

READ THIS FIRST

Notice to the Design Engineer, this document is part of Facilities and Infrastructure standards for Electrical Systems. Designers are advised to NOT use this template (*.doc) document as part of any project contract documents. Designers shall use the Port of Seattle MasterSpec specifications from the following link:

<https://www.portseattle.org/page/guide-specifications>.

Designers shall edit the corresponding Port's MasterSpec specification to meet the F&I Electrical Standard outlined in this specification. Note that Port's MasterSpec specifications contain specifications and languages for both Aviation and Maritime Divisions. F&I Standards are strictly for Aviation Division, and any Maritime related specs or languages should be removed from the project specifications.

PART 1 - GENERAL

1.01 SUMMARY OF WORK AND NOTES TO DESIGNER

- A. This Section includes packaged engine-generator sets for emergency OR optional stand-by power at 480VAC and 4160VAC with the following features:
 - 1. Diesel engine.
 - 2. Unit-mounted OR Remote-mounting cooling system.
 - 3. Unit-mounted OR Remote-mounting control and monitoring.
 - 4. Outdoor enclosure where installed outdoors.
- B. Related Sections include the following:
 - 1. Section 263600 "Transfer Switches" for transfer switches including sensors and relays to initiate automatic-starting and -stopping signals for engine-generator sets.
- C. Comply with applicable NEMA, ISO and UL standards.
- D. Designer shall utilize a generator sizing calculation in determining whether stepping of loads will be required for the engineered system.
- E. Design the fuel storage and supply, ventilation, cooling and exhaust systems in accordance with the manufacturer's recommendations. Refer to Division 23 for piping installation requirements. All electrical equipment for these systems, such as fans, pumps, controls, etc. shall be fed from emergency panels which are energized whenever the specific engine generator is operating.
- F. The Engineer shall determine the arrangements for fuel storage and supply for each individual installation. The following guidelines shall apply in general:
 - 1. 0-500kW: Units up to 500kW rating shall be provided with an integral base tank provided convenient arrangements for refueling under emergency conditions are available. No day tank is required.

2. Above 500kW: Units above 500kW rating shall be provided with a day tank and a remote fuel storage tank.

1.02 REFERENCES

A. Definitions:

1. 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.

1.03 ADMINISTRATIVE REQUIREMENTS

- ### A. Coordination: Coordinate size and location of concrete bases for package engine generators and remote radiators mounted on grade. Cast anchor-bolt inserts into bases. Concrete, reinforcement, and formwork requirements are specified with concrete.

1.04 SUBMITTALS

- ### A. Product Data: For each type of packaged engine generator indicated. Include rated capacities, operating characteristics, and furnished specialties and accessories. In addition, include the following:

1. Thermal damage curve for generator.
2. Time-current characteristic curves for generator protective device.

- ### B. Shop Drawings: Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.

1. Dimensioned outline plan and elevation drawings of engine-generator set and other components specified.
2. Design Calculations: Signed and sealed by a qualified professional engineer. Calculate requirements for selecting vibration isolators and seismic restraints and for designing vibration isolation bases.
3. Vibration Isolation Base Details: Signed and sealed by a qualified professional engineer. Detail fabrication, including anchorages and attachments to structure and to supported equipment. Include base weights.
4. Wiring Diagrams: Power, signal, and control wiring.

- ### C. Manufacturer Seismic Qualification Certification: Submit certification that day tank, engine-generator set, batteries, battery racks, accessories, and components will withstand seismic forces defined in Section 260548.16 "Seismic Controls for Electrical Systems." Include the following:

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

- a. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified and the unit will be fully operational after the seismic event."
 2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
 3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.
- D. Qualification Data: For installer, manufacturer and testing agency.
- E. Source quality-control test reports.
1. Certified summary of prototype-unit test report.
 2. Certified Test Reports: For components and accessories that are equivalent, but not identical, to those tested on prototype unit.
 3. Report of factory test on units to be shipped for this Project, showing evidence of compliance with specified requirements.
 4. Report of sound generation.
 5. Report of exhaust emissions showing compliance with applicable regulations.
 6. Certified Torsional Vibration Compatibility: Comply with NFPA 110.
- F. Field quality-control test reports.
- G. Warranty: Special warranty specified in this Section.
- H. Closeout Submittals
- I. Operation and Maintenance Data: For packaged engine generators to include in emergency, operation, and maintenance manuals. In addition to items specified in Section 017823 "Operation and Maintenance Data," include the following:
1. 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.

1.05 QUALITY ASSURANCE

- A. Installer Qualifications: Manufacturer's authorized representative who is trained and approved for installation of units required for this Project.
1. Maintenance Proximity: Not more than four hours' normal travel time from Installer's place of business to Project site.
- B. Manufacturer Qualifications: A qualified manufacturer. Maintain, within 200 miles of Project site, a service center capable of providing training, parts, and emergency maintenance repairs.
- C. Testing Agency Qualifications: An independent agency, with the experience and capability to conduct the testing indicated, that is a member company of the InterNational

Electrical Testing Association or is a nationally recognized testing laboratory (NRTL), and that is acceptable to authorities having jurisdiction.

1. Testing Agency's Field Supervisor: Person currently certified by the InterNational Electrical Testing Association or the National Institute for Certification in Engineering Technologies to supervise on-site testing specified in Part 3.
- D. Source Limitations: Obtain packaged generator sets and auxiliary components through one source from a single manufacturer.
- E. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.
- F. Comply with ASME B15.1.
- G. Comply with NFPA 37.
- H. Comply with NFPA 70.
- I. Comply with NFPA 110 requirements for Level 1 emergency power supply system.
- J. Comply with UL 2200.
- K. Engine Exhaust Emissions: Comply with applicable state and local government requirements.
- L. Noise Emission: Comply with critical noise criteria for maximum noise level for the application due to sound emitted by generator set including engine, engine exhaust, engine cooling-air intake and discharge, and other components of installation.
- M. A prototype of the engine generator shall have passed the tests defined in the following:
 1. NFPA 110
 2. IEEE 115

1.06 PROJECT CONDITIONS

- A. Environmental Conditions: Engine-generator system shall withstand the following environmental conditions without mechanical or electrical damage or degradation of performance capability:
 1. Ambient Temperature: 0 to 40 deg C.
 2. Relative Humidity: 0 to 95 percent.
 3. Altitude: Sea level to 300 feet.

1.07 SOURCE QUALITY CONTROL

- A. Make completed generator available for inspection at manufacturer's factory prior to packaging for shipment. Notify the Port at least two weeks before inspection is allowed.
- B. Allow witnessing of factory inspections and tests at manufacturer's factory or test facility. Notify the Port at least two weeks before inspections and tests are scheduled.

PART 2 - PRODUCTS

2.01 MANUFACTURERS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. Caterpillar; Engine Div.
 - 2. Kohler Co.
 - 3. Onan/Cummins Power Generation

2.02 ENGINE-GENERATOR SET

- A. Factory-assembled and -tested, engine-generator set.
- B. Mounting Frame: The engine generator shall be skid mounted to a rigid, self-supporting base equipped with lifting and pulling eyes. The base shall maintain alignment of mounted components without depending on concrete foundation.
- C. Capacities and Characteristics:
 - 1. Power Output Ratings: Engine generators shall be rated according to Prime Power Ratings as defined in the applicable standards. Units shall be sized to meet the loads of a prolonged outage. The stand-by power rating shall not be used.
 - 2. Output Connections: Three-phase, four wire.
 - 3. Nameplates: For each major system component to identify manufacturer's name and address, and model and serial number of component.
- D. Generator-Set Performance:
 - 1. Steady-State Voltage Operational Bandwidth: 4 percent of rated output voltage from no load to full load.
 - 2. Steady State Voltage Modulation Frequency: Less than 1 Hz.
 - 3. 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.
 - 4. Steady-State Frequency Operational Bandwidth: 0.5 percent of rated frequency from no load to full load.

5. **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.
6. **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.
7. **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.
8. **Sustained Short-Circuit Current:** For a 3-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.
9. **Start Time:** Comply with NFPA 110 Type 10 system requirements (i.e., 10 second maximum time to start, come up to speed and voltage and connect to load).

2.03 ENGINE

- A. **Fuel:** Diesel, Grade DF-2.
- B. **Rated Engine Speed:** 1800 rpm for units rated 750kW or less. 1200 rpm for units rated greater than 750kW.
- C. **Maximum Piston Speed for Four-Cycle Engines:** 2250 fpm.
- D. **Lubrication System:** The following items are mounted on engine or skid:
 1. **Filter and Strainer:** Rated to remove 90 percent of particles 5 micrometers and smaller while passing full flow.
 2. **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.
 3. **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.
- E. **Engine Fuel System:**
 1. **Main Fuel Pump:** Mounted on engine. Pump ensures adequate primary fuel flow under starting and load conditions.
 2. **Injection Pumps:** Integral to unit.
 3. **Relief-Bypass Valve:** Automatically regulates pressure in fuel line and returns excess fuel to source.
- F. **Governor:** Electronic, adjustable isochronous to 10% speed drop, with speed sensing.
- G. **Cooling System:** Closed loop, liquid cooled, with radiator factory mounted on engine-generator-set mounting frame with belt-driven fan OR remote radiator with electric fan and integral engine-driven coolant pump.

1. Coolant: Solution of 50 percent ethylene-glycol-based antifreeze and 50 percent water, with anticorrosion additives as recommended by engine manufacturer.
 2. Size of Radiator: Adequate to contain expansion of total system coolant from cold start to 110 percent load condition.
 3. Expansion Tank: Constructed of welded steel plate and rated to withstand maximum closed-loop coolant system pressure for engine used.
 4. Temperature Control: Self-contained, thermostatic-control valve modulates coolant flow automatically to maintain optimum constant coolant temperature as recommended by engine manufacturer.
 5. Coolant Hose: Flexible assembly with inside surface of nonporous rubber and outer covering of aging-, ultraviolet-, and abrasion-resistant fabric.
- H. Muffler/Silencer: Industrial type, sized as recommended by engine manufacturer and selected with exhaust piping system to not exceed engine manufacturer's engine backpressure requirements.
1. Minimum sound attenuation of 12 dB at 500 Hz.
 2. Sound level to conform to critical noise criteria for the application.
- I. Air-Intake Filter: Heavy-duty, engine-mounted air cleaner with replaceable dry-filter element and "blocked filter" indicator.
- J. Starting System: 24-VDC electric, with negative ground. Generators under 200kW may have 12VDC starting system.
1. Components: Sized for 3 cranking cycles (75 seconds).
 2. Cranking Motor: Heavy-duty unit that automatically engages and releases from engine flywheel without binding.
 3. Cranking Cycle: 75 seconds, per NFPA 110.
 4. Battery: Battery shall be gel cell, no-maintenance type. Adequate capacity within ambient temperature range specified in Part 1 "Project Conditions" Article to provide specified cranking cycle at least three times without recharging.
 - a. Racks shall be FRP, seismic zone 3. Charger shall be matched to battery systems.
 5. Battery Cable: Size as recommended by engine manufacturer for cable length indicated. Include required interconnecting conductors and connection accessories.
 6. Battery Compartment: Factory fabricated of metal with acid-resistant finish and thermal insulation. Thermostatically controlled heater shall be arranged to maintain battery above 10 deg C regardless of external ambient temperature within range specified in Part 1 "Project Conditions" Article. Include accessories required to support and fasten batteries in place.
 7. Battery-Charging Alternator: Furnish both 35 Amp minimum continuous rating factory mounted on engine with solid-state voltage regulation and separate 10 Amp minimum equalizing battery charger for battery recharging.
 8. Battery Charger: Current-limiting, automatic-equalizing and float-charging type. Unit shall comply with UL 1236 and include the following features:
 - a. Charger shall be matched to battery system.
 - b. Operation: Equalizing-charging rate 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.
- c. Automatic Voltage Regulation: Maintain constant output voltage regardless of input voltage variations up to plus or minus 10 percent.
 - d. Ammeter and Voltmeter: Flush mounted in door. Meters shall indicate charging rates.
 - e. 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.
 - f. Enclosure and Mounting: NEMA 250, Type 1, wall-mounted cabinet.

2.04 FUEL OIL STORAGE

- A. Units up to 500kW rating shall be provided with an integral base tank provided with convenient arrangements for refueling under emergency conditions are available. No day tank is required.
- B. Units above 500kW rating shall be provided with a day tank and a remote fuel storage tank.
- C. Comply with NFPA 30.
- D. Day Tank: Comply with UL 142, freestanding, factory-fabricated fuel tank assembly, with integral, float-controlled transfer pump and the following features:
 - 1. Containment: Integral rupture basin with a capacity of 150 percent of nominal capacity of day tank.
 - a. Leak Detector: Locate in rupture basin and connect to provide audible and visual alarm in the event of day-tank leak.
 - 2. Tank Capacity: As recommended by engine manufacturer for an uninterrupted period of 2 hours' operation at 100 percent of rated power output of engine-generator system without being refilled.
 - 3. Pump Capacity: Exceeds maximum flow of fuel drawn by engine-mounted fuel supply pump at 110 percent of rated capacity, including fuel returned from engine.
 - 4. Low-Level Alarm Sensor: Liquid-level device operates alarm contacts at 25 percent of normal fuel level.
 - 5. High-Level Alarm Sensor: Liquid-level device operates alarm and redundant fuel shutoff contacts at midpoint between overflow level and 100 percent of normal fuel level.
 - 6. Piping Connections: Factory-installed fuel supply and return lines from tank to engine; local fuel fill, vent line, overflow line; and tank drain line with shutoff valve.
- E. Base-Mounted Fuel Oil Tank: Factory installed and piped, complying with UL 142 fuel oil tank. Features include the following:
 - 1. Tank level indicator.
 - 2. Capacity: Fuel for two hours' continuous operation at 100 percent rated power output.

3. Containment Provisions: Comply with requirements of authorities having jurisdiction.

2.05 CONTROL AND MONITORING

- A. 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 generator set. When mode-selector switch is switched to the on position, generator set starts. The off position of same switch initiates generator-set shutdown. When generator set is running, specified system or equipment failures or derangements automatically initiate alarms. Operation of a remote emergency-stop switch also shuts down generator set.
- B. Configuration: Operating and safety indications, protective devices, basic system controls, and engine gauges shall be grouped in a common control and monitoring panel mounted on the generator set. Mounting method shall isolate the control panel from generator-set vibration.
 1. The engine generator shall be provided with a microprocessor based control module for operation and monitoring of the unit. It shall also incorporate a communications interface for remote control and monitoring including metering. The interface shall be compatible with the Seattle Tacoma Airport SCADA and Power Monitoring System. The module shall incorporate an interactive control panel for unit control, diagnostics and data inquiry. It shall be housed in an environmentally hardened enclosure.
- C. Configuration: Operating and safety indications, protective devices, basic system controls, and engine gages shall be grouped in a common wall-mounted control and monitoring panel.
- D. Indicating and Protective Devices and Controls: As required by NFPA 110 for Level 1 system, and the following:
 1. "RUN/OFF/AUTO" keyed switch.
 2. "EMERGENCY STOP" pushbutton
 3. AC voltmeter.
 4. AC ammeter.
 5. AC frequency meter.
 6. Generator Kilowatts
 7. Generator KVARs
 8. Generator Power Factor
 9. DC voltmeter (alternator battery charging).
 10. Engine-coolant temperature gage.
 11. Engine lubricating-oil pressure gage.
 12. Engine RPM
 13. Running-time meter.
 14. Ammeter-voltmeter, phase-selector switch(es).
 15. Generator-voltage adjusting rheostat.
 16. Fuel Level (base tank units)
 17. Engine Generator Alarms, including:

- a. Low Oil pressure
 - b. High Coolant Temperature
 - c. Low Fuel Level – Daytank
 - d. High Stator Temperature (for 4150 VAC generators with stator RTDs)
18. Engine Generator Standard Shutdowns, including:
- a. Low-Low Oil Pressure
 - b. High-High Coolant Temperature
 - c. Overcrank
 - d. Overspeed
 - e. Emergency Shutdown

- E. 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.
- F. Connection to SCADA system: A separate terminal block, factory wired to Form C dry contacts, for each alarm and status indication is reserved for connections for data-link transmission of indications to remote data terminals. Data system connections to terminals are covered in Section 260913 "Electrical Power Monitoring and Control."

2.06 GENERATOR OVERCURRENT AND FAULT PROTECTION

- A. For units rated 0-500kVA, 480VAC: Generator Circuit Breaker: Molded-case, thermal-magnetic type; 100 percent rated; complying with UL 489.
1. Tripping Characteristic: Designed specifically for generator protection.
 2. Trip Rating: Matched to generator rating.
 3. Shunt Trip: Connected to trip breaker when generator set is shut down by other protective devices.
 4. Mounting: Mount on generator.
- B. For units 501-1250kVA, 480VAC: Generator Circuit Breaker: Insulated-case, adjustable electronic-trip type; 100 percent rated; complying with UL 489.
1. Tripping Characteristics: Adjustable long-time and short-time delay and instantaneous.
 2. Trip Settings: Selected to coordinate with generator thermal damage curve.
 3. Shunt Trip: Connected to trip breaker when generator set is shut down by other protective devices.
 4. Mounting: On or adjacent to generator.
- C. For all 4160VAC units: Generator Disconnect Switch: Circuit breaker, disconnect switch and protective relaying shall be part of separate generator switchgear.
1. Protective relaying shall be a single multi-function relay, such as a General Electric Multi-Lin. Protective relaying should include the following:
 - a. 50/51 Overcurrent
 - b. 27/59 Under/Overvoltage
 - c. 32 Reverse Power
 - d. 40 Loss of Excitation

- e. 46 Current Balance
 - f. 49 Stator Temperature
 - g. 81U/81O Under/Over Frequency
 - h. Engine Overtemperature
 - i. Engine Low Oil Pressure
2. Note: some or all of this equipment may be provided as part of paralleling switchgear under separate section from this section. See Section 261300 "Medium Voltage Switchgear".
- D. Ground-Fault Indication: Comply with NFPA 70, "Emergency System" signals for ground-fault. Integrate ground-fault alarm indication with other generator-set alarm indications.

2.07 GENERATOR, EXCITER, AND VOLTAGE REGULATOR

- A. Comply with NEMA MG 1.
- B. Generator: Synchronous, 4 pole (6 pole if 1200RPM). 105° C maximum temperature rise at prime power rating, self-cooled by integral fan. Built to withstand 125% overspeed and 110% loading without damage.
- C. Drive: Single bearing rotor with amortisseur winding, direct coupled to engine by flexible drive.
- D. Generator Exciter: Permanent magnet generator, brushless exciter. Shall be capable of supplying 300% rated current into a fault for not more than 10 seconds.
- E. Electrical Insulation:
 - 1. 480VAC: Class H or Class F.
 - 2. 4160VAC: Class F. Provide two embedded stator RTDs per phase.
- F. Windings: Two-thirds pitch stator winding and fully linked amortisseur winding.
- G. Stator-Winding Leads Brought out to terminal box to permit future reconnection for other voltages if required.
- H. 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.
- I. Enclosure: Drip proof.
- J. Instrument Transformers: Mounted within generator enclosure.
- K. Voltage Regulator: Solid-state type with 3-phase sensing and underfrequency compensation. Separate from exciter, providing performance as specified.
 - 1. Adjusting rheostat on control and monitoring panel shall provide plus or minus 5 percent adjustment of output-voltage operating band.

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

2.08 OUTDOOR GENERATOR-SET ENCLOSURE

- A. Description: Vandal-resistant, 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.
- B. Description: Prefabricated or pre-engineered walk-in enclosure with the following features:
 - 1. Construction: Galvanized-steel, metal-clad, integral structural-steel-framed building erected on concrete foundation.
 - 2. Structural Design and Anchorage: Comply with ASCE 7 for wind loads.
 - 3. Space Heater: Thermostatically controlled and sized to prevent condensation.
 - 4. Louvers: Equipped with bird screen and filter arranged to permit air circulation when engine is not running while excluding exterior dust, birds, and rodents.
 - 5. Hinged Doors: With padlocking provisions.
 - 6. 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-set components.
- C. 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.
 - 1. Louvers: Fixed-engine, cooling-air inlet and discharge. Storm-proof and drainable louvers prevent entry of rain and snow.
 - 2. 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.
- D. Interior Lights with Switch: Factory-wired, vaporproof-type fixtures within housing; arranged to illuminate controls and accessible interior. Arrange for external electrical connection.
 - 1. AC lighting system and connection point for operation when remote source is available.
 - 2. Provide light switch at door of enclosure.
- E. Convenience Outlets: Factory wired, GFCI. Arrange for external electrical connection.

2.09 VIBRATION ISOLATION DEVICES

- A. Elastomeric Isolation Pads:
 - 1. Manufacturers: Subject to compliance with requirements, provide products by the following:

- a. Ace Mountings Co., Inc.
 - b. California Dynamics Corporation.
 - c. Isolation Technology, Inc.
 - d. Kinetics Noise Control, Inc.
 - e. Mason Industries, Inc.
 - f. Vibration Eliminator Co., Inc.
 - g. Vibration Isolation.
 - h. Vibration Mountings & Controls, Inc.
2. Fabrication: Single or multiple layers of sufficient durometer stiffness for uniform loading over pad area.
 3. Size: Factory or field cut to match requirements of supported equipment.
 4. Pad Material: Oil and water resistant with elastomeric properties.
- B. Restrained Spring Isolators: Freestanding, Steel, Open-Spring Isolators with Vertical-Limit Stop Restraint in Two-Part Telescoping Housing:
1. Manufacturers: Subject to compliance with requirements, provide products by the following:
 - a. Ace Mountings Co., Inc.
 - b. California Dynamics Corporation.
 - c. Isolation Technology, Inc.
 - d. Kinetics Noise Control, Inc.
 - e. Mason Industries, Inc.
 - f. Vibration Eliminator Co., Inc.
 - g. Vibration Isolation.
 - h. Vibration Mountings & Controls, Inc.
 2. Two-Part Telescoping Housing: A steel top and bottom frame separated by an elastomeric material and enclosing the spring isolators. Housings are equipped with snubbers to limit vertical movement.
 - a. Drilled base housing for bolting to structure with an elastomeric isolator pad attached to the underside. Bases shall limit floor load to 500 psig (3447 kPa).
 - b. Threaded top housing with adjustment bolt and cap screw to fasten and level equipment.
 3. Outside Spring Diameter: Not less than 80 percent of the compressed height of the spring at rated load.
 4. Minimum Additional Travel: 50 percent of the required deflection at rated load.
 5. Lateral Stiffness: More than 80 percent of rated vertical stiffness.
 6. Overload Capacity: Support 200 percent of rated load, fully compressed, without deformation or failure.

2.010 FINISHES

- A. Indoor and Outdoor Enclosures and Components: Manufacturer's standard finish over corrosion-resistant pretreatment and compatible primer.

2.011 SOURCE QUALITY CONTROL

- A. Prototype Testing: Factory test engine-generator set using same engine model, constructed of identical or equivalent components and equipped with identical or equivalent accessories.
 - 1. Tests: Comply with NFPA 110, Level 1 Energy Converters and with IEEE 115.
- B. Project-Specific Equipment Tests: Before shipment, factory test engine-generator set and other system components and accessories manufactured specifically for this Project. Perform tests at rated load and power factor. Include the following tests:
 - 1. Test components and accessories furnished with installed unit that are not identical to those on tested prototype to demonstrate compatibility and reliability.
 - 2. 45 minute run tests at each load level of:
 - a. ¼ load
 - b. 1/2 load
 - c. 3/4 load
 - d. Full load run.
 - 3. Maximum power.
 - 4. Voltage regulation.
 - 5. Transient and steady-state governing.
 - 6. Single-step load pickup.
 - 7. Operational test of safety and protective shutdown for each protective device.
 - 8. Report factory test results within 10 days of completion of test.

PART 3 - INSTALLATION

3.01 EXAMINATION

- A. Examine areas, equipment bases, and conditions, with Installer present, for compliance with requirements for installation and other conditions affecting packaged engine-generator performance.
- B. Verify that adequate space is available at the proposed unit location for the engine generator plus clearances required by NEC and/or the manufacturer. Note that some components are removed by pulling from one end of the unit (i.e., engine camshaft, generator rotor). Provide sufficient access to the unit location to allow removal and replacement of a complete unit.
- C. Examine roughing-in of piping systems and electrical connections. Verify actual locations of connections before packaged engine-generator installation. Verify that all piping systems for fuel, coolant and exhaust as well as electrical conduit runs are installed to the same seismic standard as the engine generator.
- D. Verify that the location and arrangements for refueling the engine generator are easily accessible by tanker truck under outage conditions, including the potential disruption of a seismic event.

- E. Verify that the engine generator is adequately sized to start and carry the intended load, or make alternate provisions such as additional generation or load shedding.
- F. Make provisions for load testing the unit. This may include a site to spot a portable load bank and provisions for connection including conductors and switching.
- G. Proceed with installation only after unsatisfactory conditions have been corrected.

3.02 EQUIPMENT INSTALLATION

- A. Comply with packaged engine-generator manufacturers' written installation and alignment instructions and with NFPA 110.
- B. Install packaged engine generator to provide access, without removing connections or accessories, for periodic maintenance.
- C. Install packaged engine generator on cast-in-place concrete equipment bases. Concrete shall be rated for 3000 psi minimum.
 - 1. Comply with requirements for seismic control devices specified in Section 260548.16 "Seismic Controls for Electrical Systems."
 - 2. Concrete bases shall be leveled to no more than 0.25 inches of deviation for every 3 feet in ALL directions.
 - 3. Contractor shall notify F&I and AV Maintenance prior to concrete pour to measure concrete base and assess base's levelness.
 - 4. Concrete bases shall have smooth finishes. Broom finishes are prohibited.
- D. Install remote radiator with elastomeric isolator pads OR restrained spring isolators having a minimum deflection of 1 inch on concrete base on grade.
- E. Install Schedule 40, black steel piping with welded joints for cooling water piping between engine-generator set and remote radiator where applicable. Piping materials and installation requirements are specified in Section 232113 "Hydronic Piping."
- F. 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. Flexible connectors and steel piping materials and installation requirements are specified in Section 232116 Hydronic Piping Specialties."
 - 1. Install condensate drain piping to muffler drain outlet full size of drain connection with a shutoff valve, stainless-steel flexible connector, and Schedule 40, black steel pipe with welded joints. Flexible connectors and piping materials and installation requirements are specified in Section 232116 Hydronic Piping Specialties."
- G. Electrical Wiring: Install electrical devices furnished by equipment manufacturers but not specified to be factory mounted.

3.03 **CONNECTIONS**

- A. Piping installation requirements are specified in other Sections. Drawings indicate general arrangement of piping and specialties.
- B. Connect fuel, cooling-system, and exhaust-system piping adjacent to packaged engine generator to allow service and maintenance.
- C. Connect cooling-system water piping to engine-generator set and remote radiator with flexible connectors.
- D. Connect engine exhaust pipe to engine with flexible connector.
- E. Connect fuel piping to engines with a gate valve and union and flexible connector.
- F. Ground equipment according to Section 260526 "Grounding and Bonding for Electrical Systems."
- G. Connect wiring according to Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

3.04 **IDENTIFICATION**

- A. Identify system components according to Section 230553 "Identification for HVAC Piping and Equipment" and Section 260553 "Identification for Electrical Systems."

3.05 **FIELD QUALITY CONTROL**

- A. Testing Agency: Engage a qualified testing agency to perform tests and inspections and prepare test reports. Final acceptance tests shall be performed after installation of the engine generator is complete and before final acceptance by the Port of Seattle.
- B. Tests and Inspections:
 - 1. Perform tests recommended by manufacturer and each electrical test and visual and mechanical inspection for "AC Generators and for Emergency Systems" specified in NETA Acceptance Testing Specification Section 7.22.1 Emergency Systems, Engine Generator, (omit vibration baseline tests). Certify compliance with test parameters. In addition, perform the following tests:
 - a. Perform a 100% load test for eight hours without interruption. Record key data every 15 minutes during the test.
 - b. Perform a single step full load pickup test. Record transient parameters during the test.
 - 2. Battery Tests: Equalize charging of battery cells according to manufacturer's written instructions. Record individual cell voltages.
 - a. 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.

- b. Test for contact integrity of all connectors. Perform an integrity load test and a capacity load test for the battery.
 - c. Verify acceptance of charge for each element of the battery after discharge.
 - d. Verify that measurements are within manufacturer's specifications.
 3. Battery-Charger Tests: Verify specified rates of charge for both equalizing and float-charging conditions.
 4. 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.
 5. Exhaust Emissions Test: Comply with applicable government test criteria.
 6. 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.
 7. Harmonic-Content Tests: Measure harmonic content of output voltage under 25 percent and at 100 percent of rated linear load. Verify that harmonic content is within specified limits.
 8. 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 locations and compare measured levels with required values.
- C. Coordinate tests with tests for transfer switches and run them concurrently.
- D. Test instruments shall have been calibrated within the last 12 months, traceable to standards of NIST, and adequate for making positive observation of test results. Make calibration records available for examination on request.
- E. Leak Test: After installation, charge system and test for leaks. Repair leaks and retest until no leaks exist.
- F. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.
- G. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
- H. Remove and replace malfunctioning units and retest as specified above.
- I. Retest: Correct deficiencies identified by tests and observations and retest until specified requirements are met.
- J. 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.
- K. Infrared Scanning: After Substantial Completion, but not more than two weeks before Final Acceptance, perform an infrared scan of each power wiring termination and each bus connection. Remove all access panels so terminations and connections are accessible to portable scanner.
 1. Instrument: Use an infrared scanning device designed to measure temperature or to detect significant deviations from normal values. Provide calibration record for device.

2. 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.

3.06 DEMONSTRATION

- A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain packaged engine generators. Refer to Section 017900 "Demonstration and Training."

END OF SECTION 263213