variations in ambient temperature from minus 40 deg F to 140 deg F to prevent overcharging at high temperatures and undercharging at low temperatures.

Automatic Voltage Regulation: Maintain constant output voltage regardless of input voltage variations up to plus or minus 10 percent.

Ammeter and Voltmeter: Flush mounted in door. Meters shall indicate charging rates.

"Safety Functions" subparagraph below covers sensing for safety indications on control and monitoring panel.

Safety Functions: Sense abnormally low battery voltage and close contacts providing low battery voltage indication on control and monitoring panel. Sense high battery voltage and loss of ac input or dc output of battery charger. Either condition shall close contacts that provide a battery-charger malfunction indication at system control and monitoring panel.

Enclosure and Mounting: NEMA 250, Type 1, wall-mounted cabinet.

* + - 1. GAS FUEL SYSTEM
				1. Gas Train: Comply with NFPA 37.
				2. Engine Fuel System:

Revise subparagraph below if generator will be connected to a single LP gas or natural gas service.

* + - * 1. [**Natural Gas**] [**and**] [**LP Gas**] [**Natural Gas with LP Gas Backup**], Vapor-Withdrawal System:

Carburetor.

Retain "Secondary Gas Regulators" subparagraph below if generator will be connected to a separate gas service.

Secondary Gas Regulators: One for each fuel type, with atmospheric vents piped to building exterior.

Fuel-Shutoff Solenoid Valves: NRTL-listed, normally closed, safety shutoff valves; one for each fuel source.

Fuel Filters: One for each fuel type.

Manual Fuel Shutoff Valves: One for each fuel type.

Flexible Fuel Connectors: Minimum one for each fuel connection.

Retain two subparagraphs below if generator will be connected to both LP and natural gas services.

LP gas flow adjusting valve.

Fuel change gas pressure switch.

* + - 1. CONTROL AND MONITORING

This article specifies the subsystem that monitors, protects, and controls the engine generator. See the Evaluations for more discussion of control and monitoring panels.

Retain "Automatic Starting System Sequence of Operation" paragraph below for automatically starting systems.

* + - * 1. Automatic Starting System Sequence of Operation: When mode-selector switch on the control and monitoring panel is in the automatic position, remote-control contacts in one or more separate automatic transfer switches initiate starting and stopping of engine generator. When mode-selector switch is switched to the on position, engine generator starts. The off position of same switch initiates generator-set shutdown. When engine generator is running, specified system or equipment failures or derangements automatically shut down engine generator and initiate alarms.

Retain "Manual Starting System Sequence of Operation" paragraph below for manually starting systems.

* + - * 1. Manual Starting System Sequence of Operation: Switching on-off switch on the generator control panel to the on position starts engine generator. The off position of same switch initiates generator-set shutdown. When engine generator is running, specified system or equipment failures or derangements automatically shut down engine generator and initiate alarms.
				2. Provide minimum run time control set for [**15**] [**30**] <**Insert number**> minutes with override only by operation of a remote emergency-stop switch.
				3. Comply with UL 508A.
				4. Configuration:

Retain one of three subparagraphs below to describe control and monitoring unit configuration. Coordinate retained subparagraph with Drawings. Retain first subparagraph unless special requirements justify significant extra cost of one of the other two configurations. See the Evaluations.

Operating and safety indications, protective devices, basic system controls, and engine gages shall be grouped in a common control and monitoring panel mounted on the engine generator. Mounting method shall isolate the control panel from generator-set vibration. Panel shall be powered from the engine generator battery.

Operating and safety indications, protective devices, basic system controls, and engine gages shall be grouped in a common wall-mounted control and monitoring panel. Panel shall be powered from the engine generator battery.

Operating and safety indications, protective devices, basic system controls, engine gages, instrument transformers, generator disconnect switch or circuit breaker, and other indicated components shall be grouped in a combination control and power panel. Control and monitoring section of panel shall be isolated from power sections by steel barriers. Panel shall be powered from the engine generator battery. Panel features shall include the following:

Retain one of three subparagraphs below to further define control and power panel in last subparagraph above.

Wall-Mounting Cabinet Construction: Rigid, self-supporting steel unit complying with NEMA ICS 6.

Switchboard Construction: Power bus shall be copper. Bus, bus supports, control wiring, and temperature rise shall comply with UL 891.

Control and Monitoring Panel:

Retain one or both of first two subparagraphs below. First subparagraph is for an integrated digital controller; second is for an analog controller.

Digital controller with integrated LCD, controls, and microprocessor, capable of local and remote control, monitoring, and programming, with battery backup.

Analog control panel with dedicated gages and indicator lights for the instruments and alarms indicated below.

Instruments: Located on the control and monitoring panel and viewable during operation.

Below is a list of instruments commonly used to monitor engine generator operation. Additional instruments recommended or required by the engine manufacturer to maintain the engine should be added to the list.

Engine lubricating-oil pressure gage.

Gage below is only required for engines with liquid coolant.

Engine-coolant temperature gage.

DC voltmeter (alternator battery charging).

Running-time meter.

First four subparagraphs below are required for Level 1 engines by NFPA 110, Article 5.6.9.9.

AC voltmeter, [**for each phase**] [**connected to a phase selector switch**].

AC ammeter, [**for each phase**] [**connected to a phase selector switch**].

AC frequency meter.

Generator-voltage adjusting rheostat.

Controls and Protective Devices: Controls, shutdown devices, and common visual alarm indication, including the following:

Cranking control equipment.

Retain first two subparagraphs below for automatic start systems. Delete for manual start systems.

Run-Off-Auto switch.

Control switch not in automatic position alarm.

See the Evaluations for typical local and remote alarm indications and shutdowns.

Overcrank alarm.

Overcrank shutdown device.

Low water temperature alarm.

First subparagraph below is a common optional feature.

High engine temperature prealarm.

High engine temperature.

High engine temperature shutdown device.

Overspeed alarm.

Overspeed shutdown device.

Retain instrument in first subparagraph below for gaseous systems with fuel tanks.

Low fuel main tank.

Low-fuel-level alarm shall be initiated when the level falls below that required for operation for the duration required for the indicated EPSS class.

Coolant low-level alarm.

First subparagraph below is an optional feature for Level 1 engines.

Coolant low-level shutdown device.

First four subparagraphs below are optional features not required by NFPA 110.

Coolant high-temperature prealarm.

Coolant high-temperature alarm.

Coolant low-temperature alarm.

Coolant high-temperature shutdown device.

EPS supplying load indicator.

Retain first four subparagraphs below for Level 1 battery-start engines. Consider retaining them for Level 2 systems also.

Battery high-voltage alarm.

Low cranking voltage alarm.

Battery-charger malfunction alarm.

Battery low-voltage alarm.

Lamp test.

Contacts for local and remote common alarm.

Retain one of first two subparagraphs below for Level 1 pneumatic-start engines. Consider retaining them for Level 2 systems also.

Low-starting air pressure alarm.

Low-starting hydraulic pressure alarm.

Remote manual stop shutdown device.

Air shutdown damper alarm when used.

Air shutdown damper shutdown device when used.

Hours of operation.

Engine generator metering, including voltage, current, Hz, kW, kVA, and power factor.

Retain subparagraph below for units with "generator-protector" feature.

Generator overcurrent protective device not closed alarm.

Features in "Connection to Datalink" paragraph below facilitate connection to building automation system or building control and monitoring system. Coordinate with Drawings and Section covering data transmission and data terminals.

* + - * 1. Connection to Datalink:

A separate terminal block, factory wired to Form C dry contacts, for each alarm and status indication.

Provide connections for datalink transmission of indications to remote data terminals via [**ModBus**] [**LonWorks**] [**Ethernet**] <**Insert other data protocol**>.."

Retain "Common Remote Panel with Common Audible Alarm" or "Remote Alarm Annunciator" paragraph below, or delete both. Coordinate with Drawings.

* + - * 1. Common Remote Panel with Common Audible Alarm: Include necessary contacts and terminals in control and monitoring panel. Remote panel shall be powered from the engine generator battery.
				2. Remote Alarm Annunciator: An LED indicator light labeled with proper alarm conditions shall identify each alarm event, and a common audible signal shall sound for each alarm condition. Silencing switch in face of panel shall silence signal without altering visual indication. Connect so that after an alarm is silenced, clearing of initiating condition will reactivate alarm until silencing switch is reset. Cabinet and faceplate are surface- or flush-mounting type to suit mounting conditions indicated.

Overcrank alarm.

Coolant low-temperature alarm.

High engine temperature prealarm.

High engine temperature alarm.

Low lube oil pressure alarm.

Overspeed alarm.

Low fuel main tank alarm.

Low coolant level alarm.

Low cranking voltage alarm.

Contacts for local and remote common alarm.

Audible-alarm silencing switch.

Air shutdown damper when used.

Retain first two subparagraphs below for automatic start systems. Delete for manual start systems.

Run-Off-Auto switch.

Control switch not in automatic position alarm.

Devices in first three subparagraphs below are optional.

Fuel tank derangement alarm.

Fuel tank high-level shutdown of fuel supply alarm.

Lamp test.

Retain first subparagraph below for Level 1 battery-start engines. Consider retaining it for Level 2 systems also.

Low cranking voltage alarm.

Protective device alarm in subparagraph below may not be standard or available for all engine generators. Verify availability with manufacturers.

Generator overcurrent protective device not closed.

Coordinate "Remote Emergency-Stop Switch" paragraph below with Drawings.

* + - * 1. Remote Emergency-Stop Switch: Flush; wall mounted, unless otherwise indicated; and labeled. Push button shall be protected from accidental operation.
				2. Supporting Items: Include sensors, transducers, terminals, relays, and other devices and include wiring required to support specified items. Locate sensors and other supporting items on engine or generator, unless otherwise indicated.
			1. GENERATOR OVERCURRENT AND FAULT PROTECTION
				1. Overcurrent protective devices shall be coordinated to optimize selective tripping when a short circuit occurs.

Retain first two subparagraphs below for standby generators.

* + - * 1. Overcurrent protective devices for the entire EPSS shall be coordinated to optimize selective tripping when a short circuit occurs. Coordination of protective devices shall consider both utility and EPSS as the voltage source.
				2. Overcurrent protective devices for the EPSS shall be accessible only to authorized personnel.
				3. Generator Overcurrent Protective Device:

Retain one or more subparagraphs in this article to specify disconnect switch(es) and protective devices for the generator (alternator) component of engine generator. Revise as required to accommodate multiple output devices. See the Evaluations for discussion of overload and fault protection.

Retain one of four subparagraphs below. Retain first for units smaller than 200 kW where initial cost is a concern. Device provides little or no generator protection and no selectivity with downstream circuit protective devices.

Molded-case circuit breaker, thermal-magnetic type; 100 percent rated; complying with UL 489:

Tripping Characteristic: Designed specifically for generator protection.

Trip Rating: Matched to generator output rating.

Shunt Trip: Connected to trip breaker when engine generator is shut down by other protective devices.

Mounting: Adjacent to or integrated with control and monitoring panel.

Molded-case circuit breaker, electronic-trip type; 100 percent rated; complying with UL 489:

Tripping Characteristics: Adjustable long-time and short-time delay and instantaneous.

Trip Settings: Selected to coordinate with generator thermal damage curve.

Shunt Trip: Connected to trip breaker when engine generator is shut down by other protective devices.

Mounting: Adjacent to or integrated with control and monitoring panel.

Insulated-case, electronic-trip breakers in first subparagraph below are susceptible to vibration and should be mounted in a separate enclosure not mounted on the generator skid.

Insulated-case circuit breaker, electronic-trip type; 100 percent rated; complying with UL 489:

Tripping Characteristics: Adjustable long-time and short-time delay and instantaneous.

Trip Settings: Selected to coordinate with generator thermal damage curve.

Shunt Trip: Connected to trip breaker when engine generator is shut down by other protective devices.

Mounting: Adjacent to, or integrated with control and monitoring panel.

Retain subparagraph below if generator is protected by feature described in the "Generator Protector" paragraph below.

Molded-case type disconnect switch, 100 percent rated:

Trip Rating: Matched to generator output rating.

Shunt Trip: Connected to trip switch when signaled by generator protector or by other protective devices.

Protection scheme specified in "Generator Protector" paragraph below may be proprietary. Consult manufacturers. Microprocessor-based generator protectors in paragraph are susceptible to vibration and should be mounted in a separate enclosure not mounted on the generator skid.

* + - * 1. Generator Protector: Microprocessor-based unit shall continuously monitor current level in each phase of generator output, integrate generator heating effect over time, and predict when thermal damage of alternator will occur. When signaled by generator protector or other generator-set protective devices, a shunt-trip device in the generator disconnect switch shall open the switch to disconnect the generator from load circuits. Protector performs the following functions:

Coordinate load shed actions in subparagraphs below with Drawings. Indicate which loads will be shed on generator overload and sequence of action if more than one.

Initiates a generator overload alarm when generator has operated at an overload equivalent to 110 percent of full-rated load for 60 seconds. Indication for this alarm is integrated with other generator-set malfunction alarms. Contacts shall be available for load shed functions.

Under single or three-phase fault conditions, regulates generator to 300 percent of rated full-load current for up to 10 seconds.

As overcurrent heating effect on the generator approaches the thermal damage point of the unit, protector switches the excitation system off, opens the generator disconnect device, and shuts down the engine generator.

Senses clearing of a fault by other overcurrent devices and controls recovery of rated voltage to avoid overshoot.

Retain "Ground-Fault Indication" paragraph below and coordinate with Drawings for legally required emergency engine generators rated 1000 A or more at 277/480 V.

* + - * 1. Ground-Fault Indication: Comply with NFPA 70, "Emergency System" signals for ground fault.

Retain one of two subparagraphs below. Retain first for emergency and legally required standby systems. Retain second for optional standby generator systems. See the Evaluations for discussion of ground-fault protection.

Indicate ground fault with other engine generator alarm indications.

Trip generator protective device on ground fault.

* + - 1. GENERATOR, EXCITER, AND VOLTAGE REGULATOR
				1. Comply with NEMA MG 1.
				2. Drive: Generator shaft shall be directly connected to engine shaft. Exciter shall be rotated integrally with generator rotor.

Class H insulation in "Electrical Insulation" paragraph below has a higher temperature rating than Class F. Class H insulation can give the alternator a longer life. Check with manufacturer to determine availability for the generator sized for the project loads.

* + - * 1. Electrical Insulation: [**Class H**] [**or**] [**Class F**].

Twelve lead alternator in "Stator-Winding Leads" paragraph below is also known as a "reconnectable" alternator because the leads can be reconnected in the field in series or parallel to change between delta and wye configurations.

* + - * 1. Stator-Winding Leads: Brought out to terminal box to permit future reconnection for other voltages if required. Provide [**six**] [**12**] lead alternator.

The output voltage adjustment in "Range" paragraph below increases in each of the three ranges.

* + - * 1. Range: Provide [**limited**] [**broad**] [**extended**] range of output voltage by adjusting the excitation level.
				2. Construction shall prevent mechanical, electrical, and thermal damage due to vibration, overspeed up to 125 percent of rating, and heat during operation at 110 percent of rated capacity.
				3. Enclosure: Dripproof.

Delete "Instrument Transformers" paragraph below if instrument transformers are housed in control and power panel.

* + - * 1. Instrument Transformers: Mounted within generator enclosure.
				2. Voltage Regulator: Solid-state type, separate from exciter, providing performance as specified[**and as required by NFPA 110**].

Adjusting Rheostat on Control and Monitoring Panel: Provide plus or minus 5 percent adjustment of output-voltage operating band.

One-step, full-load application in first subparagraph below should maintain voltage so load relays or contactors do not drop out. Verify percentage of voltage drop permissible to maintain loads.

Maintain voltage within [**15**] [**20**] [**30**] percent on one step, full load.

Provide anti-hunt provision to stabilize voltage.

Maintain frequency within [**5**] [**10**] [**15**] percent and stabilize at rated frequency within [**2**] [**5**] seconds.

Retain "Strip Heater" paragraph below for high-humidity environments to limit condensation in alternator windings.

* + - * 1. Strip Heater: Thermostatically controlled unit arranged to maintain stator windings above dew point.

Retain "Windings" and "Subtransient Reactance" paragraphs below for units specified for "critical" performance. Coordinate with "Engine Generator Performance" and "Engine Generator Performance for Sensitive Loads" paragraphs in "Engine Generator Assembly Description" Article. See "Installation Considerations" Article in the Evaluations for discussions on sensitive electronic equipment and nonlinear generator loads and on supplying significant harmonic currents.

* + - * 1. Windings: Two-thirds pitch stator winding and fully linked amortisseur winding.

Value in "Subtransient Reactance" paragraph below is recommended to be no higher than 12 percent. Lower values increase ability to limit voltage distortion caused by harmonics but are more expensive.

* + - * 1. Subtransient Reactance: [**12**] <**Insert number**> percent, maximum.
			1. LOAD BANK
				1. Description:

Retain one of two subparagraphs below. Retain first subparagraph and revise for resistive or resistive and reactive load elements; retain second subparagraph for resistive-only load-bank skid mounted between the radiator and the exhaust shroud. See the Evaluations for further discussion of load banks. Coordinate with Drawings.

Permanent, outdoor, weatherproof, remote-controlled, forced-air-cooled, [**resistive**] [**resistive and reactive**] unit capable of providing a balanced three-phase, delta-connected load to engine generator at [**100**] <**Insert number**> percent rated-system capacity, at [**80**] <**Insert number**> percent power factor, lagging.[**Unit may contain separate resistive and reactive load banks controlled by a common control panel.**] Unit shall be capable of selective control of load in 25 percent steps and with minimum step changes of approximately 5 and 10 percent available.

Permanent, radiator-mounted[**, resistive**] unit capable of providing a balanced three-phase, delta-connected load to engine generator at [**50**] [**70**] <**Insert number**> percent rated-system capacity. Unit shall be capable of selective control of load in 25 percent steps of load bank rating and with minimum step changes of approximately 5 and 10 percent available.

* + - * 1. Resistive Load Elements: Corrosion-resistant chromium alloy with ceramic and stainless-steel supports. Elements shall be double insulated and designed for repetitive on-off cycling. Elements shall be mounted in removable aluminized-steel heater cases. Galvanized steel is prohibited. Element's maximum resistance shall be between 100 and 105 percent of rated resistance.
				2. Reactive Load Elements: Epoxy-encapsulated reactor coils.
				3. Load-Bank Heat Dissipation: Integral fan with totally enclosed motor shall provide uniform cooling airflow through load elements. Airflow and coil operating current shall be such that, at maximum load, with ambient temperature at the upper end of specified range, load-bank elements operate at not more than 50 percent of maximum continuous temperature rating of resistance elements.
				4. Load-Element Switching: Remote-controlled contactors switch groups of load elements. Contactor coils are rated 120 V. Contactors shall be located in a separate NEMA 250, Type 3R enclosure within load-bank enclosure, accessible from exterior through hinged doors with tumbler locks.
				5. Contactor Enclosures: Heated by thermostatically controlled strip heaters to prevent condensation.
				6. Load-Bank Enclosures: NEMA 250, Type 3R, aluminized steel complying with NEMA ICS 6. Louvers at cooling-air intake and discharge openings shall prevent entry of rain and snow. Openings for airflow shall be screened with 1/2-inch- square, galvanized-steel mesh. Reactive load bank shall include automatic shutters at air intake and discharge. Components other than resistive elements shall receive exterior epoxy coating with compatible primer.
				7. Protective Devices: Power input circuits to load banks shall be fused, and fuses shall be selected to coordinate with generator circuit breaker. Fuse blocks shall be located in contactor enclosure. Cooling airflow and overtemperature sensors shall automatically shut down and lock out load bank until manually reset. Safety interlocks on access panels and doors shall disconnect load power, control, and heater circuits. Fan motor shall be separately protected by overload and short-circuit devices. Short-circuit devices shall be noninterchangeable fuses with 200,000 A interrupting capacity.

Coordinate "Load Bank Remote-Control Panel" and "Control Sequence" paragraphs below with Drawings.

* + - * 1. Load Bank Remote-Control Panel: Separate from load bank in NEMA 250, Type 1 enclosure with a control power switch and pilot light, and switches controlling groups of load elements.

Retain "Control Sequence" paragraph below if load bank is used in automatic exercising of generator. Coordinate with Section covering remote-controlled switch, contactor, or electrically operated circuit breaker used to switch load bank to generator output. Switching device is typically not part of equipment specified in this Section.

* + - * 1. Control Sequence: Control panel may be preset for adjustable single-step loading of generator during automatic exercising.
			1. OUTDOOR GENERATOR-SET ENCLOSURE
				1. Description:

Retain one of two subparagraphs below and coordinate with Drawings to define basic outdoor-enclosure type. Revise to specify enclosure features required. Coordinate requirements for water, fuel, power, controls, and alarms with Drawings.

Vandal-resistant, sound-attenuating, weatherproof steel housing, wind resistant up to 100 mph. Multiple panels shall be lockable and provide adequate access to components requiring maintenance. Panels shall be removable by one person without tools. Instruments and control shall be mounted within enclosure.

Sound Attenuation Level: <**Insert level**>.

Coordinate subparagraph below with Drawings showing features, construction details, and equipment arrangement.

Prefabricated or pre-engineered galvanized-steel-clad, integral structural-steel-framed, walk-in enclosure, erected on concrete foundation.

Revise wind speed in "Structural Design and Anchorage" paragraph below to suit local conditions.

* + - * 1. Structural Design and Anchorage: Comply with ASCE/SEI 7 for wind loads up to 100 mph.

Fire protection in an outdoor generator enclosure is optional. Although the enclosure may be heated, failure of the heater should not endanger the unit or other fire-suppression systems. Consider using a dry pipe system to reduce freezing problems.

* + - * 1. Fire Protection: Provide smoke detector in enclosure; mounted according to NFPA 72.
				2. Hinged Doors: With padlocking provisions.

Coordinate "Space Heater" paragraph below with gas piping and controls. Heater can be fueled by the gas service to a gas-fueled engine generator and should be interlocked to not run when the engine is running. This will prevent it from interfering with the engine fuel supply, and the heat will not be needed.

* + - * 1. Space Heater: Thermostatically controlled and sized to prevent condensation.
				2. Lighting: Provide weather-resistant [**fluorescent**] [**LED**] lighting with [**30 fc**] [**50 fc**] average maintained.
				3. Thermal Insulation: Manufacturer's standard materials and thickness selected in coordination with space heater to maintain winter interior temperature within operating limits required by engine generator components.
				4. Muffler Location: [**Within**] [**External to**] enclosure.
				5. Engine Cooling Airflow through Enclosure: Maintain temperature rise of system components within required limits when unit operates at 110 percent of rated load for 2 hours with ambient temperature at top of range specified in system service conditions.

Retain "Louvers" or "Automatic Dampers" subparagraph below, or delete both and insert requirement. Some installations use a fixed louver for inlet or the exhaust and an automatic for the other. Mixing louver types is less costly and does not allow free air flow through the enclosure when the unit is not running, but it does lessen the effectiveness of space heaters in the enclosure. Consider specifying automatic dampers on both inlet and exhaust if space heaters are required. See Section 089116 "Operable Wall Louvers" and Section 089119 "Fixed Louvers" for engine generator, air-inlet and exhaust louvers.

Louvers: Fixed-engine, cooling-air inlet and discharge. Storm-proof and drainable louvers prevent entry of rain and snow.

Automatic Dampers: At engine cooling-air inlet and discharge. Dampers shall be closed to reduce enclosure heat loss in cold weather when unit is not operating.

Revise "Ventilation" subparagraph below if forced ventilation rather than convection ventilation is required.

Ventilation: Provide temperature-controlled exhaust fan interlocked to prevent operation when engine is running.

Coordinate "Interior Lights with Switch" and "Convenience Outlets" paragraphs below with Drawings for lighting types and location and for supply circuits. Insert requirements for ventilation equipment, luminaires, devices, and covers to match components in facility. Verify availability if not retaining walk-in enclosure.

* + - * 1. Interior Lights with Switch: Factory-wired, vapor-proof fixtures within housing; arranged to illuminate controls and accessible interior. Arrange for external electrical connection.

AC lighting system and connection point for operation when remote source is available.

DC lighting system for operation when remote source and generator are both unavailable.

* + - * 1. Convenience Outlets: Factory wired, GFCI. Arrange for external electrical connection.
			1. REMOTE RADIATOR MOTORS

Retain this article for engine generators with remote radiators.

* + - * 1. Description: NEMA MG 1, Design B, medium induction random-wound, squirrel-cage motor.
				2. Efficiency: Energy efficient, as defined in NEMA MG 1.
				3. Service Factor: 1.15.
				4. Bearings: Regreasable, shielded, antifriction ball bearings suitable for radial and thrust loading.
				5. Motor Sizes: Minimum size as indicated. If not indicated, large enough so driven load will not require motor to operate in service factor range above 1.0.
				6. Temperature Rise: Match insulation rating.
				7. Code Letter Designation:

Starting codes in first subparagraph below are adequate for most variable-torque loads encountered in HVAC applications; 15 hp is a common breakpoint in rating among manufacturers when Code F and Code G apply. Retain both subparagraphs and options below unless Project conditions or equipment characteristics dictate otherwise.

Motors [**15**] <**Insert number**> HP and Larger: NEMA starting Code F or Code G.

Motors Smaller Than [**15**] <**Insert number**> HP: Manufacturer's standard starting characteristic.

* + - * 1. Enclosure Material: Cast iron for motor frame sizes 324T and larger; rolled steel for motor frame sizes smaller than 324T.
				2. Controllers, Electrical Devices, and Wiring: Electrical devices and connections are specified in electrical Sections.
			1. VIBRATION ISOLATION DEVICES

Note that natural rubber is not as oil resistant as other available materials and should not be specified if oil spillage is a problem in the vicinity of the generator. Minimum deflection should be verified with Structural or Seismic Engineer.

* + - * 1. Elastomeric Isolator Pads: Oil- and water-resistant elastomer or natural rubber, arranged in single or multiple layers, molded with a nonslip pattern and galvanized-steel baseplates of sufficient stiffness for uniform loading over pad area, and factory cut to sizes that match requirements of supported equipment.

See the Evaluations in Section 260548.16 "Seismic Controls for Electrical Systems" for a discussion on vibration and seismic-control devices. Pads in "Material" subparagraph below come in standard neoprene, natural rubber, and bridge-bearing neoprene. Verify availability of various materials with manufacturers. Costs range from least to most expensive in the order presented below.

Material: [**Standard neoprene**] [**Natural rubber**] [**Bridge-bearing neoprene, complying with AASHTO M 251**] separated by steel shims.

Durometer values in "Shore 'A' Scale Durometer Rating" subparagraph below range from 30 to 70 on the Shore "A" scale and are measures of hardness or, indirectly, deflection. Lower durometer values indicate softer material with more deflection. The durometer rating needed is dependent on the weight of the generator and the number and contact area of pads used. Other factors also affect the selection but are fairly constant across all generators. Durometer values in the middle of the range in subparagraph below are most common. See manufacturer's data once generator characteristics are known before selecting the desired durometer rating. Pad selection may be different for generator normal vibration than is required to withstand and dampen seismic shock. Consult with manufacturer to choose materials suitable for both criteria.

Shore "A" Scale Durometer Rating: [**30**] [**40**] [**45**] [**50**] [**60**] [**65**] [**70**] <**Insert number**>.

Use multiple layers, separated by steel shims, depending on supported equipment load. See manufacturer's data for load capacities.

Number of Layers: [**One**] [**Two**] [**Three**] [**Four**] <**Insert number**>.

Minimum Deflection: [**1 inch**] <**Insert value**>.

Coordinate "Restrained Spring Isolators" paragraph below with Drawings and with Section 260548.16 "Seismic Controls for Electrical Systems."

* + - * 1. Restrained Spring Isolators: Freestanding, steel, open-spring isolators with seismic restraint.

Housing: Steel with resilient vertical-limit stops to prevent spring extension due to wind loads or if weight is removed; factory-drilled baseplate bonded to 1/4-inch- thick, elastomeric isolator pad attached to baseplate underside; and adjustable equipment mounting and leveling bolt that acts as blocking during installation.

Outside Spring Diameter: Not less than 80 percent of compressed height of the spring at rated load.

Minimum Additional Travel: 50 percent of required deflection at rated load.

Lateral Stiffness: More than 80 percent of rated vertical stiffness.

Overload Capacity: Support 200 percent of rated load, fully compressed, without deformation or failure.

Minimum Deflection: [**1 inch**] <**Insert value**>.

* + - * 1. Vibration isolation devices shall not be used to accommodate misalignments or to make bends.
			1. FINISHES
				1. Indoor and Outdoor Enclosures and Components: Manufacturer's standard finish over corrosion-resistant pretreatment and compatible primer.
			2. SOURCE QUALITY CONTROL
				1. Prototype Testing: Factory test engine generator using same engine model, constructed of identical or equivalent components and equipped with identical or equivalent accessories.

Tests: Comply with IEEE 115[**and with NFPA 110, Level 1 Energy Converters**].

The project-specific equipment tests in the "Project-Specific Equipment Tests" paragraph below are in addition to the prototype tests listed above. They do not test the unit under the full range of conditions as the above tests, but are useful to provide assurance that the specific unit supplied to the Project meets most of the critical parameters that can be tested without stressing the unit.

* + - * 1. Project-Specific Equipment Tests: Before shipment, factory test engine generator and other system components and accessories manufactured specifically for this Project. Perform tests at rated load and power factor. Include the following tests:

Test components and accessories furnished with installed unit that are not identical to those on tested prototype to demonstrate compatibility and reliability.

Test generator, exciter, and voltage regulator as a unit.

Full load run.

Maximum power.

Voltage regulation.

Transient and steady-state governing.

Single-step load pickup.

Safety shutdown.

Retain first subparagraph below if factory tests will be witnessed by Director’s Representative.

Provide 14 days' advance notice of tests and opportunity for observation of tests by Director’s Representative.

Coordinate subparagraph below with "Informational Submittals" Article.

Report factory test results within 10 days of completion of test.

1. EXECUTION
	* + 1. EXAMINATION
				1. Examine areas, equipment bases, and conditions, with Installer present, for compliance with requirements for installation and other conditions affecting packaged engine generator performance.
				2. Examine roughing-in for piping systems and electrical connections. Verify actual locations of connections before packaged engine generator installation.
				3. Proceed with installation only after unsatisfactory conditions have been corrected.
			2. PREPARATION

Delete "Interruption of Existing Electrical Service" paragraph below if no interruption of existing electrical service is required.

* + - * 1. Interruption of Existing Electrical Service: Do not interrupt electrical service to facilities occupied by Director’s Representative or others unless permitted under the following conditions and then only after arranging to provide temporary electrical service according to requirements indicated:

Notify [**Architect**] [**Construction Manager**] [**Director’s Representative**] no fewer than [**two**] <**Insert number**> working days in advance of proposed interruption of electrical service.

Do not proceed with interruption of electrical service without [**Architect's**] [**Construction Manager's**] [**Director’s Representative's**] written permission.

* + - 1. INSTALLATION
				1. Comply with NECA 1 and NECA 404.
				2. Comply with packaged engine generator manufacturers' written installation and alignment instructions[**and with NFPA 110**].

Verify with Project participants which concrete Section in the "Equipment Mounting" paragraph below will be used for concrete pads and bases.

* + - * 1. Equipment Mounting:

Retain first subparagraph below to require equipment to be installed on cast-in-place concrete equipment bases.

Install packaged engine generators on cast-in-place concrete equipment bases.

Coordinate size and location of concrete bases for packaged engine generators[**and remote radiators mounted on grade**]. Cast anchor-bolt inserts into bases. Concrete, reinforcement, and formwork requirements are specified with concrete.

Retain one of two isolator options in second set of options in first subparagraph below for mounting equipment inside or to accommodate seismic mounting. NFPA 110 requires indoor Level 1 engine generators to be installed in a dedicated room with 1- or 2-hour fire rating. Indoor installations also require fuel storage within the building and large airflows for cooling and combustion. Consult NFPA 110 and authorities having jurisdiction for requirements. Verify minimum deflection with structural or seismic engineer.

Install [**packaged engine generator**] [**engine generator in a walk-in enclosure**] with [**elastomeric isolator pads**] [**restrained spring isolators**] having a minimum deflection of [**1 inch**] <**Insert static deflection**> on 4-inch- high concrete base. Secure [**engine generator**] [**enclosure**] to anchor bolts installed in concrete bases.

Remote Radiators:

Install remote radiator with [**elastomeric isolator pads**] [**restrained spring isolators**] on [**concrete base on grade**] [**roof equipment supports on roof**].

Retain subparagraph below for remote radiators located on roof.

Coordinate size and location of roof curbs, equipment supports, and roof penetrations for remote radiators.

* + - * 1. Install packaged engine generator to provide access, without removing connections or accessories, for periodic maintenance.

Delete "Cooling System" paragraph below if radiator is not engine mounted.

* + - * 1. Cooling System: Install Schedule 40, black steel piping with welded joints for cooling water piping between engine generator and [**heat exchanger**] [**remote radiator**].

Install isolating thimbles where exhaust piping penetrates combustible surfaces. Provide a minimum of 9 inches clearance from combustibles.

* + - * 1. Exhaust System: Install Schedule 40, black steel piping with welded joints and connect to engine muffler. Install thimble at wall. Piping shall be same diameter as muffler outlet.

See Section 077200 "Roof Accessories" for roof curbs, piping supports, and roof-penetration boots.

Install isolating thimbles where exhaust piping penetrates combustible surfaces with a minimum of 9-inch clearance from combustibles.

Coordinate first paragraph below with Drawings.

* + - * 1. Drain Piping: Install condensate drain piping to muffler drain outlet with a shutoff valve, stainless-steel flexible connector, and Schedule 40, black steel pipe, the full size of the drain connection, with welded joints.
				2. Electrical Wiring: Install electrical devices furnished by equipment manufacturers but not specified to be factory mounted.
			1. CONNECTIONS

Coordinate piping installations and specialty arrangements with Drawings and with requirements specified in piping systems. If Drawings are explicit enough, these requirements may be reduced or omitted.

* + - * 1. Piping installation requirements are specified in other Sections. Drawings indicate general arrangement of piping and specialties.
				2. Connect fuel, cooling-system, and exhaust-system piping adjacent to packaged engine generator to allow service and maintenance.

Coordinate first two paragraphs below with Section 230719 "HVAC Piping Insulation."

Coordinate first paragraph below with Section 232116 "Hydronic Piping Specialties."

* + - * 1. Connect cooling-system water piping to engine generator and [**remote radiator**] [**heat exchanger**] with flexible connectors.
				2. Connect engine exhaust pipe to engine with flexible connector.
				3. Gaseous Fuel Connections:

Connect fuel piping to engines with a gate valve and union and flexible connector.

Install manual shutoff valve in a remote location to isolate gaseous fuel supply to the generator.

Vent gas pressure regulators outside building a minimum of 60 inches from building openings.

* + - * 1. Provide a minimum of one 90-degree bend in flexible conduit routed to the engine generator from a stationary element.
				2. Balance single-phase loads to obtain a maximum of 10 percent unbalance between any two phases.
			1. IDENTIFICATION

Retain first paragraph below if generator is not installed as a separately derived system.

* + - * 1. Install a sign indicating the generator neutral is bonded to the main service neutral at the main service location.
			1. FIELD QUALITY CONTROL
				1. Testing Agency:

Retain one of first four subparagraphs below. Retain first subparagraph below if Director’s Representative will hire an independent testing agency. Retain second subparagraph below to require Contractor to hire an independent testing agency. Retain third subparagraph below to require a Company Service Advisor to perform tests and inspections. Retain fourth subparagraph below to require Contractor to perform tests and inspections and, if required, retain option to require Contractor to arrange for the assistance of a Company Service Advisor.

Director’s Representative will engage a qualified testing agency to perform tests and inspections.

Engage a qualified testing agency to perform tests and inspections.

Engage a Company Service Advisor to test and inspect components, assemblies, and equipment installations, including connections.

Perform tests and inspections[**with the assistance of a Company Service Advisor**].

* + - * 1. Tests and Inspections:

Retain test requirements below with any combination of paragraphs above. The following tests and inspections are derived from the NETA Acceptance Testing Specification (ATS). Review the NETA ATS and other standards listed and revise subparagraphs below.

Perform tests recommended by manufacturer and each visual and mechanical inspection and electrical and mechanical test listed in the first two subparagraphs below as specified in the NETA ATS. Certify compliance with test parameters.

Visual and Mechanical Inspection:

Compare equipment nameplate data with drawings and specifications.

Inspect physical and mechanical condition.

Inspect anchorage, alignment, and grounding.

Verify the unit is clean.

Electrical and Mechanical Tests:

Perform insulation-resistance tests in accordance with IEEE 43.

Machines larger than 200 hp. Test duration shall be 10 minutes. Calculate polarization index.

Machines 200 hp or less. Test duration shall be one minute. Calculate the dielectric-absorption ratio.

Test protective relay devices.

Verify phase rotation, phasing, and synchronized operation as required by the application.

Functionally test engine shutdown for low oil pressure, overtemperature, overspeed, and other protection features as applicable.

Test in first subparagraph below is optional in NETA ATS.

Perform vibration test for each main bearing cap.

Verify correct functioning of the governor and regulator.

NFPA 110 Acceptance Tests: Perform tests required by NFPA 110 that are additional to those specified here, including, but not limited to, single-step full-load pickup test.

Battery Tests: Equalize charging of battery cells according to manufacturer's written instructions. Record individual cell voltages.

Measure charging voltage and voltages between available battery terminals for full-charging and float-charging conditions. Check electrolyte level and specific gravity under both conditions.

Test for contact integrity of all connectors. Perform an integrity load test and a capacity load test for the battery.

Verify acceptance of charge for each element of the battery after discharge.

Verify that measurements are within manufacturer's specifications.

Battery-Charger Tests: Verify specified rates of charge for both equalizing and float-charging conditions.

System Integrity Tests: Methodically verify proper installation, connection, and integrity of each element of engine generator system before and during system operation. Check for air, exhaust, and fluid leaks.

Retain "Exhaust-System Back-Pressure Test" subparagraph below for long, restricted exhaust systems.

Exhaust-System Back-Pressure Test: Use a manometer with a scale exceeding 40-inch wg. Connect to exhaust line close to engine exhaust manifold. Verify that back pressure at full-rated load is within manufacturer's written allowable limits for the engine.

Verify local requirements and delete "Exhaust Emissions Test" subparagraph below for most projects. Few jurisdictions require this test for emergency or standby engine generators. See the Evaluations for discussion of Tier requirements.

Exhaust Emissions Test: Comply with applicable government test criteria.

Voltage and Frequency Transient Stability Tests: Use recording oscilloscope to measure voltage and frequency transients for 50 and 100 percent step-load increases and decreases, and verify that performance is as specified.

Harmonic-Content Tests: Measure harmonic content of output voltage at 25 percent and 100 percent of rated linear load. Verify that harmonic content is within specified limits.

Retain "Noise Level Tests" subparagraph below for projects subject to unwanted or illegal generator-set noise intrusion into adjacent properties or activities. Coordinate with Drawings and with requirements in "Action Submittals," "Quality Assurance," and "Engine Generator Assembly Description" articles. Note that some noise, such as the muffler noise, is directional and siting the generator can have a large impact on the measured noise in some directions. See the Evaluations for additional discussion of noise concerns.

Noise Level Tests: Measure A-weighted level of noise emanating from generator-set installation, including engine exhaust and cooling-air intake and discharge, at [**four**] <**Insert number**> locations [**25 feet from edge of the generator enclosure**] [**on the property line**] <**Insert location for measurement**>, and compare measured levels with required values.

* + - * 1. Coordinate tests with tests for transfer switches and run them concurrently.
				2. Test instruments shall have been calibrated within the last 12 months, traceable to NIST Calibration Services, and adequate for making positive observation of test results. Make calibration records available for examination on request.
				3. Leak Test: After installation, charge exhaust, coolant, and fuel systems and test for leaks. Repair leaks and retest until no leaks exist.
				4. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation for generator and associated equipment.
				5. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
				6. Remove and replace malfunctioning units and [**retest**] [**reinspect**] as specified above.
				7. Retest: Correct deficiencies identified by tests and observations and retest until specified requirements are met.
				8. Report results of tests and inspections in writing. Record adjustable relay settings and measured insulation resistances, time delays, and other values and observations. Attach a label or tag to each tested component indicating satisfactory completion of tests.
				9. Infrared Scanning: After Substantial Completion, but not more than 60 days after final acceptance, perform an infrared scan of each power wiring termination and each bus connection while running with maximum load. Remove all access panels so terminations and connections are accessible to portable scanner.

Follow-up Infrared Scanning: Perform an additional follow-up infrared scan 11 months after date of Substantial Completion.

Instrument: Use an infrared scanning device designed to measure temperature or to detect significant deviations from normal values. Provide calibration record for device.

Record of Infrared Scanning: Prepare a certified report that identifies terminations and connections checked and that describes scanning results. Include notation of deficiencies detected, remedial action taken, and observations after remedial action.

* + - 1. MAINTENANCE SERVICE

Retain this article for critical installations and consider including a provision for submitting a continuing maintenance agreement proposal. Revise starting date if required. Obtain a copy of maintenance agreement before retaining or editing below. Maintenance contracts may not be allowed for publicly funded projects.

* + - * 1. Initial Maintenance Service: Beginning at Substantial Completion, provide [**12**] <**Insert number**> months' full maintenance by skilled employees of manufacturer's designated service organization. Include quarterly exercising to check for proper starting, load transfer, and running under load. Include routine preventive maintenance as recommended by manufacturer and adjusting as required for proper operation. Provide parts and supplies same as those used in the manufacture and installation of original equipment.
			1. DEMONSTRATION
				1. Engage a Company Service Advisor to train Director’s Representative's maintenance personnel to adjust, operate, and maintain packaged engine generators.

END OF SECTION 263213.16