SECTION 263213 - ENGINE GENERATORS

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

A. This sections is a Division 26 Basic Electrical Materials and Methods section and is part of each Division 26 section making reference to electrical connections for equipment specified herein.

1.02 SUMMARY

A. This Section includes packaged engine-generator sets (gensets) suitable for use in emergency standby power applications with the features as specified and indicated, regardless of the requirements for code-compliance. Gensets shall be capable of providing reliable power at up to rated output with no run-time or load level limitations while the primary source of power is unavailable.

B. The proposed generator set equipment shall be production equipment from a specified supplier that has been developed through thorough prototype testing as required by NFPA 110 and in compliance with this specification.

1.03 ACTION SUBMITTALS

A. Product Data: For each model of packaged engine generator indicated include rated capacities, operating characteristics, and furnished specialties and accessories. Include the following in the order shown:

1. Generator set manufacturer's data sheet.

2. Generator set control data sheet.

3. Engine manufacturer's engine data sheet describing horsepower available and derating basis for the engine. The generator set manufacturer's engine data sheet is not acceptable. Provide calculations showing actual rating of the engine under site conditions specified herein.

4. Alternator manufacturer's data sheet describing alternator ratings at the temperature rise required by this specification, short circuit characteristics and reactance values based on the ratings of this application. Provide calculations showing actual rating of the alternator under site conditions specified herein.

5. The alternator manufacturer's thermal damage curve and reactive capability curve, both based on the generator set rating.

6. Time-current characteristic curves for alternator protective device demonstrating adequate protection for the entire operating range of the generator set based on the alternator thermal damage curve. Provide a model of the generator thermal damage curve and protection device suitable for use with SKM and ETAP software.

7. Recommended settings for all generator set AC protective equipment provided.

8. Sound test data performance in a free field environment; or alternately, an anechoic chamber.

9. Prototype test report summary.

10. Provide a description of factory tests in compliance with the requirements of this specification and typical factory certified test report form.

11. Provide a transient test report from the based on production or prototype hardware detailing transient performance with quarter-load step application and rejection at 0.8 and 1.0 power factor based on a 95% confidence level. The equipment provided will be required to meet performance of this report.

12. Detailed description of all accessories required for this project with manufacturers' data sheets.

13. Submit statement of compliance which states the proposed product(s) are seismically certified in compliance with local requirements signed and sealed by a qualified professional engineer.

14. Submit warranty documents.

15. Provide a Modbus register map for use in developing remote monitoring provisions for the generator set.

16. Shop drawings as described elsewhere in this document.

B. Shop Drawings: Detail equipment assemblies and indicate dimensions, weights, and location and size of each field connection.

1. Dimensioned outline plan and elevation drawings of engine-generator set and other components specified.

2. Provide control drawings and interconnection details, including all field connections. Drawings shall be provided to include detailed point by point interconnection details for all hardware provided. For hardware that interconnects to equipment by others, provide a functional description and interconnection detail requirements for each connection point.

C. Warranty:

1. Submit manufacturer's warranty statement in compliance to the requirements of this Project.

1.04 QUALITY ASSURANCE

A. Manufacturer Qualifications: A qualified manufacturer shall have been in regular production of equipment as specified herein for a minimum of 10 years. To be considered a manufacturer, the supplier must design and manufacture either the engine; or the alternator and complete control system.

B. Technician Qualifications: Manufacturer's authorized representative who is trained and approved for installation of units required for this Project. Provide names and service experience for the technicians who will work in the installation of the equipment.

C. Supplier Qualifications: The equipment supplier shall maintain, within 50 miles of Project site, a service center capable of providing training, parts, and emergency maintenance repairs.

D. Comply with all requirements of NEMA MG1 part 32, including all documentation requirements, for the alternator provided. Motor starting performance shall be reported based on recovery voltage as described in NEMA MG1 part 32. Performance based on transient reactance only is not acceptable.

E. Comply with NFPA 37 (Standard For the Installation and Use of Stationary Combustion Engines and Gas Turbines).

F. Comply with NFPA 70 (National Electrical Code). Generator set shall meet the requirements for equipment in emergency service.

G. The generator set shall be designed, prototype tested, manufactured, factory tested, and site tested per the requirements of NFPA 110 for level 1 systems. Prototype as required by NFPA 110 shall be accomplished by actual testing on assembled models of the specific engine, alternator frame size, cooling system, controls, and other system components proposed.

H. Generator set shall be UL2200 listed. In addition, the generator set shall be third party tested as an assembly to demonstrate compliance to the radio frequency interference and susceptibility requirements as per UL Category NRGU.

I. Noise Emission: Comply with 75 dBA for maximum noise level at property line due to sound emitted by generator set including engine, engine exhaust, engine cooling-air intake and discharge, and other components of installation.

J. The generator set manufacturer shall be the sole source of warranty support for all the generator, and paralleling equipment. The generator set supplier shall provide binding warranty documents that cover the entire generator power system.

1.05 PROJECT CONDITIONS

A. Environmental Conditions: Engine-generator system shall deliver specified power and performance based on the following environmental conditions:

1. Outdoor Ambient Temperature: -30 degrees C (-21.0 degrees F) to 40.0 degrees C (104.0 degrees F).

2. Relative Humidity: 0 to 95 percent.

3. Altitude: 100 feet (304.8 m)

B. Performance of the generator set shall be demonstrated by documentation from the engine and alternator manufacturers describing basic performance and derating factors. Test results of the generator set package with the specific cooling system, engine and alternator model at maximum site ambient shall be required to document this capability.

C. The generator set shall be compliant to the exhaust emissions regulations applicable at the site as installed, based on an EPA Stationary Emergency application.

1. Submit evidence of compliance to emissions requirements.

1.06 WARRANTY

A. Base Warranty: Manufacturer shall provide base warranty coverage on the material and workmanship of the generator set for a minimum of 24 months.

B. Extended Warranty: Manufacturer shall extend coverage to five years from date of registered commissioning and start-up. Extended warranty must, as minimum, cover all parts (except filters and lubricants) and service technician costs.

PART 2 - PRODUCTS

2.01 MANUFACTURERS

A. Manufacturers:

1. The basis for this specification is Cummins model C250N6 with alternator model HC4F. Caterpillar and Kohler equipment meeting the performance and feature performance of the specified equipment is acceptable.

2. Alternate products by other suppliers will be considered if a complete product submittal is provided for review and approval to quote not less than 30 days before project bid date. The submittal shall include a line by line compliance statement based on this specification.

2.02 ENGINE-GENERATOR SET

A. Factory-assembled and -tested, engine-generator set.

1. To the maximum extent possible, the generator set shall be designed to eliminate single points of failure. Provide documentation demonstrating system failure mode analysis and provisions.

2. Each generator set shall be designed to be completely autonomous, and capable of providing all specified functions and performance without any external control other than a system start command. Control systems that utilize external generator paralleling controls or 3rd party paralleling controls will not be accepted.

B. Mounting Frame: Maintain alignment of mounted components without depending on concrete foundation; and have lifting attachments.

1. Rigging Information: Indicate location of each lifting attachment, generator-set center of gravity, and total package weight in submittal drawings.

C. Capacities and Characteristics:

1. Power Output Ratings: Electrical output power rating for Standby operation of not less than the kW rating as shown on the drawings. The rating basis shall be emergency standby regardless of the application. .

2. Nameplates: For each major system component to identify manufacturer's name and address, and model and serial number of component. The engine-generator nameplate shall include information of the power output rating of the equipment and all other information as required by local installation standards in effect at the time of installation.

D. Generator-Set Performance:

1. Steady-State Voltage Operational Bandwidth: ±0.5 percent of rated output voltage from no load to full load. (1% from no load to full load.) The generator set shall provide a stable RMS voltage level regardless of the magnitude of non-linear load applied to the machine.

2. Transient Alternator Performance: The alternator with proposed voltage regulator operating at constant speed shall meet the following performance requirements:

   a. On application of rated load and power factor, the alternator and voltage regulator shall have a maximum voltage dip of 10% and recover to rated conditions within 2 seconds based on NEMA MG1 specified conditions.

   b. Alternator shall be capable of accepting maximum 1250 kVA in a single step and recover to a minimum of 90% of rated no load voltage following the application of the specified kVA load at near zero power factor applied to the generator set in compliance to the requirements of NEMA MG1-Part 32 section 18. The generator set shall fully recovery to rated voltage as engine accelerates and kVAR load drops to within normal levels. A factory test documenting performance to this requirement is acceptable if documentation demonstrating compliance is not available from the alternator manufacturer.

3. Transient Generator Set Voltage Performance:

   a. On application of a rated kW load step at 1.0 power factor, the maximum transient voltage dip shall not exceed 20 percent. Provide NEMA MG1 based standard voltage dip curve and calculations demonstrating compliance.

4. Steady-State Frequency Performance: Frequency regulation shall be isochronous for any load level between no load and full load; and shall vary no more than 0.25 percent of rated frequency at any steady state load level.

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

6. Transient Frequency Performance: Not more than 15 percent variation for 100 percent step-load increase or decrease. Frequency shall recover and remain within the steady-state operating band within 7 seconds. On application of a 100% load step the generator set shall recover to stable frequency within 10 seconds.

7. Output Waveform: At rated linear load, harmonic content measured line to line or line to neutral shall not exceed 5 percent total and 3 percent for any single harmonic. Telephone influence factor, determined according to NEMA MG 1, shall not exceed 50. Alternator pitch shall be 2/3.

8. Sustained Short-Circuit Current: For a 3-phase, low impedance short circuit at system output terminals, system shall supply a regulated output of 300 percent of rated full-load current for not less than 8 seconds without damage to generator system components. On a 1-phase, low impedance short circuit at generator output terminals, system shall regulate current to prevent over-voltage conditions on the non-faulted phases and premature overcurrent tripping.

9. Start Time: Comply with NFPA 110, Level 1, Type 10, system requirements regardless of the nature of the application.

    a. Ambient Condition Performance: Engine generator shall be designed to allow operation at full rated load in an ambient temperature of 40 degrees C under site conditions. Ambient temperature shall be as measured at the air inlet to the engine generator for enclosed units, and at the control of the engine generator for machines installed in equipment rooms.

10. On a black start, with engine coolant heaters operating and the generator set in a minimum 40 degrees C environment, the generator set shall be ready to accept load in not more than 8 seconds.

11. Noise Emissions: Comply with applicable state and local government requirements for maximum noise level at adjacent property boundaries due to sound emitted by generator set including engine, engine exhaust, engine cooling-air intake and discharge, and other components of installation. Equipment shall be tested by the manufacturer per the latest version of ANSI/ASA S12.34. Data documenting performance shall be provided with submittal documentation.

12. Load Sharing: Generator set shall share real and reactive load proportionally within plus or minus 3 percent with all other generator sets in the system. The load sharing control system shall be compatible with Woodward paralleling controls. Systems with proprietary load sharing interfaces shall not be accepted.

13. Synchronizing: The generator set shall synchronize and close to a live system bus within 10 seconds after reaching 90% nominal voltage and frequency (assuming stable bus frequency and voltage).

14. The generator set shall be suitable for operation at rated load and power factor for an unlimited number of hours while operating during a power failure condition under the maximum ambient conditions specified. The engine manufacturer shall certify this performance capability.

E. Prototype Testing: The generator set shall be designed, prototype tested, manufactured, factory tested, and site tested per the requirements of NFPA 110 for a level 1 system and the additional requirements of this specification. All prototype testing shall be done based on formal engineering design standards by the engine, alternator, and control system manufacturers. Prototype testing shall include, as a minimum:

1. The suitability of the mechanical structure of the generator set shall be validated by testing of prototype with control, alternator and engine model identical to that proposed for this project, in an endurance test of a minimum of 500 hours at varying loads equal to the ISO standby duty cycle , and including vibration monitoring throughout the test.

2. The generator set shall be tested for linear and torsional vibration and compatibility with the alternator. Calculations alone are not sufficient to demonstrate torsional compatibility requirements. The engine manufacturer shall certify torsional compatibility of the system.

3. The generator set assembly shall be tested to demonstrate the ability of the assembled package to operate successfully while be subjected to radio frequency interference and surge voltages in compliance to the requirements of IEEE C37 and C62.

4. Prototype testing shall include generator set to generator and generator set to utility prototype testing of paralleling functions to demonstrate accuracy and performance in compliance to this specification.

5. Submit a prototype test report summarizing tests completed and results of testing.

2.04 ENGINE

A. The engine shall be rated by the engine manufacturer per ISO 8528 to provide necessary horsepower to deliver the required kW output based on specified site conditions, including all parasitic loads, whether or not the loads are generator set mounted.

B. Engine: The engine shall be 1800 RPM diesel and radiator/fan cooled. Natural Gas, 1800 RPM, radiator and fan-cooled. Minimum displacement shall be 14 liters. The horsepower rating of the engine at its minimum tolerance level shall be sufficient to drive the alternator and all connected accessories. The engine shall be 2009 EPA SI NSPS EPA Certified.

1. Lubrication System: The following items are mounted on engine or skid:

   a. Lube oil pump: shall be positive displacement, mechanical, full pressure pump.

   b. Lube Oil Filter and Strainer: Provided by the engine manufacturer of record to provide adequate filtration for the prime mover to be used.

   c. 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.

2. On-Engine Fuel System: The engine fuel system shall be installed in strict compliance to the engine manufacturer's instructions and the requirements of NFPA 54.

   a. Natural Gas

   b. Carburetor

   c. Fuel-Shutoff Solenoid Valves

   d. Flexible Fuel Connectors

C. Governor:

1. The engine fuel control system shall be engine-mounted and manage the engine based on speed sensors integral to the engine and the operating state of the generator set control system (starting/stopping sequence, operating isolated from the electrical system, operating in parallel with other generator sets, operating in parallel with the utility, and synchronizing).

2. 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.

3. Fuel rate shall be regulated as a function of starting, accelerating to start-disconnect speed, accelerating to rated speed, and operating in various isochronous states as well as various parallel condition states.

4. All the control and protection functions specified in this specification shall be configurable through the operating panel of the generator set, without removing any covers and without use of tools or a computer connection/program. Settings shall be password-protected. Rotary pots are not acceptable for adjustments. Settings shall include base operating levels, gains, and other required stability settings.

D. Cooling System: Closed Loop, Liquid Cooled:

1. The generator set manufacturer shall provide prototype test data for the specific hardware proposed demonstrating that the machine will operate continuously at rated standby load in an outdoor ambient condition of 40 degrees C. Form of data required shall be one of the following:

   a. Prototype test data of the specific engine proposed and similar alternator with the specific cooling system (radiator and fan) operating in a controlled environment of a minimum of 40 degrees C with a minimum air flow restriction of 0.5 in. of water external static head will carry full load for a minimum of 2 hours and the enclosure proposed (when used) will impose less than the restriction level the generator was tested with; or

   b. Prototype test demonstrating the specific engine proposed and similar alternator with the specific cooling system (radiator and fan) operating in the specific enclosure proposed with a 40 degrees C ambient will carry full load for a minimum of 2 hours.

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

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

4. 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.

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

6. Coolant pump: The engine coolant pump shall be mechanically driven by the engine. It shall be a single-shaft, dual-element double-curvature impeller pump to minimize the potential for leaks and failures and improve efficiency.

7. Coolant Heater: UL 499 listed and labeled electric-immersion type, factory installed in coolant jacket system. Comply with NFPA 110 requirements for Level 1 equipment for heater capacity and performance. The coolant heaters shall heat the engine to an appropriate temperature to assure 10-second starting and load pick up at the minimum ambient temperature specified for the installation, but not require operation at more than 40 degrees C engine coolant temperature.

   a. Heater voltage shall be shown on the project drawings.

   b. Flexible hoses shall be high temperature/pressure silicon. Installation shall include isolation valves to isolate the heater for replacement of the element without draining the engine cooling system or significant coolant loss. Steel coolant lines shall be provided for coolant line runs of more than 2 feet.

   c. Provided with a 24VDC thermostat, installed at the engine thermostat housing

   d. Coolant heaters shall allow starting and full load pick-up as per the requirements of this specification while operating at not more than 40C engine coolant temperature. Prototype testing shall demonstrate that under specified conditions and with the coolant heaters operating, the engine thermostats shall not open.

8. Duct Flange: Generator sets shall be provided with a flexible radiator duct adapter flange.

E. Muffler/Silencer: Selected with performance as required to meet sound requirements of the application, sized as recommended by engine manufacturer and selected with exhaust piping system to not exceed engine manufacturer's engine backpressure requirements. For generator sets with outdoor enclosures the silencer shall be inside the enclosure.

F. Air-Intake Filter: Engine-mounted air cleaner with replaceable dry-filter element and restriction indicator.

G. AC Power Distribution System: A set-mounted AC auxiliary distribution panel shall provide a single point of connection to the generator set's powered accessories. The panel shall include circuit breakers for all individual loads, and shall have been prototype tested with the engine/alternator provided to validate capability to survive vibration and temperature conditions present in the generator set under all operating conditions.

H. Starting System: 24V or higher, or as recommended by the engine manufacturer; electric, with negative ground.

1. Components: Sized so they will not be damaged during three full engine-cranking cycles with ambient temperature at maximum specified in Part 1 "Project Conditions" Article.

2. Cranking Cycle: As required by NFPA 110 for a level 1 system.

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

4. Battery Compartment: Factory fabricated of metal with acid-resistant finish. Battery terminals shall be protected from accidental contact.

5. Battery-Charging Alternator: Factory mounted on engine with solid-state voltage regulation. The battery charging alternator shall have sufficient capacity to fully recharge the batteries with all parasitic loads connected within 4 hours after a normal engine starting sequence while powering all DC loads connected to the generator set control.

6. Battery Chargers: Shall comply with UL 1236, provide fully regulated, constant voltage, current limited, battery charger for each battery bank. It will include the following features:

   a. Rating: Chargers shall be rated based on the batteries supplied, to fully recharge the batteries within 24 hours in compliance to NFPA 110 requirements for Level 1 systems. Multiple paralleled chargers shall be used to meeting the charge rate requirements, connected so that failure of a single charger will not totally disable charging capability. Minimum charging capabilities shall be based on the type and number of batteries and shall be as follows:

      1) Battery bank size: Two 8D, charger capacity 20A

   b. Operation: Equalizing-charging rate based on generator set manufacturer's recommendations shall be initiated automatically after battery has lost charge until an adjustable equalizing voltage is achieved at battery terminals. Unit shall then be automatically switched to a lower float-charging mode and shall continue to operate in that mode until battery is discharged again.

   c. Automatic Temperature Compensation: Adjust float and equalize voltages for variations in ambient temperature from minus 20 degrees C to plus 50 degrees C to prevent overcharging at high temperatures and undercharging at low temperatures.

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

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

f. Provide LED indication of general charger condition, including charging, faults, and modes. Provide a LCD display to indicate charge rate and battery voltage. Charger shall provide relay contacts for fault conditions as required by NFPA110.

g. Enclosure and Mounting: NEMA, Type 1, wall-mounted cabinet. The charger shall not be mounted on the generator set unless it has been prototype-tested in an endurance test to verify suitability for that application. Provide suitable prototype test documentation as required.

7. Provide vibration isolators of type and quantity as recommended by generator manufacturer. Isolators shall include seismic restraints if required by site location.

2.05 FUEL SUPPLY SYSTEM

A. The fuel supply to the generator set shall include:

1. Fuel solenoid, operated by the control system to provide fuel when the control commands generator set operation.

2. Primary and secondary regulators as required by the engine manufacturer and fuel supply conditions to performance as required by this specification.

3. Pressure switch for use in the indication of low fuel pressure.

4. Fuel pressure gauge

2.06 CONTROL AND MONITORING

A. Engine generator control shall be microprocessor-based and provide automatic starting, monitoring, protection and control functions for the generator set as described by this specification. The control system shall be designed and manufactured by the generator set manufacturer. Third party controls

that are brand-labeled by the generator set manufacturer may be accepted if evidence documenting reliable service and parts support is provided. The control system operator panel shall be configured to allow for mounting in alternate positions to meet electrical code requirements for accessibility as installed.

1. The controls must maintain accuracy and be capable of operating with supply voltage ranging from 8 to 30VDC and over a temperature range of -40 to +70C so that they are operational during cranking and at the higher voltage levels imposed by the battery charger and temperature extremes.

2. Field control terminations shall be made in a single common terminal box which is isolated from the control enclosure and includes no terminal points operating at more than 50 volts. Field connections to higher voltage devices shall be made in a separate AC control termination box.

3. For generator sets installed in outdoor enclosures and applications with remote switchgear powered by the generator set, provide a remote operator panel at a location as designated in the drawings to allow for the following functions:

    a. Monitoring of AC output characteristics.

    b. Monitoring of engine operating conditions Auto/Manual switches with manual start/stop capability.

    c. Alarm indication panel displaying all alarm conditions in the generator set.

    d. Manual adjustment of voltage and frequency. Voltage and frequency adjustments shall be configurable through the operator panel and configurable to password protected if required by end user. Manual adjustments shall not affect load sharing settings.

4. Controls for generators in outdoor enclosures shall include an anti-condensation control heater.

B. Automatic Starting System Sequence of Operation: When mode-selector switch on the control and monitoring panel is in the AUTOMATIC mode, remote-control contacts in one or more separate automatic transfer controls (or other device) initiate starting and stopping of generator set based on a normally open contact that closes, or a normally closed contact that opens (field configurable for either option). The starting system shall comply with NFPA 70-2017 requirements for NEC emergency applications.

C. Manual Starting System Sequence of Operation: Switching auto/manual switch on the generator control panel to the manual position and pressing the START button 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 the local (generator set-mounted) and/or remote emergency-stop switch also shuts down generator set.

D. Configuration: Operating and safety indications, protective devices, system controls, engine gages and associated equipment shall be grouped in a common control and monitoring panel. Mounting method shall isolate the control panel from generator-set vibration. Suitability of the design shall be demonstrated by prototype testing of the specific design proposed for a minimum of 200 hours at varying load levels. No AC voltage devices shall be mounted in the control panel other than fused voltage reference signals which are shielded from direct contact per the requirements of UL 2200 or CSA 22.1. The control system shall be powered by the generator set starting batteries.

E. A minimum 20 square inch graphical LCD display panel with appropriate navigation devices shall be provided to view all information noted herein, as well as all engine status and alarm/shutdown conditions (including those from an integrated engine emission control system). Touchscreen interfaces will not be approved. The display shall also include integrated provisions for adjustment of the gain and stability settings for the governing and voltage regulation systems, as well as all paralleling control and protection functions. Indicating and Protective Devices and Controls: As required by NFPA 110 for Level 1 system, and the following:

1. AC metering equipment shall be true RMS and include the following functions:

    a. AC voltmeter (3-phase, line to line and line to neutral values).

    b. Bus AC voltmeter (3-phase, line to line and line to neutral values).

    c. AC ammeter (3-phases).

    d. AC frequency meter.

    e. AC kW output (total and for each phase). Display shall indicate power flow direction.

    f. AC kVA output (total and for each phase). Display shall indicate power flow direction.

g. AC Power factor (total and for each phase). Display shall indicate leading or lagging condition.

h. Ammeter-voltmeter displays shall simultaneously display conditions for all three phases.

2. Provide an analog AC display panel indicating all phases of AC voltage and current, power factor, kW, and frequency. The display shall be color coded "green/yellow/red" to indicate normal, impending problem, and near shutdown level conditions.

3. Emergency Stop Switch: Switch shall be a red "mushroom head" pushbutton device complete with lock-out/tag-out provisions. Depressing switch shall cause the generator set to immediately stop the generator set and prevent it from operating. The switch shall directly operate on the fuel supply valve on the generator without operating through any other components. Provide a second loose emergency stop switch for installation at a location as shown on the drawings.

4. Fault Reset Switch: Supply a dedicated control switch to reset/clear fault conditions.

5. Engine status conditions to include:

a. DC voltmeter (alternator battery charging).

b. Engine-coolant temperature

c. Engine lubricating-oil pressure

d. Low fuel pressure alarm

e. Running-time, total hours, and hours since reset

f. Duty cycle monitor for the generator set, to include percent of operating time, in 10% increments from no load to 130% of rated capacity. Duty cycle monitoring shall include total since last reset, and total values since generator set commissioning.

6. Generator-voltage and frequency digital raise/lower switches. No rheostats for these functions or any other generator set functions are acceptable. The control shall adjustment of voltage and frequency in a range of plus or minus 5% of the voltage and frequency operating set point (not nominal voltage and frequency values.) The voltage and frequency adjustment functions

shall be disabled when the paralleling breaker is closed, and operator adjustment of voltage and frequency shall not impact on load sharing functionality.

7. Status LED indicating lamps to indicate remote start signal present at the control, existing shutdown condition, existing alarm condition, not in auto, and generator set running.

8. Panel lighting system to allow viewing and operation of the control when the generator room or enclosure is not lighted.

9. DC control Power Monitoring: The control system shall continuously monitor DC power supply to the control, and annunciate low or high voltage conditions. It shall also provide an alarm indicating imminent failure of the battery bank based on degraded voltage recover on loading (engine cranking).

10. Paralleling Control Equipment: Paralleling controls are required on the generator set, regardless of whether paralleling is used as installed, as provisions for future use. Independent paralleling controls shall be integral to the fuel rate and excitation control system for each generator set in the system. The controls shall be mounted on the generator set, incorporated in the same control assembly as the generator set control and completely autonomous in operation, so that failure of other generator paralleling controls, or a system master control (if used), interconnecting wiring, etc., will not prevent the generator set from automatically starting and paralleling to all the other generators in the system. The controls shall include the following functions:

    a. Paralleling Breaker control: The control shall include automatic opening and closing of the breakers during normal operation. It shall also include manual open and close provisions for the paralleling breaker with "synchronized" indication and direction/magnitude out of phase indication, and LED status lamps indicating whether the breaker is open or closed. Breaker controls shall include alarms for fail to open, fail to close, and auxiliary contact failure.

    b. The control system of the generator set shall communicate with all other generator sets in the system and determine which generator set is first to close to the bus, while preventing other generators from closing. The system shall include a redundant back up to operate in the event that communication with the other generator set(s) fails.

    c. The control system shall include automatic voltage matching/phase lock loop synchronizing for the generator set. The controls shall be field configurable for voltage matching and synchronizing window, as well as a separate permissive circuit

for manual paralleling. The synchronizer shall also be configurable for slip frequency synchronizing.

d. The control system shall include active isochronous load sharing controls for both kW and kVAR output. The generator shall communicate to all other generator sets via a communication channel that is redundant between all machines, as demonstrated by any break in the channel shall not cause disruption of the normal system load sharing operation. The load sharing signal shall be compatible with Woodward paralleling control equipment.

e. The control system shall include active control of the generator set kW and kVAR output when paralleled with an infinite source, such as a utility grid. It shall be configurable for operation at a fixed load level in that mode; or at a programmable output level.

11. Data Management:

a. Data Logging: The generator set control system shall log the latest 20 different alarm and shut down conditions, the total number of times each alarm or shutdown has occurred, and the date and time the latest of these shutdown and fault conditions occurred. The fault log shall also record applicable operating data at the time of the latest fault occurrence. Alternate data logging functionality will be accepted, if provided with a 5TB external storage device to allow storage of historical data for the life of the system.

b. The control system shall maintain a duty cycle log for the generator set which reports percent of operating hours in 10% increments from no load to 110% of rated load.

c. The control system shall report instantaneous fuel rate and maintain a fuel consumption log for the generator set which reports total fuel consumption and total fuel consumption since reset.

12. The control system shall include configurable input and output for up to 16 discrete inputs and 16 discrete outputs. The inputs and outputs shall be configurable for function and display their status on the generator set control operator panel. The I/O shall be capable of logical interaction with the generator control system.

F. AC Protective Equipment: The control system shall include over/under voltage, reverse kVAR, reverse kW, over load (kW), short circuit, over current, ground fault (when required by code), loss of voltage reference, and over excitation shut down protection.

1. Reverse kW and kVAR shall be operational when the generator is not operating.

2. All functions shall be field-configurable through the operator panel of the generator set.

3. Provide setting ranges and recommended settings for all functions for premium service reliability in submittal materials

4. Equipment shall be UL listed and labeled under Category NRGU.

5. Multiple sets of AC protective equipment are not acceptable.

6. Control functions shall include:

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

    b. Under single phase or multiple phase fault conditions, or on overload conditions, indicates an alarm conditions when the current flow is in excess of 110% of rated current for more than 10 seconds.

    c. Under single phase or multiple phase fault conditions, operates to switch off alternator excitation at the appropriate time to prevent damage to the alternator.

    d. The operator panel shall indicate the nature of the fault condition as either a short circuit or an overload.

    e. Senses clearing of a fault by other overcurrent devices and controls recovery of rated voltage to avoid overshoot greater than 120% of nominal voltage.

    f. Senses clearing of a fault by other overcurrent devices and controls recovery of rated voltage to avoid overshoot greater than 120% of nominal voltage.

    g. The protective system provided shall not include an instantaneous trip function.

G. The control system shall include a native Modbus RTU/RS485 output for remote monitoring of the control.

H. Control Heater: Generator sets that are installed in outdoor enclosures, or are in tropical or coastal environments shall be provided with control heaters for anti-condensation protection.

I. Remote Alarm Annunciator: Comply with NFPA 110. An LED labeled with proper alarm conditions shall identify each alarm event and a common audible signal shall sound for each alarm condition. The remote annunciator shall have provisions for display of a minimum of 20 alarm and status conditions, and be field configurable for function. Alarms shall include all NFPA 110 alarms for level 1 systems, as well as "generator in maintenance mode" and "generator load shed command".

J. Remote Emergency-Stop Switch: Flush; wall mounted, unless otherwise indicated otherwise on the drawings; and labeled. Push button shall be protected from accidental operation.

2.07 ALTERNATOR (INCLUDING EXCITER) AND VOLTAGE REGULATOR

A. Comply with NEMA MG 1-32 for both hardware requirements and reporting of alternator capability.

B. Drive: Generator shaft shall be directly connected to engine shaft. Exciter shall be rotated integrally with generator rotor.

C. Electrical Insulation: Class H throughout.

D. Temperature Rise: 105C or lower as required to meet performance requirements of this specification, including any necessary derating factors for specified ambient temperature.

E. Construction shall prevent mechanical, electrical, and thermal damage due to vibration, over speed up to 125 percent of rating, and heat during operation at 110 percent of rated capacity.

F. Permanent Magnet Generator (PMG) shall provide excitation power for optimum motor starting and short circuit performance.

G. Enclosure: Drip-proof. The alternator connections shall include a removable neutral to ground bonding link. The generator set shall be externally labeled to indicate whether the neutral is shipped bonded to ground; or shipped isolated.

H. Windings: Two-thirds pitch stator winding and fully linked amortisseur winding.

I. Subtransient Reactance: 12 percent maximum, based on the rating of the engine generator set.

J. The alternator shall be capable of operating with stable voltage with reverse kVAR of 0.30 per unit based on the generator set rating.

K. Voltage Regulator: Solid-state type, separate from exciter, providing performance as specified. The voltage regulation system shall be microprocessor-controlled, 3-phase true RMS sensing, full wave rectified, and provide a pulse-width modulated signal to the exciter. SCR-based voltage regulators are acceptable if alternator is sized based on 80C temperature rise Class F insulation. The voltage regulator shall be adjustable by an operator without tools from the generator set operator panel for voltage and dynamic characteristics without removing any protective panels on the generator set. Settings shall be password-protected.

L. The alternator shall be provided with anti-condensation heater in all applications where the generator set is provided in an outdoor enclosure, or when the generator set is installed in a coastal or tropical environment.

M. The alternator connection box shall include neutral and ground buses; and a removable neutral to ground link.

2.08 ALTERNATOR OVERLOAD AND OVERCURRENT PROTECTION

A. The generator set shall be provided with a UL Listed/CSA Certified protective device that is coordinated with the alternator provided to prevent damage to the generator set on any possible overload or overcurrent condition external to the machine. The protective device shall be listed as a utility grade protective device under UL category NRGU. The control system shall be subject to UL follow-up service at the manufacturing location to verify that the protective system is fully operational as manufactured. Protector shall perform the following functions:

1. The protective device shall allow continuous operation at rated current level of the generator set without tripping. It shall initiate a generator kW overload alarm when generator has operated at an overload equivalent to 110 percent of full-rated load for 60 seconds. Indication for this alarm is integrated with other generator-set malfunction alarms.

2. Under single phase or multiple phase fault conditions, or on overload conditions, indicates an alarm conditions when the current flow is in excess of 110% of rated current for more than 10 seconds.

3. Under single phase or multiple phase fault conditions, operates to switch off alternator excitation at the appropriate time to prevent damage to the alternator. The control logic of the protective device shall include integrated time-based functions to prevent alternator damage on multiple fault conditions that occur over short time periods.

4. The protective system provided shall not include an instantaneous trip function.

5. The operator panel shall indicate the nature of the fault condition as either a short circuit or an overload.

6. The over current protective system shall include a maintenance mode in compliance to the National Electrical Code section 240.87 which disables the alternator excitation system within 50 milliseconds when output current on any phase is more than three times rated current. The mode shall be operational for any fault from the terminals of the generator throughout the distribution system.

7. Senses clearing of a fault by other overcurrent devices and controls recovery of rated voltage to avoid overshoot greater than 120% of nominal voltage.

B. The control system shall be provided with arc flash reduction capability in compliance to NEC 240.87(B)(3).

2.09 REMOTE MONITORING

A. The generator system shall be provided with a web-based monitoring control system that is designed and warranted by the generator set manufacturer, and capable of monitoring all generator sets, transfer switches, and switchgear. The monitoring system shall provide the following functions:

B. Generator set monitoring, data-logging and control. All status (including event logging), data and settings from each generator set control shall be displayed. Data shall be capable of being logged by the system. Control shall include manual start/stop, and acknowledgement of warning conditions.

C. Transfer switch monitoring, data-logging and control. All status (including event logging), data and settings from each generator set control shall be displayed. Data shall be capable of being logged by the system. Control shall include manual start/stop, and acknowledgement of warning conditions.

D. The system shall be capable of sending system and device notifications via Simple Mail Transfer Protocol (SMTP)/e-mail and Short Message Service (SMS)/text. The user shall have the ability to configure notification settings, activate notifications, acknowledge alarms/events and add multiple email/SMTP and text/SMS recipients.

E. The system shall be capable of sending system and device information over the Internet Protocol (IP) to the customer's building management system (BMS). For notifications, this will be via Simple Network Management Protocol (SNMP)/traps; and for device information, this will be via Modbus TCP/IP. The user shall have the ability to configure SNMP settings, Modbus TCP/IP settings, notification settings, activate notifications and acknowledge alarms/events.

F. The system shall provide configurable report generation capabilities.

G. The system shall be capable of storing 5-years of data for the system based on operation once per week for testing or maintenance purposes and for two sustained outages totaling 2 weeks of operation.

2.10 OUTDOOR GENERATOR-SET ENCLOSURE

A. The generator set shall be provided with an outdoor enclosure that fits within the available space and allow for proper cooling and ventilation of the generator set, and required access to the equipment in compliance to the National Electrical Code. The enclosure shall reduce the sound level of the generator set while operating at full rated load to a maximum of the dBA level specified herein at any location 7 meters from the generator set in a free field environment. The enclosure shall be insulated with non-hydroscopic materials. Housing shall provide ample airflow for generator set operation at rated load in an ambient temperature as specified herein.

1. Provide all items as shown and directed on the drawings. Refer to contract drawings for outline and spacing of all items and materials

2. All electrical wiring and installation practices shall be in strict compliance to the requirements of the National Electrical Code.

3. The enclosure shall be specifically designed to provide adequate air flow for cooling of the generator sets in the ambient conditions specified herein based on the supplied cooling fans. The enclosure shall be specifically designed to provide adequate air flow for cooling of the generator sets in the ambient conditions specified herein based on the supplied cooling fans. Demonstration of this capability shall be either via test at maximum ambient temperature conditions or via calculations by the enclosure manufacturer. Calculations shall be adequate to demonstrate that, based on the cooling/ventilation system data from the generator set manufacturer, the generator set will operate at 100% load at the highest ambient temperature specified for the project.

B. Construction Details:

1. The total assembly of generator set and enclosure shall be designed to be lifted into place using spreader bars. 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.

2. Exterior: All sheet metal shall be primed for corrosion protection and finish painted with the manufacturer's standard color using a powder coat paint process, or equal. All surfaces of all metal parts shall be primed and painted.

3. Interior: 4" x 2" thick steel tube frame, primedand painted, filled 100% with 4-inch sound-absorbing insulation(flame spread of 10, fuel contributed 0 and smoke developed0), covered with 18 gauge .040 mill-finished perforated aluminum.

4. Access: One solid single door 36" wide x 72" high, and one solid double door 72" wide x 72" high with locking handles keyed alike,three-point latches, bar-type panic release from inside enclosure,stainless steel butt hinges, stainless steel door holders, and raingutters above doors..

5. Louvers: At engine cooling-air inlet and discharge. Dampers shall be closed to reduce enclosure heat loss in cold weather when unit is not operating. Dampers shall be of a "fail open" design to allow airflow in the event of failure

6. Air Intake: Exterior rear-mounted sound-absorbing hoods with sound-absorbing baffle systems and bird screen for a combined total of cooling and combustion air required for the generator set with a velocity of 950-feet per minute. Interior galvanized motor operated dampers with Belimo actuators (spring-open/motor-close).

7. Air Discharge: Exterior sound-absorbing vertical plenums with noise reduction as required based on site conditions, bird screen, and gravity dampers at radiator discharges.

8. Enclosure connections: Muffler brackets, muffler straps, rain collar(s), and rainshield(s) for internal installation of ASI-supplied GTE 511-C1-5118 (dual inlet) critical grade carbon steel rectangular slim-line mufflers. Radiator cap access. Electric stub-up area(s) in bases. Thermal insulation for internal mufflers and internal exhaust piping. Installation for customer-supplied free-standing day tank. Removable air discharge hood for radiator access. One week onsite supervision for re-assemblyof triple-wide enclosure.

9. Enclosure features: 2-inch high environmental protection around electrical stub-up area and enclosure interior wall tohelp prevent liquid spill-over into the environment. Stainless steel door holders & butt hinges. Oil, water, fume drains to exterior of enclosure. Rain gutters above all doors. Fall protection rings at each end of enclosure.

10. Enclosure Base: Built with 3/16" steel plate, 14-inch I Beam, and 1/4-inch steel diamond plate floor. Base primed and painted with black enamel finish. 8 point lift rings. Lifting pockets for rigging of multiple bolt together sections.

11. Electrical Requirements (Generator Enclosure):

    a. Two 208Y/120V 3P 4W 100A Panelboard or as shown on the drawings.

    b. Twelve 4-foot LED lamps.

    c. Two 3-way light switches.

    d. Four interior GFCI receptacles.

    e. Connections for control heaters, jacket water heaters, alternator heater, and battery chargers

    f. Connections for lead acid batteries

    g. Two 5 kW Heaters with thermostats and shut-off relays or as required to maintain a 40F environment in the enclosure at the lowest ambient temperature expected at the site.

    h. One 24-inch exhaust fan (4,000 CFM) with thermostat and exterior hood.

    i. Exterior LED light with photocell at each exterior entrance.

    j. Motor operated dampers and electrical connections per drawings.

    k. Emergency break-glass station.

    l. Four 24 VDC LED panels powered by generator starting batteries.

C. Enclosure System Testing: Upon assembly of the entire enclosure system, Owner and Owner's engineering representatives shall witness generator/switchgear enclosure functional testing. Testing agenda shall be provided for review 30 days prior to witness testing at the enclosure facility. All transportation and flight shall be provided by the generator manufacturer.

D. Site Provisions:

1. Lifting: Complete assembly of engine generator, enclosure, and sub base fuel tank (when used) shall be designed to be lifted into place as a single unit, using spreader bars.

2.11 EQUIPMENT SHIPPED LOOSE FOR FIELD MOUNTING

A. Vibration Isolation: Generators installed on grade shall be provided with elastomeric isolator pads integral to the generator, unless the engine manufacturer requires use of spring isolation.

1. IBC Compliance: Isolators complying with IBC requirements shall be specified in the equipment documentation, as well as the installation requirements for the unit.

B. Remote Emergency Stop Switch: The system shall include a remote emergency stop switch, mounted in an accessible location as shown on the drawings in compliance to the requirements of the National Electrical Code. Switch shall be a red "mushroom head" pushbutton device complete with lock-out/tag-out provisions. Depressing switch shall cause the generator set to immediately stop the generator set and prevent it from operating.

2.12 FINISHES

A. Indoor and Outdoor Enclosures and Components: Powder-coated and baked over corrosion-resistant pretreatment and compatible primer. Manufacturer's standard color or as directed on the drawings.

2.13 SOURCE QUALITY CONTROL

A. Prototype Testing: The manufacturer of the generator set shall prototype test engine-generator set using same engine model, constructed of identical or equivalent components and equipped with identical or equivalent accessories.

1. Tests: Comply with NFPA 110, Level 1 Energy Converters. The equipment engine, skid, cooling system, and alternator shall have been subjected to actual prototype tests to validate the capability of the design under the normal and abnormal conditions noted in NFPA110. Calculations and testing on similar equipment which are allowed under NFPA110 are not sufficient to meet this requirement.

2. Prototype testing shall be accomplished under strict engineering supervision, with published prototype test procedures under engineering design control by the generator set manufacturer. Minimum tests shall include:

a. Torsional evaluation

b. Single and 3-phase short circuit testing. Testing shall be based on alternator and engine with equivalent characteristics of the proposed generator set.

c. Cooling system testing. Testing shall be conducted on the exact cooling system proposed for this project. The cooling system shall be documented to allow continuous full load operation of the generator set at the maximum ambient temperature specified herein, and a restriction level of a minimum of 0.5 in. H_2O.

d. Endurance testing. The engine and alternator manufacturers shall have documented the capability of the engine and alternator for suitability of the proposed equipment under standby loads with an expected life of not less than 10,000 hours. The generator set package proposed shall successfully complete an endurance test of a minimum of 250 hours under standby loading conditions with no failures during the testing. Any failure shall require complete re-testing.

e. Transient testing. The generator set package proposed shall have been tested under transient loading conditions to demonstrate performance under quarter load step acceptance and rejection. The generator set manufacturer shall provide data for expected performance based on a statistical analysis of performance based on at least 10 generator sets equal to the proposed generator set package.

B. Project-Specific Equipment Tests: Before shipment, factory test engine-generator set manufactured specifically for this Project. Perform tests at rated load and power factor and at 1.0 and 0.8 power factor. Include the following tests and provide certified test report for all tests:

1. Test engine generator set manufactured for this Project to demonstrate compatibility and functionality.

2. Full load run.

3. Maximum power.

4. Voltage regulation.

5. Steady-state governing.

6. Single-step load pickup.

7. Simulated safety shutdowns.

8. Motor Starting recovery voltage test if not documented with prototype test data.

9. Provide 14 days' advance notice of tests and opportunity for observation of tests by Owner's representative.

10. A certified test report is required for documentation of this testing. Provide a certified test report to the engineer at completion of the testing, and a copy shipped with the generator set.

PART 3 - EXECUTION

3.01 INSTALLATION

A. Comply with packaged engine-generator manufacturers' written installation, application, and alignment instructions and with NFPA 110.

B. 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.

C. 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.

D. 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.

E. Equipment shall be initially started and operated by representatives of the manufacturer. All protective settings shall be adjusted as instructed by the consulting engineer.

F. 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 initial operation and final testing of the system.

G. On completion of the installation by the electrical contractor, the generator set supplier shall conduct a site evaluation to verify that the equipment is installed per manufacturer's recommended practice.

3.02 ON-SITE ACCEPTANCE TEST

A. The complete installation shall be tested to verify compliance with the performance requirements of this 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. The generator set manufacturer shall provide a site test specification covering the entire system. Tests shall include:

1. Prior to start of active testing, all field connections for wiring, power conductors, and bus bar connections shall be checked for proper tightening torque.

2. Installation acceptance tests to be conducted on site shall include a "cold start" test, a two hour full load (resistive) 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.

3. 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.

3.03 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 four hours in duration and the class size shall be limited to five persons. Training date shall be coordinated with the facility owner.

3.04 FIELD QUALITY CONTROL

A. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect components, assemblies, and equipment installations, including connections, and to assist in testing.

3.05 SERVICE AND SUPPORT

A. The generator set supplier shall maintain service parts inventory for the entire power system at a central location which is accessible to the service location 24 hours per day, 365 days per year. The inventory shall have a commercial value of $3 million or more. The manufacturer of the generator set shall maintain a central parts inventory to support the supplier, covering all the major components of

the power system, including engines, alternators, control systems, paralleling electronics, and power transfer equipment.

B. The generator set shall be serviced by a local service organization that is trained and factory certified in engine, alternator, control and generator set service for the equipment supplied. The supplier shall maintain an inventory of critical power system replacement parts in the local service location. Service vehicles shall be stocked with critical replacement parts. The service organization shall be on call 24 hours per day, 365 days per year. The service organization shall be physically located within on site of the site.

C. The manufacturer shall maintain model and serial number records of each generator set provided for at least 20 years.

3.06 SERVICE AGREEMENT

A. The supplier shall include in the base price, a one-year service agreement. The maintenance shall be performed by factory authorized service technicians capable of servicing both the engine generator set and the transfer switch. This agreement shall include the following:

1. Generator supplier must have an in-house rental fleet with equipment sized to back up this project site.

2. All engine maintenance as recommended by the service manual.

3. All electrical controls maintenance and calibrations as recommended by the manufacturer.

4. All auxiliary equipment as a part of the emergency systems.

5. The supplier shall guarantee emergency service.

6. All expendable maintenance items are to be included in this agreement.

7. A copy of this agreement and a schedule shall be given to the Owner at the time of his acceptance, showing what work is to be accomplished and when.

END OF SECTION 263213