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**Section 16230**

**Engine Generators**

1. **GENERAL**
   1. **WORK INCLUDED**
      1. Drawings and general provisions of the contract, including general and supplementary conditions and Division 01 specification sections, apply to this section.
   2. **RELATED WORK**
      1. Section 16285 - "Transfer Switches" for transfer switches including sensors and relays to initiate automatic-starting and stopping signals for engine-generator sets.
   3. **SUMMARY**
      1. This specification is for diesel fueled, standby permanent generators. Generator voltages, KW & KVA ratings, power factors, phases, amperages, etc., will be indicated on the drawings.
      2. This section includes packaged engine-generator sets for standby power supply with the following features:
         1. Diesel engine.
         2. Unit-mounted cooling system.
         3. Unit-mounted control and monitoring.
         4. Outdoor enclosure.
         5. Sub base fuel tank
   4. SUBMITTALS
      1. Action submittals
         1. 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:
         2. Thermal damage curve for generator.
         3. Time-current characteristic curves for generator protective device.
         4. Shop drawings: detail equipment assemblies and indicate dimensions, weights, loads, and required clearances, method of field assembly, components, and location and size of each field connection.
         5. Dimensioned outline plan and elevation drawings of engine-generator set and other components specified.
         6. Wiring diagrams: power, signal, and control wiring.
      2. Informational submittals
      3. Retain paragraph and subparagraphs below if required by seismic criteria applicable to Project. Coordinate with Section 260548.16 "Seismic Controls for Electrical Systems."
      4. Retain option below for diesel-engine generators with day tank.
      5. Retain one of first two subparagraphs 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. Second definition is used for essential facilities where equipment must operate immediately after an earthquake.
      6. Coordinate paragraph below with qualification requirements in Section 014000 "Quality Requirements" and as supplemented in "Quality Assurance" Article.
         1. Qualification data: for manufacturer.
         2. Source quality-control test reports.
         3. Certified summary of prototype-unit test report.
         4. Certified test reports: for components and accessories that are equivalent, but not identical, to those tested on prototype unit.
         5. Retain first subparagraph below for generator sets specified to meet performance requirements and for generator sets serving sensitive loads.
         6. Report of sound generation.
         7. Report of exhaust emissions showing compliance with applicable environmental protection agency emission standards.
         8. Field quality-control test reports.
         9. Warranty: special warranty specified in this section.
      7. Closeout submittals
         1. Operation and maintenance data: for packaged engine generators to include in emergency, operation, and maintenance manuals. In "operation and maintenance data," include the following:
         2. 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.
      8. Maintenance material submittals
      9. Extra materials may not be allowed for publicly funded projects.
         1. Furnish extra materials described below that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
         2. Fuses: one for every 10 of each type and rating, but no fewer than one of each.
         3. Indicator lamps: two for every six of each type used, but no fewer than two of each.
         4. Filters: one set each of lubricating oil, fuel, and combustion-air filters.
   5. **QUALITY ASSURANCE**
      1. Installer qualifications: manufacturer's authorized representative who is trained and approved for installation of units required for this project.
      2. Maintenance proximity: not more than four hours' normal travel time from installer's place of business to project site.
      3. Manufacturer qualifications: a qualified manufacturer. Maintain, within 200 miles of project site, a service center capable of providing training, parts, and emergency maintenance repairs.
      4. Testing qualifications: testing shall be by the generator manufacturers authorized, factory trained technician.
      5. Source limitations: obtain packaged generator sets and auxiliary components through one source from a single manufacturer.
      6. 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.
      7. Comply with ASME b15.1.
      8. Comply with NFPA 37.
      9. Comply with NFPA 70, 2008 edition.
      10. Comply with NFPA 99.
      11. Comply with NFPA 110 requirements for level 2 emergency power supply system.
      12. Comply with UL 2200.
      13. Engine exhaust emissions: Tier 3, environmental protection agency certified for standby applications emissions standards and applicable state and local government requirements.
   6. **PROJECT CONDITIONS**
      1. Interruption of existing electrical service: do not interrupt electrical service to facilities occupied by owner or others unless permitted under the following conditions and then only after arranging to provide temporary electrical service according to requirements indicated:
      2. Notify owner no fewer than two days in advance of proposed interruption of electrical service.
      3. Do not proceed with interruption of electrical service without owner's written permission.
      4. Environmental conditions: engine-generator system shall withstand the following environmental conditions without mechanical or electrical damage or degradation of performance capability:
         1. Retain first option in subparagraph below if generator-set start time must be within NFPA 110 limits. This temperature range usually implies installation indoors in heated space. Coordinate with Drawings.
      5. Ambient temperature: -10 deg F to plus 100 deg F.
      6. Relative humidity: 0 to 95 percent.
      7. Altitude: Sea level to 2500 feet.
   7. **COORDINATION**
      * 1. Coordinate size and location of concrete bases for package engine generators. Cast anchor-bolt inserts into bases. Concrete, reinforcement, and formwork requirements are specified with concrete.
        2. The generator concrete base shall be at least 50 feet from any water wellheads per health department regulations.
   8. **WARRANTY**
      1. When warranties are required, verify with Owner's counsel that special warranties stated in this Article are not less than remedies available to Owner under prevailing local laws. Coordinate with Section 016000 "Product Requirements."
         1. Special warranty: manufacturer's standard form in which 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.
         2. Warranty period: 5 years from date of substantial completion.
   9. **MAINTENANCE SERVICE**
      1. 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 months of 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.
2. **PRODUCTS**
   * 1. Manufacturers
        1. As the PSA has procured all generators through them and has standardized on parts, supplies, and service; subject to compliance with requirements, provide products by Kohler Power Systems Generator Division. All automatic transfer switches shall be provided by the generator set manufacturer. All transfer switches are to be automatic unless otherwise shown on drawings.
     2. Engine-generator set
        1. Factory-assembled and -tested, engine-generator set.
        2. Mounting frame: maintain alignment of mounted components without depending on concrete foundation; and have lifting attachments.
        3. 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.
     3. Capacities and Characteristics
        1. Power output ratings: nominal ratings as indicated, with capacity as required to operate as a unit as evidenced by records of prototype testing.
        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.
     4. Generator-set performance
        1. Steady-state voltage operational bandwidth: 3 percent of rated output voltage from no load to full load.
        2. 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.
        3. Steady-state frequency operational bandwidth: 0.5 percent of rated frequency from no load to full load.
        4. 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.
        5. 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.
        6. 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.
     5. Engine
     6. Depending on NFPA 110 class and local codes, LP-gas standby may not be required for natural gas-fueled systems. Verify requirements with authorities having jurisdiction.
        1. Fuel: fuel oil, grade df-2.
        2. Rated engine speed: 1800 rpm.
        3. 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.
        4. Engine fuel system:
        5. Retain first two subparagraphs below for diesel-fueled engine; retain third subparagraph and associated subparagraphs for natural-gas- and LP-gas-fueled engine.
           1. Main fuel pump: mounted on engine. Pump ensures adequate primary fuel flow under starting and load conditions.
           2. Relief-bypass valve: automatically regulates pressure in fuel line and returns excess fuel to source.
           3. Coolant jacket heater: electric-immersion thermal circulation type, factory installed in coolant jacket system. It shall be thermostatic controlled, sized to maintain engine jacket water at 90 degrees f and suitable for operation on 120/240 or 120/208 volts ac as available from pump station step down transformers.
           4. Governor: adjustable isochronous, with speed sensing.
           5. Cooling system: closed loop, liquid cooled, with radiator factory mounted on engine-generator-set mounting frame and integral engine-driven coolant pump.
           6. Coolant: solution of 50 percent ethylene-glycol-based antifreeze and 50 percent water, with anticorrosion additives as recommended by engine manufacturer.
           7. Size of radiator: adequate to contain expansion of total system coolant from cold start to 110 percent load condition.
           8. 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.
           9. Temperature control: self-contained, thermostatic-control valve modulates coolant flow automatically to maintain optimum constant coolant temperature as recommended by engine manufacturer.
           10. Coolant hose: flexible assembly with inside surface of nonporous rubber and outer covering of aging-, ultraviolet-, and abrasion-resistant fabric.
           11. Rating: 50-psig maximum working pressure with coolant at 180 deg f, and noncollapsible under vacuum.
           12. End fittings: flanges or steel pipe nipples with clamps to suit piping and equipment connections.
           13. Muffler/Silencer: sized as recommended by engine manufacturer and selected with exhaust piping system to not exceed engine manufacturer's engine backpressure requirements.
           14. Coordinate with paragraph 2.8.a for sound attenuation.
           15. Air-intake filter: heavy-duty, engine-mounted air cleaner with replaceable dry-filter element and "blocked filter" indicator.
           16. Starting system: 12 or 24-v electric, with negative ground.
           17. Components: sized so they will not be damaged during a full engine-cranking cycle with ambient temperature at maximum specified in part 1 "project conditions" article.
           18. Cranking motor: heavy-duty unit that automatically engages and releases from engine flywheel without binding.
           19. Cranking cycle: 60 seconds.
           20. Battery: adequate capacity within ambient temperature range specified in part 1 "project conditions" article to provide specified cranking cycle at least three times without recharging.
           21. Battery cable: size as recommended by engine manufacturer for cable length Indicated. Include required interconnecting conductors and connection accessories.
           22. 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.
           23. Battery-charging alternator: factory mounted on engine with solid-state voltage regulation and 35-a minimum continuous rating.
           24. Battery charger: current-limiting, automatic-equalizing and float-charging type. Unit shall comply with ul 1236 and include the following features:
           25. Operation: equalizing-charging rate of 10 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.
           26. Automatic temperature compensation: adjust float and equalize voltages for variations in ambient temperature from minus 40 deg c to plus 60 deg c to prevent overcharging at high temperatures and undercharging at low temperatures.
           27. Automatic voltage regulation: maintain constant output voltage regardless of input voltage variations up to plus or minus 10 percent.
           28. Ammeter and voltmeter: flush mounted in door. Meters shall indicate charging rates.
           29. 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.
     7. Fuel oil storage
     8. Retain this Article for diesel-engine units.
        1. Comply with NFPA 30.
        2. Contractor shall fill the fuel tanks with diesel fuel as recommended by the manufacturer.
        3. Base-Mounted fuel oil tank: factory installed and piped, double wall steel tank with fill, vent and leak detection complying with UL 142 fuel oil tank. Features include the following:
           1. Tank level indicator.
           2. Capacity: fuel for 48 hours continuous operation at 100 percent rated power output for permanent installations and 24 hours for the portable unit.
           3. Vandal-resistant lockable remote fill cap.
           4. 5 gallon spill containment
           5. Remote vent cap.
           6. Containment provisions: comply with requirements of authorities having jurisdiction.
     9. Control and monitoring
     10. This Article specifies the subsystem that monitors, protects, and controls the engine generator. See Editing Instruction No. 8 in the Evaluations.
     11. Retain first paragraph below for automatically starting systems; retain second paragraph for manually 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 generator set. The controls shall be arranged such that the existing or new scada system will control the start-stop functions in the automatic position (see sequence below). 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 shut down generator set and initiate alarms. Operation of a remote emergency-stop switch also shuts down generator set.
         2. Scada system generator control
     12. The sequence of operation shall be:
         1. When normal power goes off:
            1. If the pump was running allow the transfer switch to start the generator, switch to its emergency position and the generator will continue to run until the scada system stops the pump. After an adjustable time delay, to allow the pump to ramp down and stop, the scada system will then initiate the generator shut down cycle. When the scada system calls for the pump to run again, when the power is still off, it will allow the generator to start and after an adjustable time delay to allow the generator to get up to speed it will start the pump.
            2. If pump was not running the scada system will block the start signal from the transfer switch to the generator. When the scada system calls for the pump to run it will unblock the generator start signal from the transfer switch to the generator and the normal start-run sequence will happen. The generator will continue to run until the scada system stops the pump. After an adjustable time delay, to allow the pump to ramp down and stop, the scada system will then initiate the generator shut down cycle.
         2. When normal power is restored:
            1. The transfer switch will switch back to normal power and initiate the generator cool down cycle.
         3. Cold weather over-ride: Provide a wall mounted outdoor thermostat at each pump station and connect into the scada system such that if the outdoor temperature drops below 35 degrees it will bypass the scada control of the generator and the transfer switch/generator will function normally. When the outdoor temperature reaches 45 degrees the scada system will again control the generator start times as outlined above.
         4. On/Off control: Provide each scada unit with a generator control on/off switch. In the off position the transfer switch and generator will operate in a normal fashion.
         5. Manual starting system sequence of operation: switching on-off switch on the generator control panel to the on position starts generator set. The off position of same switch initiates generator-set shutdown. When generator set is running, specified system or equipment failures or derangements automatically shut down generator set and initiate alarms. Operation of a remote emergency-stop switch also shuts down generator set.
     13. Indicating and protective devices and controls: as required by nfpa 110 for level  2 system, and the following:
         1. Ac Voltmeter.
         2. Ac ammeter.
         3. Ac frequency meter.
         4. Dc voltmeter (alternator battery charging).
         5. Engine-coolant temperature gage.
         6. Engine lubricating-oil pressure gage.
         7. Running-time meter.
         8. Ammeter-voltmeter, phase-selector switch(es).
         9. Generator-voltage adjusting rheostat.
         10. Fuel tank low fuel level alarm.
         11. Fuel tank high-level shutdown of fuel supply alarm.
         12. Generator overload.
     14. Indicating and protective devices and controls:
         1. Comply with NEMA MG 1.
         2. Ac voltmeter.
         3. Ac ammeter.
         4. Ac frequency meter.
         5. Dc voltmeter (alternator battery charging).
         6. Engine-coolant temperature gage.
         7. Engine lubricating-oil pressure gage.
         8. Running-time meter.
         9. Ammeter-voltmeter, phase-selector switch(es).
         10. Generator-voltage adjusting rheostat.
         11. Start-Stop switch.
         12. Overspeed shutdown device.
         13. Coolant high-temperature shutdown device.
         14. Coolant low-level shutdown device.
         15. Oil low-pressure shutdown device.
         16. Fuel tank low fuel level alarm.
         17. Fuel tank high-level shutdown of fuel supply alarm.
         18. Generator overload.
         19. Fuel tank rupture alarm.
         20. Overcrank shutdown.
         21. Coolant low-temperature alarm.
         22. Control switch not in auto position.
         23. Battery-charger malfunction alarm.
         24. Battery low-voltage alarm.
         25. Generator, exciter, and voltage regulator
         26. Generator overcurrent and fault protection
         27. 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.
         28. Connection to data link: 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."
         29. Common remote audible alarm: comply with nfpa 110 requirements for level 2 systems. Include necessary contacts and terminals in control and monitoring panel.
         30. Remote alarm annunciator: comply with nfpa 99. A led 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-mounting type to suit mounting conditions indicated.
         31. Remote emergency-stop switch: where indicated on the drawings. Surface; wall mounted, unless otherwise indicated; and labeled. Push button shall have a 3” diameter, red, mushroom head, provide an alarm on the generator remote annunciator when button is pushed and alarm remains until the pushbutton is pulled back out. Push button shall be protected from accidental operation.
         32. Generator circuit breaker: molded-case, thermal-magnetic type; 100 percent rated; complying with nema ab 1 and ul 489.
         33. Tripping characteristic: designed specifically for generator protection.
         34. Trip rating: matched to generator rating or as noted otherwise.
         35. Shunt trip: connected to trip breaker when generator set is shut down by other protective devices.
         36. Mounting: adjacent to or integrated with control and monitoring panel.
         37. Drive: generator shaft shall be directly connected to engine shaft. Exciter shall be rotated integrally with generator rotor.
         38. Electrical insulation: Class H or class F.
         39. Stator-winding leads: brought out to terminal box to permit future reconnection for other voltages if required.
         40. 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.
         41. Instrument transformers: mounted within generator enclosure.
         42. Voltage regulator: solid-state type, separate from exciter, providing performance as specified.
         43. Adjusting rheostat on control and monitoring panel shall provide plus or minus 5 percent adjustment of output-voltage operating band.
         44. Provide three phase sensing for three phase applications.
         45. Strip heater: thermostatically controlled unit arranged to maintain stator windings above dew point.
         46. Windings: two-thirds pitch stator winding and fully linked amortisseur winding.
   1. Retain this Article and revise for resistive load elements only or for another type of load bank. See Editing Instruction No. 11 in the Evaluations. Coordinate with Drawings.
   2. Coordinate two paragraphs below with Drawings.
   3. Retain 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. Outdoor generator-set enclosure
      2. Retain one of first two paragraphs and associated subparagraphs below and coordinate with Drawings to define basic outdoor-enclosure type. Edit to specify enclosure features required.
         1. 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. The enclosure shall be sound attenuated such that the complete generator unit, including the muffler, is a maximum of 75 dba at 23 feet under 100% rated load.
         2. 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.
         3. Louvers: fixed-engine, cooling-air inlet and discharge. Storm-proof and drainable louvers prevent entry of rain and snow. Provide with insect screens.
         4. Vibration isolation devices
            1. Restrained spring isolators or integral isolators: freestanding, steel, open-spring isolators with seismic restraint.
         5. 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 – (6-mm-) thick, elastomeric isolator pad attached to baseplate underside; and adjustable equipment mounting and leveling bolt that acts as blocking during installation.
         6. Retain "Manufacturers" Subparagraph and list of manufacturers below to require products from manufacturers listed or a comparable product from other manufacturers.
         7. Retain "Basis-of-Design Product" Subparagraph and list of manufacturers below to identify a specific product or a comparable product from manufacturers listed. Retain option and delete insert note if manufacturer's name and model number are indicated on Drawings.
         8. Outside spring diameter: not less than 80 percent of the compressed height of the spring at rated load.
         9. Minimum additional travel: 50 percent of the required deflection at rated load.
         10. Lateral stiffness: more than 80 percent of rated vertical stiffness.
         11. Overload capacity: support 200 percent of rated load, fully compressed, without deformation or failure.
      3. Finishes
         1. Indoor and outdoor enclosures and components: manufacturer's standard finish over corrosion-resistant pretreatment and compatible primer.
      4. Source quality control
         1. Prototype testing: factory test engine-generator set using same engine model, constructed of identical or equivalent components and equipped with identical or equivalent accessories.
         2. 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:
         3. Test components and accessories furnished with installed unit that are not identical to those on tested prototype to demonstrate compatibility and reliability.
         4. Full load run.
         5. Maximum power.
         6. Voltage regulation.
         7. Transient and steady-state governing.
         8. Single-step load pickup.
         9. Safety shutdown.
         10. Sound attenuation of 75 dba maximum at 23 feet.
         11. Provide 14 days' advance notice of tests and opportunity for observation of tests by owner's representative.
         12. Report factory test results within 10 days of completion of test.
3. **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.
         1. Examine roughing-in of piping systems and electrical connections. Verify actual locations of connections before packaged engine-generator installation.
         2. Proceed with installation only after unsatisfactory conditions have been corrected.
      2. Installation
         1. Comply with packaged engine-generator manufacturers' written installation and alignment instructions and with nfpa 110.
         2. Install packaged engine generator to provide access, without removing connections or accessories, for periodic maintenance.
         3. Install packaged engine generator with restrained spring isolators having a minimum deflation of 1 inch concrete base. Secure sets to anchor bolts installed in concrete bases.
         4. 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 required.
         5. Electrical wiring: install electrical devices furnished by equipment manufacturers but not specified to be factory mounted.
         6. Connections
      3. Coordinate piping installations and specialty arrangements with schematics on 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.
           2. Connect fuel, cooling-system, and exhaust-system piping adjacent to packaged engine generator to allow service and maintenance.
      4. Coordinate first paragraph below with Section 232116 Hydronic Piping Specialties."
         * 1. Connect engine exhaust pipe to engine with flexible connector.
           2. Connect fuel piping to engines with a gate valve and union and flexible connector.
           3. Ground equipment according to section 16160 - "grounding and bonding for electrical systems."
           4. Connect wiring according to section 16120 - "low-voltage electrical power conductors and cables."
      5. Field quality control
         1. Testing agency: engage generator manufacturers authorized factory trained technician to perform tests and inspections and prepare test reports.
         2. Manufacturer's field service: engage a factory-authorized service representative to inspect, test, and adjust components, assemblies, and equipment installations, including connections. Report results in writing.
         3. Perform tests and inspections and prepare test reports.
         4. Manufacturer's field service: engage a factory-authorized service representative to inspect components, assemblies, and equipment installations, including connections, and to assist in testing.
         5. Retain first paragraph and subparagraphs below to describe tests and inspections to be performed by any of the entities in three paragraphs above.
      6. Tests and inspections:
         1. Perform tests recommended by manufacturer and each electrical test and visual and mechanical inspection (except those indicated to be optional) for "ac generators and for emergency systems". Certify compliance with test parameters of NFPA 110.
         2. 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. Complete operation and test log - annex, NFPA 110 sheet 31 or approved data forms.
         3. Battery tests: equalize charging of battery cells according to manufacturer's written instructions. Record individual cell voltages.
         4. 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.
         5. Test for contact integrity of all connectors. Perform an integrity load test and a capacity load test for the battery.
         6. Verify acceptance of charge for each element of the battery after discharge.
         7. Verify that measurements are within manufacturer's specifications.
         8. Battery-charger tests: verify specified rates of charge for both equalizing and float-charging conditions.
         9. 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.
            1. Retain subparagraph below for long, restricted exhaust systems.
            2. Verify local requirements and delete first subparagraph below for most projects. Few jurisdictions require this test for emergency or standby generator sets.
         10. Exhaust emissions test: comply with applicable government test criteria.
         11. Confirm the generator output voltage is in phase rotation with the power company voltage.
         12. Retain 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 Part 1 "Action Submittals" and "Quality Assurance" articles and in Part 2 "Engine" Article.
         13. Coordinate tests with tests for transfer switches and run them concurrently.
         14. 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.
         15. Leak test: after installation, charge system and test for leaks. Repair leaks and retest until no leaks exist.
         16. Operational test: after electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.
         17. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
         18. Remove and replace malfunctioning units and retest as specified above.
         19. Retest: correct deficiencies identified by tests and observations and retest until specified requirements are met.
         20. 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.
         21. Refill the generator fuel tank after all tests are completed.
      7. Demonstration
         1. Engage a factory-authorized service representative to spend time a necessary to train owner's maintenance personnel to adjust, operate, and maintain packaged engine generators.

END OF SECTION