

SECTION 16621 DIESEL GENERATOR SETS

PART 1 GENERAL

- 1.1 SUMMARY: EXTENT OF DIESEL GENERATOR SET WORK IS INDICATED BY DRAWINGS AND SCHEDULES, AND IS HEREBY DEFINED TO INCLUDE, BUT NOT BY WAY OF LIMITATION, DIESEL ENGINE, ELECTRICAL GENERATOR, ENGINE STARTING SYSTEM INCLUDING BATTERIES, INSTRUMENT CONTROL PANEL, WEATHER-PROTECTIVE HOUSING, TRANSFER SWITCHES, DAY TANK(S), ANNUNCIATOR PANEL, EXHAUST SILENCER, WALL THIMBLE, AND ACCESSORIES.
- A. System Description:
1. Diesel engine-driven generator to provide source of stand-by and emergency power.
- B. Concrete and grout work for engine-driven generator pads, foundations, frames and bedplates are specified in Division-3 "Concrete" sections; not work of this section.
- C. Main fuel tank(s), piping, ductwork, controls and associated accessories required for installation of diesel engine-driven generator units are specified in Division-15 sections.
- 1.2 SUBMITTALS:
- A. Product Data: Submit manufacturer's data on diesel engine-driven generator sets and components and include a copy of the manufacturer's standard product warranty.
- B. Checklist: Submit a detailed checklist which acknowledges compliance or a reason for non-compliance to each of the specification requirements. Arrange the checklist according to the headings of each item identified in this specification (i.e. Shop Drawings, Wiring Diagrams individual line items, etc.) Mark items as "N/A" where the item is not applicable.
- C. Shop Drawings: Submit ½ inch scale layout drawings of diesel engine-driven generator units and accessories being supplied, including, but not limited to, generator, engine control panel, master control panel, fuel line piping, fuel tank(s) and related equipment, batteries, battery racks, battery chargers, remote start-stop stations, instrumentation, and transfer switches or breakers. In addition, show diesel generator set unit and its spatial relationship to associated equipment. Allow adequate clearance space for removal of engine generator elements for maintenance purposes. The drawings shall be for the particular unit to be supplied, with all other information removed.
- D. Wiring Diagrams: Submit wiring diagrams for diesel engine-driven generator unit showing connections to generator output breaker, control panels, transfer switches or breakers, alarms, remote alarms and ancillary equipment. Show and differentiate between portions of wiring that are manufacturer-installed and portions that are field-installed. The unit diagrams shall be for the particular unit to be supplied with all other information removed.
1. All interconnection and wiring diagrams shall include the following information as a minimum:
 - a. Complete diagrams of the internal wiring for each of the items of equipment.
 - b. The diagrams shall have their terminals identified to facilitate installation, operation and maintenance.

2. In addition to paper copies of the interconnecting and wiring diagrams, an AUTOCAD, v.2000, electronic file shall be submitted for each diagram.
- E. Certifications:
1. Provide diesel engine-driven generator set's manufacturer certified test record of the final production testing prior to shipping the unit from the factory to the project site. Include the following tests:
 - a. Single-step load pickup.
 - b. Transient and steady-state governing.
 - c. Safety shutdown device testing.
 - d. Voltage regulation.
 - e. Rated power.
 - f. Maximum power.
- F. Factory Testing: Submit a factory test log of diesel engine-alternator set showing a minimum of four (4) hours testing at 100 percent rated load to the Owner prior to shipment of the generator set. Load testing shall have a 0.8 power factor lagging continuously.
1. Normal preliminary diesel engine and generator tests shall be performed before unit assembly.
 2. All engine safety features shall be tested for operation and calibrated prior to the load test.
 3. All control and relay functions shall be tested for proper operation.
 4. A high potential test of the alternator shall be performed.
 5. All tests shall be conducted at 110°F. The actual radiators to be installed shall be used.
 6. The following engine run data shall be recorded at 15 minute intervals:
 - a. Time
 - b. kW output
 - c. Output Voltage
 - d. Amperes
 - e. RPM
 - f. Input water temperature
 - g. Output water temperature
 - h. Input oil temperature
 - i. Fuel pressure
 - j. Oil pressure
 - k. Ambient temperature
 - l. Radiator inlet air temperature if different than ambient.
 7. All test sheets will be submitted at the completion of the test. The vendor shall contact the Owner for scheduling and coordination of the factory test. Owner personnel or an Owner representative shall have the opportunity to witness the test.
- G. Submit engine horsepower curves indicating manufacturer's approval of the engine rating for standby power application based on actual testing of a similar package. Special ratings or "maximum" ratings are not acceptable.
- H. Provide information on the content and capacity of exhaust gases emitted by the engine at 1/4, 1/2, 3/4, and full load. The exhaust gas omission shall comply with all Federal, State and Local Codes in force at the site location.

- I. Submit de-rating data, calculations, and final unit rating for the specified operating conditions at the site, where they differ from the vendor's stated standard operating conditions.
 - J. Submit the generator harmonic analysis report for the 3rd, 5th and 7th harmonics that shows compliance with this specification.
- 1.3 QUALITY ASSURANCE:
- A. Manufacturer's Qualifications: Firms regularly engaged in manufacture of diesel engine-driven generator units and ancillary equipment, of types, ratings and characteristics required, whose products have been in satisfactory use in similar service for not less than 5 years.
 - 1. The engine-generator shall be assembled, thoroughly tested and warranted, as the product of a single manufacturer. Sets which are assembled components by a service type facility are not acceptable.
 - 2. The engine-generator set supplier shall be fully capable of providing all site service work on the engine-generator set and all accessories including:
 - a. Repair or replacement of any component including large assemblies such as generator rotors, drive shafts, etc.
 - b. Testing and trouble shooting.
 - c. General maintenance.
 - 3. The engine generator set supplier shall have in local stock, all customary parts required for service of the unit including engine parts and electrical assemblies.
 - 4. The engine generator set supplier shall maintain a service shop located within two/four hours drive from the job site and shall have fully equipped service trucks with mechanic/technicians available and on-call 24 hours per day.
 - B. Installer's Qualifications: Firm with at least 3 years of successful installation experience on projects with diesel engine-driven generator units similar to that required for this project.
 - 1. Agreement to Maintain: The Installer must be willing to execute with the Owner, an agreement for continued maintenance of diesel engine-driven generator units.
- 1.4 DELIVERY, STORAGE AND HANDLING:
- A. Deliver diesel engine-driven generators properly packaged and mounted on pallets, or skids to facilitate handling of heavy items. Utilize factory-fabricated type containers or wrappings for engine-generator and components which protect equipment from damage.
 - B. Store diesel engine-driven generator equipment in original packaging and protect from weather and construction traffic. Wherever possible, store indoors; where necessary to store outdoors, store above grade and enclose with watertight wrapping.
 - C. Handle diesel engine-driven generator equipment carefully to prevent physical damage to equipment and components. Do not install damaged equipment; remove from site and replace damaged equipment with new.

PART 2 - PRODUCTS

2.1 MANUFACTURERS:

- A. Manufacturers: Subject to compliance with requirements, provide diesel generator sets of one of the following:
1. Cummins/Onan Engine Co.
 2. Caterpillar Tractor Co.
 3. Kohler Corp;
 4. Waukesha Engine Div. Natural gas only
 5. Detroit Diesel
 6. Generac 100KW and lower

2.2 RATINGS:

- A. The engine-generator set shall have the following minimum measured ratings when installed at the specified site and all derating factors including those for temperature, altitude, fan, charging generator, water pump, etc. are considered.
1. Duty :Standby Prime
 2. Kilowatts:_____KW
 3. Power Factor:0.8
 4. Frequency:60 Hz Nominal
 5. Voltage:120/240 120/208 277/480
 6. Phase:1 3
 7. Wire:3 4
 8. Synchronous Speed:1200/1800 RPM

2.3 ENVIRONMENTAL CONDITIONS:

- A. The equipment specified is intended for application in an environment as described below:
1. Altitude:5500 feet above sea level.
 2. Maximum Temperature:100 degrees F 120 degrees F
 3. Minimum Temperature:40 degrees F -20 degrees F
 4. Location: Indoor/Outdoor

2.4 ENGINE:

- A. Type: direct fuel injected, liquid cooled with unit mounted radiator and engine driven water pump, multi-cylinder inline or v-type, four stroke cycle, compression ignition diesel, internal combustion engine. Diesel engine shall comply with the requirements of SAE 1349, ISO 8528 (Part 2), EGSA 101P and IEEE Standard 446 as they apply to standby application.
- B. Fuel System: Appropriate for use of No. 1 or 2 fuel oil.
- C. Governor: Isochronous type to maintain governed speed at rated frequency regardless of the kW load and shall meet the following requirements:
1. Stability: 0.25 percent maximum frequency variation at any constant load from no load to full load.

2. Regulation; 0.25 percent maximum frequency deviation at steady state. Provide a separate overspeed device, independent of the governor, to prevent runaway in the event of any failure which may render the governor inoperable.
- D. Engine Accessories: Provide the following engine accessories.
1. Fuel filter.
 2. Lube oil filter.
 3. Intake air filter.
 4. Lube oil cooler.
 5. Fuel transfer pump.
 6. Fuel priming pump.
 7. Gear-driven water pump.
- E. The engine shall be designed to develop rated speed and torque capable of developing full load within 8 seconds from the time the engine starts. Engine cranking period shall not exceed 30 seconds.
- F. The lubrication system shall incorporate a threaded, spin-on or canister type, full flow, duplex filtration system with a spring loaded, pressure calibrated, bypass valve to allow lubrication to continue in the event of unusually high filter restriction. The bypass valve must be an integral part of the engine filters or filter housings. Locate filters for easy servicing. A local alarm shall be generated if bypass occurs.
1. A prelube oil system shall be used only when recommended by the manufacturer to reduce engine wear and improve starting time.
 2. Provide engine with an initial fill (including oil makeup tank) of manufacturer's recommended multi-viscosity lubricating oil.
- G. Provide a valved oil drain extended past the engine frame with braided stainless steel hose and reusable fittings.
- H. Provide an automatic lube oil make-up system (REN or equivalent) to automatically maintain proper oil level in the engine crank case. Equip the system with a reserve oil supply tank sized for the engine provided, and based on the manufacturer's recommendation for oil consumption during a 72 hour engine run. Provide a shut-off valve between the tank and float valve and a shut-off valve between the float valve and oil pan. All flexible hoses shall be of the braided stainless steel type.
- I. The engine shall be equipped with protective devices to meet control requirements specified elsewhere in this specification. The control devices shall be tied into the engine generator control. All protective devices shall be wired into a master engine terminal box with terminal strips for remote connections and connections to annunciators or controls as required.
- J. All equipment shall operate with minimum vibration throughout the operating range as assembled units. The equipment supplier shall assume all additional shop, shipping and transportation expense, and/or cost at the job site necessary to reduce excessive vibration attributable to unbalance of the equipment.
- 2.5 GENERATOR CHARACTERISTICS:
- A. The generator shall be provided in accordance with the following:

1. The generator shall be of the single-bearing type, dripproof construction, externally regulated, directly connected to the engine flywheel through a semi-flexible coupling. The generator shall be complete with inboard brushless exciter. The generator rotor shall be dynamically balanced to withstand overspeeds up to 125 percent rated speed.
2. The generator shall comply with NEMA Standard MG-1, latest revision. Insulation shall be Class F. Rotor and stator temperature rise shall not exceed 105 degrees C. over a 40 degree C. ambient temperature at specified site altitude. Generator must be derated in accordance with NEMA MG-1.
3. The generator shall be capable of continuously delivering its rated output at any power factor from 1.0 to 0.8 lagging at ± 5 percent of rated voltage and at 60Hz, in the environmental conditions as specified.
4. Insulation shall be 100 percent epoxy material, pressure impregnated.
5. Stator winding pitch shall be optimized for best waveshape.
6. The generator voltage regulator shall be solid state, with external voltage adjust rheostat. Provide a setscrew stability adjustment. Voltage regulation shall be +1.0 percent. Steady state voltage stability shall remain within a 0.5 percent band of rated voltage.
7. The engine alternator shall be capable of accepting a one-step application of 100% of nameplate kW load at 0.8 power factor and recover to steady state conditions without disruption of power to the load. When the alternator is sequentially loaded with rated full load in three equal steps, the transient voltage drop at any step shall be limited such that the alternator voltage is not less than 75% of nominal voltage, and frequency is not less than 91% of nominal. In addition, the voltage at the alternator shall recover to within 90% of nominal voltage and the frequency to within 97% of nominal within 4 seconds after each sequential load application, or 60% of each step time interval (whichever is less).
8. During recovery from transients caused by step-load increases, step-load decreases, or resulting from 100% load rejection, the speed of the diesel alternator set shall not reach the overspeed shutdown setpoint.
9. The generator shall be capable of providing 300 percent of rated current for ten seconds during a short circuit condition.
10. The generator shall be of four/ten/twelve lead design connected in three phase, 4 wire/wye single phase, 3 wire/wye configuration. Neutral capacity shall be 100 percent of each phase.
11. Telephone influence factor (TIF) shall not exceed 50.
12. Generator bearing shall be designed for a minimum B-10 bearing life of 40,000 hours. The bearing shall be of the shielded type with provisions for lubricating without opening terminal compartment.
13. All generator leads (including neutral) shall be extended un-spliced from windings to generator connection junction box external to generator.

2.6 STARTING EQUIPMENT:

- A. General: The engine shall be equipped with a 12/24 volt electric starting system of sufficient capacity to crank the engine at a speed which will allow starting of the engine.
1. Starting system shall be capable of starting the engine either manually or automatically.
- B. Batteries:
1. The batteries shall be dedicated to the engine.
 2. Provide lead acid batteries having sufficient capacity for cranking the engine for at least 40 seconds at firing speed in the minimum ambient temperature specified.
 3. The cell container shall be made of high impact translucent polypropylene with clearly marked maximum and minimum electrolyte levels. All cell data such as battery type, manufacturer's name, electrolyte level marks shall be displayed clearly. Each cell shall have terminal voltage of 1.2 volts DC nominal voltage. The lid shall be thermally welded onto the cell container to eliminate any risk of electrolyte leakage. Gluing or chemical bonding is not acceptable.
 4. The battery shall be suitable for continuous operation, within the temperature range of -20 degrees C and +40 degrees C and able to operate adequately with occasional temperature excursions of up to +60 degrees C.
 5. The battery electrolyte shall be an aqueous solution of potassium hydroxide with a specific gravity of approximately 1.20. Lithium hydroxide may be used as an additive. There shall be no need to change the electrolyte over the life of the battery.
 6. The battery positive and negative terminals shall be of threaded type. The positive terminal shall be identified by a red plastic disc at the base.
 7. Rigid connections shall be manufactured of nickel plated high quality copper bar. Flexible intercell connections shall be made out of copper cable with appropriate insulation. Nickel plated lead, or nickel plated steel are not acceptable for flexible or rigid connections. The battery cables shall be welding type cable using compression connectors and shall have physical protection. Provide corrosion inhibiting compound on all cable terminations.
- C. Accessories:
1. Provide a battery rack and necessary cables and clamps.
 2. A suitable battery charging alternator shall be provided with sufficient capacity to recharge the batteries back to normal starting requirements within 90 minutes.
 3. Provide battery blanket for 120 volt a.c. supply.
 4. Provide continuous clear non-conductive covers for each row of terminals in rack.
- D. Battery Charger:

1. Provide a battery charger specifically designed for engine starting batteries which shall maintain the starting batteries at full charge. The charger shall be capable of restoring the batteries to a fully-charged state within eight hours after a complete duty cycle discharge.
2. The charging system shall permit charging from either a normal or emergency 120 volt AC power source.
3. The charger shall be so designed that it will not be damaged during the engine cranking.
4. The charger shall be a static, dual rate, float/equalize type (10 ampere capacity minimum) with automatic and manual charge control to charge at high rate or float the battery and maintain it fully charged. The actual size of the charger to be provided shall be a function of engine cranking requirements and continuous DC control requirements.
5. The charger shall be properly treated for NEMA 1 with chemical resistant epoxy coating.
6. The charger shall be equipped with the following accessories, as a minimum:
 - a. Ammeter
 - b. Voltmeter
 - c. Fused AC input and fused DC output

Optional:

 - d. AC input failure contacts for alarms
 - e. DC output failure contacts for alarms
 - f. High Volts (red)
 - g. Low Volts (red)
 - h. Rectifier fail (red)
 - i. AC fail (red)
 - j. Float mode status (green)
 - k. High rate status (amber)

2.7 COOLING SYSTEM:

- A. Provide the engine with a liquid cooled unit mounted radiator. Radiator fan shall be of the pusher type. Radiator shall be rated for the specified ambient temperature and shall be of the de-aeration type.
 1. Provide each engine with a dedicated system of radiator, pumps, piping controls and alarms.
 2. Provide a radiator auxiliary pump (if required) with starter.
 3. Provide radiator fan, motor and starter. The fan shall be direct drive and have guards to OSHA Standards.
 4. Where the radiator is located above the engine, provide heat exchanger if the hydraulic head will be greater than the manufacturer's recommendation for the engine.
 - a. Provide heat exchanger capacity 15 percent greater than the engine heat rejection.

5. Noise level shall be a maximum of 75 db at 23 feet (7m.).
- B. All coolant system hoses shall be rated for the maximum pressure that can be experienced under normal conditions, with system blockages, and shall not collapse under the most severe suction conditions. Coolant hoses shall not be painted. Provide a coolant recovery system that will prevent coolant overflow and spillage. The system shall have a capacity of 20 percent of the total coolant capacity of the unit.
- C. Provide spin-on type water filters with anti-scale agent.
- D. The engine cooling system shall be filled with anti-freeze with a minimum of 50 percent ethylene glycol antifreeze in water. Provide glycol for complete piping and radiator system.
- E. Provide a valved radiator drain with pipe extension and threaded connection at a location easily accessible to maintenance personnel.
- F. Provide OSHA guards on all belts, pulleys and fans.
- G. Provide necessary pipe fittings. Provide necessary valves for ease of access and maintenance.
- H. Provide minimum of two belts to radiator fan drive

2.8 AIR INTAKE SYSTEM AND EXHAUST SYSTEM:

- A. Provide a dry type air intake filter and silencer. Mount on the engine in an accessible location.
- B. Provide a stainless steel, corrugated, flexible exhaust pipe in between the engine exhaust flange and silencer to prevent the transmission of vibration. Minimum length shall be 18 inches.
- C. Provide a critical type exhaust silencer. The silencer shall be compact type.(For confined indoor spaces.)
 1. Provide exhaust silencer mounting bands and brackets.
- D. Provide flanges, non-slip type connectors and gaskets. Exhaust lines shall be gas tight. Connections are to be welded and/or flange type.

2.9 FUEL SYSTEM:

- A. Provide a double walled steel day tank/sub base mounted fuel tank and fuel system designed for #2 (#1) fuel oil.
- B. Tank shall meet UL 20.85 requirements.
- C. Provide fuel tank with sufficient capacity to operate the system at 100 percent kW load for 24 hours continuous.
- D. Provide necessary pumps, floats, piping and connections including connections to external fuel fill via a drop tube. Plumbing and wiring shall be pre-connected.
- E. Fuel tanks shall have initial fill for testing and be refilled when testing is complete with specified diesel fuel.

- F. Provide the following accessories:
1. Two, 3 inch fuel ports in tank for fuel stirring. Each port shall have a fuel cap. Locate ports at remote and opposite ends of tank.
 2. Calibrated fuel level stick.
 3. Tank drain.
 4. Provide interstitial monitoring and alarm to detect a fuel leak between tank walls.
- G. Controls shall cycle transfer pump to maintain fuel level in day tank.
- 2.10 STARTING AIDS:
- A. Provide 120/208/240/277 volt AC single phase engine jacket water heaters installed on the engine. The heaters shall be sized to provide an engine jacket temperature of 90 degrees F. in the minimum ambient temperature specified.
- 2.11 MOUNTING:
- A. Provide a suitable full length sub-base for mounting the engine generator unit on a concrete foundation.
- B. Provide assembly with spring type vibration isolators for use between the sub-base and the concrete foundation. A pin shall be installed through the spring isolators and sub-base, and bolted into concrete inserts for lateral movement limitation.
- C. Mounting shall be designed, constructed, and installed to meet applicable seismic zone requirements.
- 2.12 ENGINE GENERATOR CONTROL PANEL:
- A. Provide a NEMA 1 automatic starting control panel, powered via engine start batteries.
1. The control panel shall be installed on the generator, facing the rear of the unit.
- OR
- The control panel shall be designed for floor mounting.
- B. The engine generator control panel shall be equipped with the following items:
1. Provide the following digital meters with 2% accuracy, minimum size 2-1/2":
 - a. Generator ammeter
 - b. Generator voltmeter
 - c. Generator frequency meter
 - d. Generator kilowatt meter
 - e. Power factor meter, 0.5 lag to 0.5 lead.
 2. Manual/Off/Reset/Automatic selector switch.
 3. Ammeter-Voltmeter phase selector switch.
 4. Voltage level adjustment rheostat.
 5. Accessory output contact which closes when the generator starts, for interlocking with remote items.
 6. Fuel level status.

7. CT test block with shorting CT contacts and insertion tool, mounted on the front of the control panel.
 8. Lube oil pressure gauge.
 9. Alarm silence.
 10. Parallel relays from each pre-alarm and alarm condition with dry contacts wired to alarm terminal strip.
 11. Elapsed time meter.
 12. Alarm lamp test pushbutton.
 13. Adjustable Start/Stop time delay.
 14. Fuel pressure gauge.
- C. Control Start Sequence: Upon a remote contact closure, the auto-start panel shall automatically provide up to four cranking periods of ten seconds each with up to three rest periods of ten seconds in between. Should the engine fail to start, an over-crank timer shall lock out the engine from further attempts, sound an alarm, and provide an output contact closer for a remote alarm.
- D. Provide a local and remote alarm annunciator with audible and visual indications as listed below and to comply with NFPA 110 Level 1.
1. Provide with test/cancel pushbuttons, audible alarm silencing switch, contacts for local and remote alarms.
 2. Locate the alarm panel in the engine generator control panel.
 3. The annunciator shall alarm the following conditions:

Alarm	Type	Control Panel Annun.	Remote Annunciator
Generator running	Indicator	White	White
Low lube oil pressure	Pre-alarm	Amber	Amber
Low lube oil pressure	Alarm/shutdown	Red	Red
High lube oil pressure	Alarm/shutdown	Red	Red
High coolant temperature	Pre-alarm	Amber	Amber
High coolant temperature	Alarm/shutdown	Red	Red
Low coolant level	Pre-alarm	Amber	Amber
Low coolant level	Alarm/shutdown	Red	Red
Low coolant temperature (<70 degree F/20 degree C)	Alarm	Amber	Amber
Overcrank	Alarm/shutdown	Red	Red

Overspeed	Alarm/shutdown	Red	Red
Overvoltage	Alarm/shutdown	Red	Red
Underfrequency	Alarm/shutdown	Red	Red
Control switch off normal	Alarm	Flashing red	Flashing red
Engine breaker open	Alarm	Red	Red
Battery charger low DC voltage/output failure	Alarm	Amber	Amber
Battery charger AC failure	Alarm	Amber	Amber
High battery voltage	Alarm	Amber	Amber
Low fuel level-day tank	Alarm	Amber	Amber
High fuel level-day tank	Alarm	Amber	Amber
Emergency stop	Alarm/shutdown	Red	Red
Fuel in interstitial space/containment basin	Alarm	Amber	Amber
Water in fuel	Alarm	Red	Red
Ground fault	Alarm	Red	Red
Low fuel- main tank	Alarm	Red	Red
Emergency power system (EPS) supplying load	Alarm	Red	Red
High starting air pressure (when used)	Alarm	Red	Red
Low starting air pressure (when used)	Alarm	Red	Red
Low starting hydraulic pressure	Alarm	Red	Red
Air shutdown damper (when used)	Alarm/shutdown	Red	Red
Low cranking voltage	Alarm	Red	Red

4. Provide the following additional alarm outputs with Form C contacts (normally closed, open on alarm). The contacts shall be connected to a terminal strip in an enclosure set

adjacent to the generator, for connection to the remote monitoring system. Provide 10 spare pairs of conductors and terminals:

- a. Standby engine run
- b. Standby engine failure (To originate from the alarm annunciator)
- c. Standby engine start system failure (To originate from the alarm annunciator)
- d. Low fuel main tank
- e. Low fuel day tank

OR

- 5. Provide the following additional alarm outputs with Form C contacts (normally closed, open on alarm). The contacts shall be connected to the facility Building Alarm Cabinet. Coordinate this work with the Controls contractor. Provide 10 spare pairs of conductors and terminals.

- a. Standby engine run
- b. Standby engine failure (To originate from the alarm annunciator)
- c. Standby engine start system failure (To originate from the alarm annunciator)
- d. Low fuel main tank
- e. Low fuel day tank

- E. Provide auxiliary engine run contacts for control of auxiliary systems required for operation of engine, such as ventilation, fuel system, electric start, regulator, governor, remote mounted fan, etc. Provide normally closed contacts for operation of intake and exhaust air dampers. In addition, provide a minimum of four (4) spare SPDT contacts.

2.13 GENERATOR CIRCUIT BREAKER:

- A. Provide output main line circuit breaker which shall operate both manually as an isolation switch and automatically during overload and short circuit conditions.
- B. The trip unit for each pole shall have elements providing inverse time delay during overload conditions and instantaneous magnetic tripping for short circuit protection. The circuit breaker shall meet standards established by UL, NEMA and the NEC.

OR

Generator breakers shall be molded-case, solid-state trip, rated for the appropriate voltage and symmetrical interrupting capacity. Provide adjustable solid-state/digital long-time-delay (LTD), short-time-delay (STD), ground fault (GRD), and instantaneous (INST) trip elements with each breaker. Pickup/delay adjustments and ranges associated with these trips will be as follows: LTD pickup - (0.5-1.0) x sensor, four time delay bands; STD pickup - (2-9) x LTD pickup, three time bands (0.1-0.35) second with I^2t ramp; (GRD) pickup - (0.2-0.6) x sensor, three time bands (0.1-0.35) second with I^2t ramp; INST pickup - (2-10) x sensor. Ground fault trip may be omitted when ground fault alarm is provided by a time overcurrent relay across the generator neutral current transformer. Provide trip indicators to show "overload", "short-circuit", and "ground-fault" trip.

- C. Provide generator circuit breaker in a NEMA 1 enclosure adjacent to the generator terminal compartment. Provide sufficient space for conduit and cable termination in and around the circuit breaker enclosure.

- D. Provide circuit breaker with auxiliary contacts which provide contact closure upon breaker automatic trip or manual opening. The alarm contact is to be used for remote annunciation of circuit breaker tripped or open.
- 2.14 STATE OF ASSEMBLY:
- A. The engine generator system shall be factory assembled. Clean and paint all components per manufacturer's standards.
 - B. Accessory items shall be mounted directly on engine generator skid except where freestanding or remotely mounted. Provide all wiring and conduit fully installed and include termination points for remote or freestanding items.
 - 1. Connections between generator and remote or freestanding items are excluded from this specification.
- 2.15 EXTRA MATERIALS:
- A. Provide spare parts for one year's maintenance of the engine generator system. Parts shall be labeled with the equipment identification which they are associated with and packed for storage. Spare parts shall include but not be limited to:
 - 1. Belts: Provide 2 of each type.
 - 2. Hoses: Provide 2 of each type.
 - 3. Fuses for voltage regulator and controls: Provide 3 of each type.
 - 4. Filters: Provide 2 of each type, (fuel, air, water, oil, etc.)
 - 5. Lamps: Provide 2 of each type.
- 2.16 SOUND ATTENUATING WEATHERPROOF HOUSING:
- A. General: Provide a complete and operational generator enclosure, including all devices and equipment specified herein, as shown on the drawings, or as required for service. Enclosure shall be new and delivered ready for installation. Enclosure shall be a manufacturer's catalog item, with product information to be submitted.
 - B. The enclosure shall conform to local building codes for the specified location and to withstand the highest level of winds as listed by the ANSI Basic Wind Speed Map for the contiguous United States.
 - C. Fabrication and Features:
 - 1. Enclosure shall be constructed of all welded, formed sheet steel.
 - a. The enclosure shall be skintight type
 - b. Mount enclosure to concrete pad/sub-base fuel tank/integrated sub-base floor.
 - c. The base and top frame sections shall be constructed of 2"x2"x1/4" and 1/8" structural steel angle erected continuously on the inside perimeter of the enclosure, with corner gussets and floor mounting brackets to secure to foundation.
 - d. Wall panels shall be 12 gauge sheet steel or aluminum of equivalent strength.

- e. Provide corner hold down brackets with $\frac{1}{4}$ inch steel plate interior corner gussets for enclosures that are transported separately.
2. Provide lift-off type access doors to enclosure. Doors shall have the following features:
 - a. The door over the control panel shall be lift-up type, with two struts.
 - b. The doors shall be the same thickness as the wall panels, including 1 inch interior support flange.
 - c. All doors shall be crossed braced, including corner gussets for rigidity.
 - d. The doors shall be mounted using heavy duty weld-on hinges with brass inserts, and shall include a lift-off feature for easy door removal and hinge lubrication.
 - e. Provide a 30 degree rain gutter flange over the top of each door assembly and seal all doors using a neoprene bulb gasket.
 - f. The door hardware shall be stainless steel, and keyed alike. Provide an interior hat channel over the locking assembly for protection.
3. The entire enclosure shall be finished as follows:
 - a. The enclosure shall be hot steam or pressure cleaned, sanded and prepared to remove oils and debris.
 - b. Metal surfaces and all seams shall be sealed with a high quality sealant.
 - c. The enclosure shall be primed, coated, and finished with a high-grade automotive acrylic enamel.
 - d. The enclosure shall be color/the manufacturer's standard color.
4. Provide louvers sized to properly cool the generator set at site conditions as specified. Louvers shall be fixed/gravity/motor operated discharge and fixed/motor operated intake.
5. Provide sound attenuation on all four sides and top of enclosure to _____ dbA at 25 feet per local code requirements.
6. Enclosure Accessories:
 - a. Provide exhaust silencer mounting bands and brackets for internal/external silencer.
 - b. Provide 2 internal engine voltage DC lights and 2 control panel DC lights. Provide separate switches for internal lights and control panel lights.
 - c. Provide skid mounted battery racks.
 - d. Provide wall mounted battery charger.
 - e. Extend coolant and oil drains to outside of enclosure.
 - f. Extend fuel tank vents through roof of enclosure.

PART 3 EXECUTION:

3.1 EXAMINATION:

- A. Examine areas and conditions under which diesel engine-driven generator units are to be installed and notify the Engineer in writing of conditions detrimental to proper completion of the work. Do not proceed with the work until unsatisfactory conditions have been corrected in a manner acceptable to the Installer.

3.2 INSTALLATION OF DIESEL ENGINE-DRIVEN GENERATOR SETS:

- A. Install diesel engine-driven generator units in accordance with the equipment manufacturer's written instructions, and with recognized industry practices, to ensure that engine-generator units fulfill requirements. Comply with NFPA and NEMA standards pertaining to installation of engine-generator sets and accessories.
- B. Coordinate with other work, including raceways, electrical boxes and fittings, fuel tank(s), piping and accessories, as necessary to interface installation of engine-generator equipment work with other work.
- C. Tighten connectors and terminals, including screws and bolts, in accordance with equipment manufacturer's published torque values for equipment connectors. Where manufacturer's torque requirements are not indicated, tighten connectors and terminals to comply with torque values specified in UL Stds 486A, B and the National Electrical Code.
- D. Install units on vibration isolators in accordance with manufacturer's indicated method of installation.
- E. Connect fuel oil piping to generator equipment as indicated, and comply with manufacturer's installation instructions.

3.3 GROUNDING:

- A. Provide equipment grounding connections for diesel engine-driven generator units as indicated. Tighten connections to comply with torque values specified in UL Std 486A to assure permanent and effective grounding.

3.4 FIELD QUALITY CONTROL:

- A. Start-up Testing: Engage local equipment manufacturer's representative to perform start-up and load tests upon completion of installation, with the Engineer in attendance; provide certified test record.
- B. The Contractor shall provide qualified personnel, load bank, cables, test equipment and all other necessary materials required and perform the following tests:
 - 1. Check fuel, lubricating oil, and antifreeze in liquid cooled models for conformity to the manufacturer's recommendations under environmental conditions present.
 - 2. Test accessories that normally function while the set is in a standby mode for proper operation, prior to cranking engine. Accessories include but are not limited to: engine heaters, battery charger, generator strip heater, remote annunciator, etc.

3. Check for exhaust leaks, path of exhaust gases outside the building, cooling air flow, movement during starting and stopping, vibration during running, normal and emergency line-to-line voltage and phase rotation during start-up test mode.
 4. Test automatic start-up by remote-automatic starting, transfer of load, and automatic shutdown, by simulating a power outage. Prior to auto-start test, adjust transfer switch timers for proper system coordination. Monitor engine temperature, oil pressure, battery charge level, generator voltage, amperes, and frequency throughout the test, in accordance with NFPA 110 requirements.
 5. Test the complete system using a combination reactive/resistive load bank to 0.8 P.F.:
 - a. 2 hours at 50 percent rated load
 - b. 2 hours at 100 percent rated load (NFPA)
 6. During load bank tests, record the following data on 15 minute intervals:
 - a. Generator kW
 - b. Generator amps on each phase
 - c. Generator volts on each phase and phase to neutral
 - d. Generator frequency
 - e. Jacket input water temperature
 - f. Jacket output water temperature
 - g. Lube oil pressure
 - h. Lube oil temperature
 - i. Fuel pressure
 - j. Exhaust back-pressure
 - k. Ambient temperature
 - l. Radiator inlet air temperature
 - m. Oil, coolant or fuel leakage
 - n. Generator stator temperature
 - o. Battery charge rate (at 5 minute intervals for first 15 minutes then 15 minute intervals thereafter).
 7. Provide additional data for the following:
 - a. Time to recover stable rated frequency and voltage after step addition of 50 percent, 75 percent and 100 percent rated load.
 - b. Voltage dip when applying the above step loads.
- C. Upon completion of installation, demonstrate capability and compliance of system with requirements. Where possible, correct malfunctioning units at site, then retest to demonstrate compliance; otherwise, remove and replace with new units, and proceed with retesting. Retesting shall be no additional cost to Owner.
- 3.5 ADJUSTING:
- A. Adjust battery charger output.
 - B. Adjust generator output voltage and engine speed.
- 3.6 CLEANING:
- A. Clean engine and generator surfaces. Replace oil and fuel filters.

3.7 DEMONSTRATIONS:

- A. Generator supplier shall provide Owner with a minimum of (4) hours field training and instruction.
- B. Describe system operation under emergency conditions and restrictions for future load additions.
- C. Simulate power outage by interrupting normal source, and demonstrate that system operates to provide emergency power.
- D. Field training and instruction shall be video taped and the tape shall be turned over to maintenance personnel.

3.8 OPERATION AND MAINTENANCE:

A. Documentation:

- 1. Upon completion of the project, provide two complete operational and maintenance manuals to the owner. The manuals shall contain the following information:
 - a. Emergency instructions including addresses and telephone numbers for service sources.
 - b. Troubleshooting guidelines.
 - c. Complete operating instructions. All operating instructions shall include the following information as a minimum:
 - 1) Manufacturer's operating instructions for each piece of equipment furnished.
 - 2) Specific operating instructions for each portion of the system which involves multiple items of equipment.
 - 3) Instructions for charging, start-up, control or sequencing of operation, phase or seasonal variations, shut-down, safety and similar operations.
 - d. Recommended maintenance procedures and maintenance intervals for all equipment.
 - e. Complete shop drawings related to the entire system.
 - f. Technical data sheets for all equipment.
 - g. Complete interconnection diagrams which indicate all components of the system, including control systems and alarm interface.
 - h. Manufacturer's maintenance data including complete parts lists, partial detailed parts drawings, etc. for each operational item in each system.
 - i. Ordering information for spare parts.
 - j. Manufacturer's product warranties and guarantee relating to the system and equipment items in the system.

- B. Each maintenance manual shall be bound in vinyl-covered, 3-ring binders, with pocket-folders for folded drawings. The manual shall have an index with tabs for each section.
- C. Provide the following additional operating documents:
 - 1. A safety shutdown list provided on the generator set and in the generator maintenance manual. Verify that the appropriate safety controls have been provided based on the shutdown list.
 - 2. Satisfactory engine/alternator test records, lubrication, fuel and start battery maintenance records with space for continued entries.
 - 3. "Engine operating instructions" posted near the unit, providing clearly defined, step-by-step procedures for starting, running and stopping the engine.
 - 4. Lockout/tag-out procedures in place for the AC switchgear and distribution during normal operation, manual operation, and testing.

3.9 WARRANTY:

- A. Provide manufacturer's warranty for the duration of not less than two (2) years from the date of substantial completion of the project. The warranty shall include, but not be limited to, the replacement of materials and equipment used in diesel generator systems.
- B. Extended Warranty Agreement: Offer terms and conditions for furnishing parts and for providing continued testing and servicing, beyond the warranty period, including replacement of materials and equipment, for a one-year period with an option for renewal of the Agreement by the Owner.
- C. Maintenance Agreement: Prior to time of final acceptance, the supplier shall submit 4 copies of an agreement for continued service and maintenance of the diesel engine-driven generator sets, for the Owner's review and possible acceptance.

END OF SECTION 16621