

## SECTION 16915 EMERGENCY/STANDBY GENERATOR SET

### PART 1 – GENERAL

#### 1.1 SCOPE

- A. Provide complete factory assembled generator set equipment with digital (microprocessor-based) electronic controls.
- B. Provide factory test, startup by a supplier authorized by the manufacturer, and on-site testing of the system.
- C. The generator set manufacturer shall warrant all equipment provided under this section, so that there is one source for warranty and product service. Technicians specifically trained and certified by the manufacturer to support the product and employed by the generator set supplier shall service the generator sets.

#### 1.2 CODES AND STANDARDS

- A. The generator set installation and on-site testing shall conform to the requirements of the following codes and standards, as applicable. The generator set shall include necessary features to meet the requirements of these standards.
  - 1. CSA 282, 1989 Emergency Electrical Power Supply for Buildings
  - 2. IEEE446 – Recommended Practice for Emergency and Standby Power Systems for Commercial and Industrial Applications
  - 3. NFPA37 – Installation and Use of Stationary Combustion Engines and Gas Turbines
  - 4. NFPA70 – National Electrical Code. Equipment shall be suitable for use in systems in compliance to Article 700, 701, and 702.
  - 5. NFPA99 – Essential Electrical Systems for Health Care Facilities
  - 6. NFPA110 – Emergency and Standby Power Systems. The generator set shall meet all requirements for Level 1 systems. Level 1 prototype tests required by this standard shall have been performed on a complete and functional unit, component level type tests will not substitute for this requirement.
- B. The generator set and supplied accessories shall meet the requirements of the following standards:
  - 1. NEMA MG1-1998 part 32. Alternator shall comply with the requirements of this standard.
  - 2. UL142 – Sub-base Tanks
  - 3. UL1236 – Battery Chargers
  - 4. UL2200. The generator set shall be listed to UL2200 or submit to an independent third party certification process to verify compliance as installed.
- C. The control system for the generator set shall comply with the following requirements.
  - 1. CSA C22.2, No. 14 – M91 Industrial Control Equipment.
  - 2. EN50082-2, Electromagnetic Compatibility – Generic Immunity Requirements, Part 2: Industrial.
  - 3. EN55011, Limits and Methods of Measurement of Radio Interference Characteristics of Industrial, Scientific and Medical Equipment.
  - 4. FCC Part 15, Subpart B.

5. IEC8528 part 4. Control Systems for Generator Sets
  6. IEC Std 801.2, 801.3, and 801.5 for susceptibility, conducted, and radiated electromagnetic emissions.
  7. UL508. The entire control system of the generator set shall be UL508 listed and labeled.
  8. UL1236 –Battery Chargers.
- D. The generator set manufacturer shall be certified to ISO 9001 International Quality Standard and shall have third party certification verifying quality assurance in design/development, production, installation, and service, in accordance with ISO 9001.

### 1.3 ACCEPTABLE MANUFACTURERS

- A. Only approved bidders shall supply equipment provided under this contract. Equipment specifications for this project are based on microprocessor-based generator sets manufactured by Cummins Power Generation. Equipment by other suppliers that meets the requirement of this specification are acceptable, if approved not less than 2 weeks before scheduled bid date. Proposals must include a line-by-line compliance statement based on this specification.
- B. Submittals: Provide six sets of the following information for review:
1. Manufacturer's product literature and performance data, sufficient to verify compliance to specification requirements.
  2. A paragraph-by-paragraph specification compliance statement, describing the differences between the specified and the proposed equipment.
  3. Manufacturer's certification of prototype testing.
  4. Manufacturer's published warranty documents.
  5. Shop drawings showing plan and elevation views with certified overall dimensions, as well as wiring interconnection details.
  6. Interconnection wiring diagrams showing all external connections required; with field wiring terminals marked in a consistent point-to-point manner.
  7. Manufacturer's installation instructions.

### 1.4 WARRANTY

- A. The generator set and associated equipment shall be warranted for a period of not less than 5 years from the date of commissioning against defects in materials and workmanship.
- B. The warranty shall be comprehensive. No deductibles shall be allowed for travel time, service hours, repair parts cost, etc.

## PART 2 – PRODUCTS

### 2.1 GENERATOR SET

- A. Generator set shall be model number GGHE as manufactured by *Cummins Power Systems* or approved equal as manufactured by *Onan* or *Kohler*.

- B. Ratings:
1. The generator set shall operate at 1800 rpm and at a voltage of: 120.208 Volts AC, 3-phase, 4-wire, 60 hertz.
  2. The generator set shall be rated at 60kW, 75 kVA at 0.8 PF, standby rating, based on site conditions of: Altitude 500ft. (152 meters), ambient temperatures up to 77 degrees F (25 degrees C).
  3. The generator set rating shall be based on emergency/standby service.
- C. Performance
1. Voltage regulation shall be plus or minus 0.5 percent for any constant load between no load and rated load for both parallel and non-parallel applications. Random voltage variation with any steady load from no load to full load shall not exceed plus or minus 0.5 percent.
  2. Frequency regulation shall be isochronous from steady state no load to steady state rated load. Random frequency variation with any steady load from no load to full load shall not exceed plus or minus 0.25%.
  3. The engine-generator set shall be capable of single step load pick up of 100% nameplate kW and power factor, less applicable derating factors, with the engine-generator set at operating temperature.
  4. Motor starting capability shall be a minimum of 1213 kVA. The generator set shall be capable of sustaining a minimum of 90% of rated no load voltage with the specified kVA load at near zero power factor applied to the generator set.
  5. The alternator shall produce a clean AC voltage waveform, with not more than 5% total harmonic distortion at full linear load, when measured from line to neutral, and with not more than 3% in any single harmonic. Telephone influence factor shall be less than 40.
- D. Construction
1. The engine-generator set shall be mounted on a heavy-duty steel base to maintain alignment between components. The base shall incorporate a battery tray with hold-down clamps within the rails
  2. All switches, lamps, and meters in the control system shall be oil-tight and dust-tight, and the enclosure door shall be gasketed. There shall be no exposed points in the control (with the door open) that operate in excess of 50 volts.
- E. Connections
1. The generator set load connections shall be composed of silver or tin plated copper bus bars, drilled to accept mechanical or compression terminations of the number and type as shown on the drawings. Sufficient lug space shall be provided for use with cables of the number and size as shown on the drawings.
  2. Power connections to auxiliary devices shall be made at the devices, with required protection located at a wall-mounted common distribution panel.
  3. Generator set control interfaces to other system components shall be made on a common, permanently labeled terminal block assembly.
- F. Engine and Engine Equipment
1. The engine shall be natural gas fueled, radiator and fan cooled. Minimum displacement shall be 45 cubic inches, with 10 cylinders. The horsepower rating of the engine at its minimum tolerance level shall be sufficient to drive the

alternator and all connected accessories. Engine accessories and features shall include:

- a. Complete engine fuel system, including all pressure regulators, strainers, and control valves. The fuel system shall be plumbed to the generator set skid for ease of site connections to the generator set. For dual fuel systems, changeover from primary to secondary fuel shall be automatic.
  - b. An electronic governor system shall provide automatic isochronous frequency regulation. The governing system dynamic capabilities shall be controlled as a function of engine coolant temperature to provide fast, stable operation at varying engine operating temperature conditions. The control system shall actively control the fuel rate and excitation as appropriate to the state of the generator set. Fuel rate shall be regulated as a function of starting, accelerating to start disconnect speed, accelerating to rated speed, and operating in various isochronous or parallel states.
  - c. Skid-mounted radiator and cooling system rated for full load operation in 104 degrees F (40 degrees C) ambient as measured at the generator air inlet, based on 0.5 in H<sub>2</sub>O external static head. Radiator shall be sized based on a core temperature that is 20F higher than the rated operation temperature, or prototype tested to verify cooling performance of the engine/radiator/fan operation in a controlled environment. Radiator shall be provided with a duct adapter flange. The equipment manufacturer shall fill the cooling system with a 50/50-ethylene glycol/water mixture. Rotating parts shall be guarded against accidental contact.
  - d. Electric starter(s) capable of three complete cranking cycles without overheating.
  - e. Positive displacement, mechanical, full pressure, lubrication oil pump.
  - f. Full flow lubrication oil filters with replaceable spin-on canister elements and dipstick oil level indicator.
  - g. Replaceable dry element air cleaner with restriction indicator.
  - h. Flexible fuel lines.
  - i. Engine mounted battery charging alternator, 40-ampere minimum and solid-state voltage regulator.
2. Coolant heater
- a. Engine-mounted, thermostatically controlled, coolant heater(s) for each engine. Heater voltage shall be as shown on the project drawings. The coolant heater shall be UL499 listed and labeled.
  - b. The coolant heater shall be installed on the engine with high temperature silicone hose connections. Steel tubing shall be used for connections into the engine coolant system wherever the length of pipe run exceeds 12 inches. The coolant heater installation shall be specifically designed to provide proper venting of the system. The coolant heaters shall be installed using quick disconnect couplers to isolate the heater for replacement of the heater element. The quick disconnect/automatic sealing couplers shall allow the heater element to be replaced without draining the engine cooling system or significant coolant loss.
  - c. The coolant heater shall be provided with a 24VDC thermostat, installed at the engine thermostat housing. An AC power connection box shall be provided for a single AC power connection to the coolant heater system.
  - d. The coolant heater(s) shall be sized as recommended by the engine manufacturer to warm the engine to a minimum of 100F (40C) in a 40F

- ambient, in compliance with NFPA110 requirements, or the temperature required for starting and load pickup requirements of this specification.
3. Provide vibration isolators, spring/pad type or as recommended by the manufacturer, quantity as recommended by the generator set manufacturer. Isolators shall include seismic restraints if required by site location.
  4. Starting and Control Batteries shall be calcium/lead antimony type, 24 volt DC, sized as recommended by the engine manufacturer, complete with battery cables and connectors.
  5. Provide exhaust silencer(s) for each engine of size and type as recommended by the generator set manufacturer and approved by the engine manufacturer. The mufflers shall be critical grade. Exhaust system shall be installed according to the engine manufacturer's recommendations and applicable codes and standards.
  6. Provide a minimum 12 amp battery charger for each generator set battery bank. Generator sets incorporating two battery banks shall be provided with two chargers connected together and operating in parallel, with alarm output(s) connected in parallel. The charger(s) shall include the following capabilities:
    - a. Chargers shall be UL 1236-BBHH listed and CSA or CUL certified for use in emergency applications.
    - b. The charger shall be compliant with UL991 requirements for vibration resistance.
    - c. The charger shall comply with the requirements of EN61000-4-5 for voltage surge resistance; EN50082-2 for immunity; EN61000-4-2 for ESD; EN61000-4-3 for radiated immunity; ANSI/IEEE C62.41 category B and IN61000-4-4 for electrically fast transient; EN61000-4-6 for conducted emissions; and FCC Part 15 Class A for radiated emissions.
    - d. The charger shall be capable of charging a fully discharged battery without damage to the charger. It shall be capable of returning a fully discharged battery to fully charged condition within 24 hours. The charger shall be UL-labeled with the maximum battery amp-hour rating that can be recharged within 24 hours.
    - e. The charger shall incorporate a 4-state charging algorithm, to provide trickle charge rate to restore fully discharged batteries, a bulk charge rate to provide fastest possible recharge after normal discharge, an absorption state to return the battery to 100 percent of charge, and a float stage to maintain a fully charge battery and supply battery loads when the generator set is not operating. In addition, the charger shall include an equalization timer. Charge rates shall be temperature compensated based on the temperature directly sensed at the battery.
    - f. The DC output voltage regulation shall be within plus or minus 1%. The DC output ripple current shall not exceed 1 amp at rated output current level.
    - g. The charger shall include the following features:
      - 1) two line alphanumeric display with programming keys to allow display of DC output ammeter and voltmeters (5% accuracy or better), display alarm messages, and perform programming;
      - 2) LED indicating lamp(s) to indicating normal charging condition (green), equalize charge state (amber), and fault condition (red);
      - 3) AC input overcurrent, over voltage, and undervoltage protection;
      - 4) DC output overcurrent protection;
      - 5) Alarm output relay
      - 6) Corrosion resistant aluminum enclosure

G. AC Generator

1. The AC generator shall be; synchronous, four pole, 2/3 pitch, revolving field, drip-proof construction, single pre-lubricated sealed bearing, air cooled by a direct drive centrifugal blower fan, and directly connected to the engine with flexible drive disc. All insulation system components shall meet NEMA MG1 temperature limits for Class H insulation system. Actual temperature rise measured by resistance method at full load shall not exceed 15 degrees Centigrade.
2. The generator shall be capable of delivering rated output (kVA) at rated frequency and power factor, at any voltage not more than 5 percent above or below rated voltage.
3. A permanent magnet generator (PMG) shall be included to provide a reliable source of excitation power for optimum motor starting and short circuit performance. The PMG and controls shall be capable of sustaining and regulating current supplied to a single phase or three phase fault at approximately 300% of rated current for not more than 10 seconds.
4. The subtransient reactance of the alternator shall not exceed 15 percent, based on the standby rating of the generator set.
5. The alternator shall be capable of operation with reverse kVAR of 0.15 per unit.

H. Generator set Control.

1. The generator set shall be provided with a microprocessor-based control system that is designed to provide automatic starting, monitoring, and control functions for the generator set. The control system shall also be designed to allow local monitoring and control of the generator set, and remote monitoring and control as described in this specification.
2. The control shall be mounted on the generator set, or may be mounted in a free-standing panel next to the generator set if adequate space and accessibility is available. The control shall be vibration isolated and prototype tested to verify the durability of all components in the system under the vibration conditions encountered.
3. The generator set mounted control shall include the following features and functions:
  - a. Control Switches
    - 1) Mode Select Switch: The mode select switch shall initiate the following control modes. When in the RUN or MANUAL position the generator set shall start, and accelerate to rated speed and voltage as directed by the operator. A separate push-button to initiate starting is acceptable. In the OFF position the generator set shall immediately stop, bypassing all time delays. In the AUTO position the generator set shall be ready to accept a signal from a remote device to start and accelerate to rated speed and voltage.
    - 2) EMERGENCY STOP switch: Switch shall be Red "mushroom-head" push-button. Depressing the emergency stop switch shall cause the generator set to immediately shut down, and be locked out from automatic restarting.
    - 3) RESET switch: The RESET switch shall be used to clear a fault and allow restarting the generator set after it has shut down for any fault condition.

- 4) PANEL LAMP switch: Depressing the panel lamp switch shall cause the entire panel to be lighted with DC control power. The panel lamps shall automatically be switched off 10 minutes after the switch is depressed, or after the switch is depressed a second time.
- b. Generator Set AC Output Metering. The generator set shall be provided with a metering set including the following features and functions:
- 1) Digital metering set, 1% accuracy, to indicate generator RMS voltage and current, frequency, output current, output KW, KW-hours, and power factor. Generator output voltage shall be available in line-to-line and line-to-neutral voltages, and shall display all three-phase voltages (line to neutral or line to line) simultaneously.
  - 2) The control system shall monitor the total load on the generator set, and maintain data logs of total operating hours at specific load levels ranging from 0 to 110% of rated load, in 10% increments. The control shall display hours of operation at less than 30% load and total hours of operation at more than 90% of rated load.
  - 3) The control system shall log total number of operating hours, total kWh, and total control on hours, as well as total values since reset.
- c. Generator Set Alarm and Status Display.
- 1) The generator set control shall include LED alarm and status indication lamps. The lamps shall be high-intensity LED type. The lamp condition shall be clearly apparent under bright room lighting conditions. Functions indicated by the lamps shall include:
    - a) The control shall include five configurable alarm-indicating lamps. The lamps shall be field adjustable for any status, warning, or shutdown function monitored by the genset. They shall also be configurable for color, and control action (status, warning, or shutdown).
    - b) The control shall include green lamps to indicate that the generator set is running at rated frequency and voltage, and that a remote start signal has been received at the generator set. The running signal shall be based on actual sensed voltage and frequency on the output terminals of the generator set.
    - c) The control shall include a flashing red lamp to indicate that the control is not in automatic state, and red common shutdown lamp.
    - d) The control shall include an amber common warning indication lamp.
  - 2) The generator set control shall indicate the existence of the warning and shutdown conditions on the control panel. All conditions indicated below for warning shall be field-configurable for shutdown. Conditions required to be annunciated shall include:
    - a) low oil pressure (warning)
    - b) low oil pressure (shutdown)

- c) oil pressure sender failure (warning)
  - d) low coolant temperature (warning)
  - e) high coolant temperature (warning)
  - f) high coolant temperature (shutdown)
  - g) high oil temperature (warning)
  - h) engine temperature sender failure (warning)
  - i) low coolant level (warning)
  - j) fail to crank (shutdown)
  - k) fail to start/overcrank (shutdown)
  - l) overspeed (shutdown)
  - m) low DC voltage (warning)
  - n) high DC voltage (warning)
  - o) weak battery (warning)
  - p) low fuel-daytank (warning)
  - q) high AC voltage (shutdown)
  - r) low AC voltage (shutdown)
  - s) under frequency (shutdown)
  - t) over current (warning)
  - u) over current (shutdown)
  - v) short circuit (shutdown)
  - w) over load (warning)
  - x) emergency stop (shutdown)
  - y) (4) configurable conditions
- 3) Provisions shall be made for indication of four customer-specified alarm or shutdown conditions. Labeling of the customer-specified alarm or shutdown conditions shall be of the same type and quality as the above-specified conditions. The non-automatic indicating lamp shall be red, and shall flash to indicate that the generator set is not able to automatically respond to a command to start from a remote location.
- d. Engine Status Monitoring. The following information shall be available from a digital status panel on the generator set control:
- 1) engine oil pressure (psi or kPA)
  - 2) engine coolant temperature (degrees F or C)
  - 3) engine oil temperature (degrees F or C)
  - 4) engine speed (rpm)
  - 5) number of hours of operation (hours)
  - 6) number of start attempts
  - 7) battery voltage (DC volts)
- e. The control system shall also incorporate a data logging and display provision to allow logging of the last 10 warning or shutdown indications on the generator set, as well as total time of operation at various loads, as a percent of the standby rating of the generator set.
- f. Engine Control Functions.
- 1) The control system provided shall include a cycle cranking system, which allows for user selected crank time, rest time, and # of cycles. Initial settings shall be for 3 cranking periods of 15 seconds each, with 15-second rest period between cranking periods.



- 2) The control system shall include an idle mode control, which allows the engine to run in idle mode in the RUN position only. In this mode, the alternator excitation system shall be disabled.
  - 3) The control system shall include an engine governor control, which functions to provide steady state frequency regulation as noted elsewhere in this specification. The governor control shall include adjustments for gain, damping, and a ramping function to control engine speed and limit exhaust smoke while the unit is starting.
  - 4) The control system shall include time delay start (adjustable 0-300 seconds) and time delay stop (adjustable 0-600 seconds) functions.
  - 5) The control system shall include sender failure monitoring logic for speed sensing, oil pressure, and engine temperature which is capable of discriminating between failed sender or wiring components, and an actual failure conditions.
- g. Alternator Control Functions:
- 1) The generator set shall include a full wave rectified automatic digital voltage regulation system that is matched and prototype tested by the engine manufacturer with the governing system provided. It shall be immune from misoperation due to load-induced voltage waveform distortion and provide a pulse width modulated output to the alternator exciter. The voltage regulation system shall be equipped with three-phase line to neutral RMS sensing and shall control buildup of AC generator voltage to provide a linear rise and limit overshoot. The system shall include a torque-matching characteristic, which shall reduce output voltage in proportion to frequency below an adjustable frequency threshold. Torque matching characteristic shall be adjustable for roll-off frequency and rate, and be capable of being curve-matched to the engine torque curve with adjustments in the field. The voltage regulator shall include adjustments for gain, damping, and frequency roll-off. Adjustments shall be broad range, and made via digital raise-lower switches, with an alphanumeric LED readout to indicate setting level. Rotary potentiometers for system adjustments are not acceptable.
- h. Controls shall be provided to monitor the output current of the generator set and initiate an alarm (over current warning) when load current exceeds 110% of the rated current of the generator set on any phase for more than 60 seconds. The controls shall shut down and lock out the generator set when output current level approaches the thermal damage point of the alternator (over current shutdown). The protective functions provided shall be in compliance to the requirements of NFPA70 article 445. The protection for this function shall be 3<sup>rd</sup> party certified to very performance.
- i. Controls shall be provided to individually monitor all three phases of the output current for short circuit conditions. The control/protection system shall monitor the current level and voltage. The controls shall shut down and lock out the generator set when output current level approaches the thermal damage point of the alternator (short circuit shutdown). The

protective functions provided shall be in compliance to the requirements of NFPA70 article 445. The protection for this function shall be 3<sup>rd</sup> party certified to very performance.

- j. Controls shall be provided to monitor the KW load on the generator set, and initiate an alarm condition (over load) when total load on the generator set exceeds the generator set rating for in excess of 5 seconds. Controls shall include a load shed control, to operate a set of dry contacts (for use in shedding customer load devices) when the generator set is overloaded.
  - k. A line to neutral sensing AC over/under voltage monitoring system that responds only to true RMS voltage conditions shall be provided. The system shall initiate shutdown of the generator set when alternator output voltage exceeds 110% of the operator-set voltage level for more than 10 seconds, or with no intentional delay when voltage exceeds 130%. Under voltage shutdown shall occur when the output voltage of the alternator is less than 85% for more than 10 seconds.
  - l. The generator set control shall include a 120VAC-control heater.
4. Other Control Functions
- a. The generator set shall be provided with a network communication module to allow LonMark compliant communication with the generator set control by remote devices. The control shall communicate all engine and alternator data, and allow starting and stopping of the generator set via the network in both test and emergency modes.
  - b. A battery monitoring system shall be provided which initiates alarms when the DC control and starting voltage is less than 25VDC or more than 32 VDC. During engine cranking (starter engaged), the low voltage limit shall be disabled, and DC voltage shall be monitored as load is applied to the battery, to detect impending battery failure or deteriorated battery condition.
  - c. Control Interfaces for Remote Monitoring:
    - d. The control system shall provide four programmable output relays. These relay outputs shall be configurable for any alarm, shutdown, or status condition monitored by the control. The relays shall be configured to indicate: (1) generator set operating at rated voltage and frequency, (2) common warning, (3) common shutdown, (4) load shed command.
    - e. A fused 10 amp switched 24VDC power supply circuit shall be provided for customer use. DC power shall be available from this circuit whenever the generator set is running.
    - f. A fused 10 amp 24VDC power supply circuit shall be provided for customer use. DC power shall be available from this circuit at all times from the engine starting/control batteries.
    - g. The control shall be provided with a direct serial communication link for the LonWorks communication network interface as described elsewhere in this specification and shown on the drawings.
- I. Other equipment to be provided with the generator set
- 1. The generator set shall be provided with a mounted main line circuit breaker, sized to carry the rated output current of the generator set. The circuit breaker shall incorporate an electronic trip unit that operates to protect the alternator under all overcurrent conditions, or a thermal-magnetic trip with other overcurrent protection devices that positively protect the alternator under overcurrent conditions. The supplier shall submit time overcurrent characteristic curves and thermal damage curve for the alternator, demonstrating the effectiveness of the protection provided.

2. Outdoor Weather-Protective Enclosure

- a. The generator set shall be provided with an outdoor enclosure, with the entire package listed under UL2200. The package shall comply with the requirements of the National Electrical Code for all wiring materials and component spacing. The total assembly of generator set, enclosure, and sub-base fuel tank (when used) shall be designed to be lifted into place using spreader bars. Housing shall provide ample airflow for generator set operation at rated load in an ambient temperature of 100F. The housing shall have hinged access doors as required to maintain easy access for all operating and service functions. All doors shall be lockable, and include retainers to hold the door open during service. Enclosure roof shall be cambered to prevent rainwater accumulation. Openings shall be screened to limit access of rodents into the enclosure. All electrical power and control interconnections shall be made within the perimeter of the enclosure.
- b. All sheet metal shall be primed for corrosion protection and finish painted with the manufacturers standard color using a two step electro-coating paint process, or equal meeting the performance requirements specified below. All surfaces of all metal parts shall be primed and painted. The painting process shall result in a coating that meets the following requirements:
  - 1) Primer thickness, 0.5-2.0 mils. Top coat thickness, 0.8-1.2 mils.
  - 2) Gloss, per ASTM D523-89, 80% plus or minus 5%. Gloss retention after one year shall exceed 50%.
  - 3) Crosshatch adhesion, per ASTM D3359-93, 4B-5B.
  - 4) Impact resistance, per ASTM D2794-93, 120-160 inch-pounds.
  - 5) Salt Spray, per ASTM B117-90, 1000+ hours.
  - 6) Humidity, per ASTM D2247-92, 1000+ hours.
  - 7) Water Soak, per ASTM D2247-92, 1000+ hours.
  - 8) Painting of hoses, clamps, wiring harnesses, and other non-metallic service parts shall not be acceptable. Fasteners used shall be corrosion resistant, and designed to minimize marring of the painted surface when removed for normal installation or service work.
- c. Enclosure shall be constructed of minimum 12 gauge steel for framework and 14 gauge steel for panels. All hardware and hinges shall be stainless steel.
- d. A factory-mounted exhaust silencer shall be installed inside the enclosure. The exhaust shall exit the enclosure through a rain collar and terminate with a rain cap. Exhaust connections to the generator set shall be through seamless flexible connections.
- e. The enclosure shall include the following maintenance provisions:
  - 1) Flexible coolant and lubricating oil drain lines, that extend to the exterior of the enclosure, with internal drain valves
  - 2) External radiator fill provision.
  - 3) Provide motorized louvers to minimize air flow through the enclosure when generator set is not operating. Louvers shall include provisions to prevent accumulation of ice or snow that might prevent operation.
  - 4) Inlet ducts shall include rain hoods.

- f. Provide a factory mounted and wired electrical distribution panel to serve the generator set and enclosure. The provisions required include:
  - 1) 100-amp distribution panelboard connected to a 120/240VAC utility service by the installer.
  - 2) Two duplex GFI receptacles, one inside the enclosure, and a weatherproof receptacle on the outside of the enclosure.
  - 3) Factory-wired normal AC service from the panelboard to the engine coolant and alternator heaters, and battery charger.
- g. The generator set shall be provided with a sound-attenuated housing which allows the generator set to operate at full rated load in an ambient temperature of up to 100F. The enclosure shall reduce the sound level of the generator set while operating at full rated load to a maximum of 70.1dBA at any location 7 meters from the generator set in a free field environment.
- h. The enclosure shall be insulated with non-hydroscopic materials.

## PART 3 – EXECUTION

### 3.1 SEQUENCE OF OPERATION

- A. Generator set shall start on receipt of a start signal from remote equipment. The start signal shall be via hardwired connection to the generator set.
- B. The generator set shall complete a time delay start period as programmed into the control.
- C. The generator set control shall initiate the starting sequence for the generator set. The starting sequence shall include the following functions:
  - 1. The control system shall verify that the engine is rotating when the starter is signaled to operate. If the engine does not rotate after two attempts, the control system shall shut down and lock out the generator set, and indicate “fail to crank” shutdown.
  - 2. The engine shall fire and accelerate as quickly as practical to start disconnect speed. If the engine does not start, it shall complete a cycle cranking process as described elsewhere in this specification. If the engine has not started by the completion of the cycle cranking sequence, it shall be shut down and locked out, and the control system shall indicate “fail to start”.
  - 3. The engine shall accelerate to rated speed and the alternator to rated voltage. Excitation shall be disabled until the engine has exceeded programmed idle speed, and regulated to prevent over voltage conditions and oscillation as the engine accelerates and the alternator builds to rated voltage.
  - 4. On reaching rated speed and voltage, the generator set shall operate as dictated by the control system in isochronous, synchronize, load share, load demand, or load govern state.
  - 5. When all start signals have been removed from the generator set, it shall complete a time delay stop sequence. The duration of the time delay stop period shall be adjustable by the operator.
  - 6. On completion of the time delay stop period, the generator set control shall switch off the excitation system and shall shut down.
- D. Any start signal received after the time stop sequence has begun shall immediately terminate the stopping sequence and return the generator set to isosynchronous operation.

### 3.2 FACTORY TESTING

- A. The generator set supplier shall perform a complete operational test on the generator set prior to shipping from the factory. A certified test report shall be provided. Equipment supplied shall be fully tested at the factory for function and performance.
- B. Factory testing may be witnessed by the owner and consulting engineer. Costs for travel expenses will be the responsibility of the owner and consulting engineer. Supplier is responsible to provide two weeks notice for testing.
- C. Generator set factory tests on the equipment shall be performed at rated load and rated power factor. Generator sets that have not been factory tested at rated power factor will not be acceptable. Tests shall include: run at full load, maximum power, voltage regulation, transient and steady-state governing, single step load pickup, and function of safety shutdowns.

### 3.3 INSTALLATION

- A. Equipment shall be installed by the contractor in accordance with final submittals and contract documents. Installation shall comply with applicable state and local codes as required by the authority having jurisdiction. Install equipment in accordance with manufacturer's instructions and instructions included in the listing or labeling of UL listed products.
- B. Installation of equipment shall include furnishing and installing all interconnecting wiring between all major equipment provided for the on-site power system. The contractor shall also perform interconnecting wiring between equipment sections (when required), under the supervision of the equipment supplier.
- C. Equipment shall be installed on concrete housekeeping pads. Equipment shall be permanently fastened to the pad in accordance with manufacturer's instructions and seismic requirements of the site.
- D. Equipment shall be initially started and operated by representatives of the manufacturer.
- E. All equipment shall be physically inspected for damage. Scratches and other installation damage shall be repaired prior to final system testing. Equipment shall be thoroughly cleaned to remove all dirt and construction debris prior to final testing of the system.

### 3.4 ON-SITE ACCEPTANCE TEST

- A. The complete installation shall be tested for compliance with the specification following completion of all site work. Testing shall be conducted by representatives of the manufacturer, with required fuel supplied by Contractor. The Engineer shall be notified in advance and shall have the option to witness the tests.
- B. Installation acceptance tests to be conducted on-site shall include a "cold start" test, a two hour full load test, and a one step rated load pickup test in accordance with NFPA 110. Provide a resistive load bank and make temporary connections for full load test, if necessary.

- C. Perform a power failure test on the entire installed system. This test shall be conducted by opening the power supply from the utility service, and observing proper operation of the system for at least 2 hours. Coordinate timing and obtain approval for start of test with site personnel.

### 3.5 TRAINING

- A. The equipment supplier shall provide training for the facility operating personnel covering operation and maintenance of the equipment provided. The training program shall be not less than 4 hours in duration and the class size shall be limited to 5 persons. Training date shall be coordinated with the facility owner.

### 3.6 SERVICE AND SUPPORT

- A. The manufacturer of the generator set shall maintain service parts inventory at a central location which is accessible to the service location 24 hours per day, 365 days per year.
- B. The generator set shall be serviced by a local service organization that is trained and factory certified in generator set service. The supplier shall maintain an inventory of critical replacement parts at the local service organization, and in service vehicles. The service organization shall be on call 24 hours per day, 365 days per year.
- C. The manufacturer shall maintain model and serial number records of each generator set provided for at least 20 years.

END OF SECTION