

SECTION 26 3213 - ENGINE GENERATORS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

- A. This Section includes packaged, outdoor, [**all projects unless variance approved in writing by the Chief Electrician**] engine-generator sets for Level 1 emergency power supply with the following features:
 - 1. Diesel engine.
 - 2. Unit-mounted cooling system.
 - 3. Unit-mounted control and monitoring.
 - 4. Performance requirements for sensitive loads.
 - 5. Integral fuel tank.
 - 6. Network Communications.
 - 7. Outdoor enclosure.
- B. Related Sections:
 - 1. Division 26 Section 26 3600 "Transfer Switches" for transfer switches including sensors and relays to initiate automatic-starting and -stopping signals for engine-generator sets.

1.3 DEFINITIONS

- A. Operational Bandwidth: The total variation from the lowest to highest value of a parameter over the range of conditions indicated, expressed as a percentage of the nominal value of the parameter.

1.4 SUBMITTALS

- A. Product Data: For each type of packaged engine generator indicated. Include rated capacities, operating characteristics, and furnished specialties and accessories. In addition, include the following:
 - 1. Thermal damage curve for generator.
 - 2. Catalog data for generator protective device.
 - 3. Time-current characteristic curves for generator protective device.
- B. Shop Drawings: "Typical" drawings are not acceptable. Provide project specific drawings for engine-generator and all specified components. Drawings shall detail equipment assemblies

and indicate dimensions, weights, loads, and required clearances, method of field assembly, components, and location and size of each field connection.

1. Dimensioned outline plan and elevation drawings of engine-generator set and other components specified including enclosure.
2. Detail fabrication, including anchorages and attachments to structure and to supported equipment. Include base weights.
3. Wiring Diagrams: Power, signal, and control wiring.

C. Qualification Data: For manufacturer.

D. Source quality-control test reports.

1. Certified summary of prototype-unit test report.
2. Certified Test Reports: For components and accessories that are equivalent, but not identical, to those tested on prototype unit.
3. Certified Summary of Performance Tests: Certify compliance with specified requirement to meet performance criteria for sensitive loads.
4. Report of factory test on units to be shipped for this Project, showing evidence of compliance with specified requirements.
5. Report of sound generation.
6. Report of exhaust emissions showing compliance with applicable regulations.
7. Certified Torsional Vibration Compatibility: Comply with NFPA 110.

E. Field quality-control test reports.

F. Operation and Maintenance Data: For packaged engine generators to include in emergency, operation, and maintenance manuals. In addition to items specified in Division 01 Section "Operation and Maintenance Data," include the following:

1. List of tools and replacement items recommended for storage at Project for ready access. Include part and drawing numbers, current unit prices, and source of supply.

G. Warranty: Special warranty specified in this Section.

1.5 QUALITY ASSURANCE

A. Installer Qualifications: Manufacturer's authorized representative who is trained and approved for installation of units required for this Project.

1. Maintenance Proximity: Not more than two hours' normal travel time from Installer's place of business to Project site.
2. Engineering Responsibility: Preparation of data for vibration isolators and seismic restraints of engine skid mounts, including Shop Drawings, based on testing and engineering analysis of manufacturer's standard units in assemblies similar to those indicated for this Project.

B. Manufacturer Qualifications: A Firm experienced in the manufacturing of equipment of the type and capacity described herein and have a verifiable successful in-service performance record. Manufacturer shall maintain within 50 miles of Project site, a service center capable of providing training, parts, and emergency maintenance repairs.

- C. Source Limitations: Obtain packaged generator sets and auxiliary components through one source from a single manufacturer.
- D. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by UL and marked for intended use.
- E. Comply with ASME B15.1.
- F. Comply with NFPA 30.
- G. Comply with NFPA 37.
- H. Comply with NFPA 70.
- I. Comply with NFPA 110 requirements for Level 1 emergency power supply system.
- J. Comply with latest EPA Tier requirements.
- K. Comply with latest Illinois EPA requirements.
- L. Comply with FM Global requirements.
- M. Comply with most current edition of the Northwestern University Design Standards.
- N. Engine Exhaust Emissions: Comply with applicable state and local government requirements.
- O. Comply with UL 2200.
- P. Noise Emission: 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.

1.6 PROJECT CONDITIONS

- A. ***(Delete This Paragraph If Not Required)*** [Interruption of Existing Electrical Service: Do not interrupt electrical service to facilities occupied by the University or others unless permitted under the following conditions and then only after arranging to provide temporary electrical service according to requirements indicated:
 - 1. **Notify the University's Chief Electrician no fewer than seven days in advance of proposed electrical service interruptions.**
 - 2. **Indicate method of providing temporary utilities.**
 - 3. **Do not proceed with interruption of electrical service without the University's Chief Electrician's written permission.**
 - 4. **The University Lock-out/Tag-out procedures shall be used with Contractor controlled locks and tags.**
 - 5. **Comply with NFPA 70E.]**
- B. Installation Pathway: Remove and replace building components and structures to provide pathway for moving transformers into place.

- C. Products Selection for Restricted Space: Drawings indicate maximum dimensions for generators including clearances between generators and adjacent surfaces and other items. Comply with indicated maximum dimensions.
- D. Environmental Conditions: Engine-generator system shall withstand the following environmental conditions without mechanical or electrical damage or degradation of performance capability:
 - 1. Ambient Temperature: Minus 15 to plus 40 deg C.
 - 2. Relative Humidity: 0 to 95 percent.
 - 3. Altitude: Sea level to 1000 feet (300 m).

1.7 COORDINATION

- A. Coordinate size and location of concrete bases for package engine generators. Cast anchor-bolt inserts into bases. Concrete, reinforcement, and formwork requirements are specified in Division 3 Sections.

1.8 WARRANTY

- A. Comply with Division 1 requirements.
- B. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace components of packaged engine generators and associated auxiliary components that fail in materials or workmanship within specified warranty period.
 - 1. Warranty Period: **Five** years from date of Beneficial Occupancy.

1.9 MAINTENANCE SERVICE

- A. Initial Maintenance Service: Beginning at Substantial Completion, provide 12 months' full maintenance by skilled employees of manufacturer's designated service organization. Include monthly exercising to check for proper starting, load transfer, and running under load and a yearly load bank test. Include routine preventive maintenance as recommended by manufacturer and adjusting as required for proper operation. Provide parts and supplies same as those used in the manufacture and installation of original equipment.

1.10 EXTRA MATERIALS

- A. Furnish extra materials described below that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
 - 1. Fuses: Three for each battery charger and control panel.
 - 2. Indicator Lamps: Two for every six of each type used, but no fewer than two of each.
 - 3. Filters: One set each of lubricating oil, fuel, and combustion-air filters.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Manufacturers: Subject to compliance with requirements, provide products by the following:

1. Caterpillar Inc.; Engine – Generator Division (no substitutions).

2.2 ENGINE-GENERATOR SET

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

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

1. Rigging Diagram: Inscribed on metal plate permanently attached to mounting frame to indicate location and lifting capacity of each lifting attachment and generator-set center of gravity.

C. Capacities and Characteristics:

1. Power Output Ratings: Nominal ratings as indicated, with capacity as required to operate as a unit as evidenced by records of prototype testing and providing a minimum of 168 hours run time at 100% rated power output of the generator.
2. Output Connections: Three-phase, four-wire.
3. Nameplates: For each major system component to identify manufacturer's name and address, and model and serial number of component.

D. Generator-Set Performance:

1. Oversizing generator compared with the rated power output of the engine is permissible to meet specified performance.
 - a. Nameplate Data for Oversized Generator: Show ratings required by the Contract Documents rather than ratings that would normally be applied to generator size installed.
2. Steady-State Voltage Operational Bandwidth: 1 percent of rated output voltage from no load to full load.
3. Transient Voltage Performance: Not more than 10 percent variation for 50 percent step-load increase or decrease. Voltage shall recover and remain within the steady-state operating band within 0.5 second.
4. Steady-State Frequency Operational Bandwidth: Plus or minus 0.25 percent of rated frequency from no load to full load.
5. Steady-State Frequency Stability: When system is operating at any constant load within the rated load, there shall be no random speed variations outside the steady-state operational band and no hunting or surging of speed.
6. Transient Frequency Performance: Less than 2-Hz variation for 50 percent step-load increase or decrease. Frequency shall recover and remain within the steady-state operating band within three seconds.
7. Output Waveform: At no load, harmonic content measured line to neutral shall not exceed 2 percent with no slot ripple. Telephone influence factor, determined according to NEMA MG 1, shall not exceed 50 percent.

8. Sustained Short-Circuit Current: For a 3-phase, bolted short circuit at system output terminals, system shall supply a minimum of 300 percent of rated full-load current for not less than 10 seconds and then clear the fault automatically, without damage to winding insulation or other generator system components.
9. Excitation System: Performance shall be unaffected by voltage distortion caused by nonlinear load.
 - a. Provide permanent magnet excitation for power source to voltage regulator.
10. Start Time: Comply with NFPA 110, Type 10, system requirements.
11. Accept rated load in one step.
12. **If required by Project: [UPS load: ___% of connected].**

2.3 ENGINE

- A. Fuel: Fuel oil, Grade DF-2.
- B. Rated Engine Speed: 1800 rpm.
- C. Maximum Piston Speed for Four-Cycle Engines: 2250 fpm (11.4 m/s).
- D. Lubrication System: The following items are mounted on engine or skid:
 1. Filter and Strainer: Rated to remove 90 percent of particles 5 micrometers and smaller while passing full flow.
 2. Thermostatic Control Valve: Control flow in system to maintain optimum oil temperature. Unit shall be capable of full flow and is designed to be fail-safe.
 3. Crankcase Drain: Arranged for complete gravity drainage to an easily removable container with no disassembly and without use of pumps, siphons, special tools, or appliances.
- E. Engine Fuel System:
 1. Main Fuel Pump: Mounted on engine. Pump ensures adequate primary fuel flow under starting and load conditions.
 2. Relief-Bypass Valve: Automatically regulates pressure in fuel line and returns excess fuel to source.
 3. Fuel Filtering: Fuel / water separator to remove water and contaminants larger than 1 micron.
- F. Coolant Jacket Heater: Electric-immersion type, factory installed in coolant jacket system. Comply with NFPA 110 requirements for Level 1 equipment for heater capacity.
- G. Governor: Adjustable isochronous, with speed sensing.
- H. Cooling System: Closed loop, liquid cooled, with radiator factory mounted on engine-generator-set mounting frame and integral engine-driven coolant pump.
 1. Coolant: Solution of 50 percent ethylene-glycol-based antifreeze and 50 percent water, with anticorrosion additives as recommended by engine manufacturer.
 2. Size of Radiator: Adequate to contain expansion of total system coolant from cold start to 110 percent load condition.

3. Expansion Tank: Constructed of welded steel plate and rated to withstand maximum closed-loop coolant system pressure for engine used. Equip with gage glass and petcock.
 4. Temperature Control: Self-contained, thermostatic-control valve modulates coolant flow automatically to maintain optimum constant coolant temperature as recommended by engine manufacturer.
 5. Coolant Hose: Flexible assembly with inside surface of nonporous rubber and outer covering of aging-, ultraviolet-, and abrasion-resistant fabric.
 - a. Rating: 50-psig (345-kPa) maximum working pressure with coolant at 180 deg F (82 deg C), and non-collapsible under vacuum.
 - b. End Fittings: Flanges or steel pipe nipples with clamps to suit piping and equipment connections.
- I. Muffler/Silencer: Critical type, sized as recommended by engine manufacturer and selected with exhaust piping system to not exceed engine manufacturer's engine backpressure requirements.
1. Minimum sound attenuation of 25 dB at 500 Hz.
 2. Sound level measured at a distance of 10 feet (3 m) from exhaust discharge after installation is complete shall be 85 dBA or less.
 3. Factory installed and piped.
 4. Weather-cap on outlet. **(Delete For Indoor Units)**
- J. Air-Intake Filter: Heavy-duty, engine-mounted air cleaner with replaceable dry-filter element and "blocked filter" indicator.
- K. Starting System: **[up to and including 250 kW]** 12-V electric, with negative ground; **[greater than 250 KW]** 24-V electric, with negative ground.
1. Components: Sized so they will not be damaged during a full engine-cranking cycle with ambient temperature at maximum specified in Part 1 "Project Conditions" Article.
 2. Cranking Motor: Heavy-duty unit that automatically engages and releases from engine flywheel without binding.
 3. Dual cranking motors. **[For Units > 1000 KW]**
 4. Cranking Cycle: As required by NFPA 110 for system level specified.
 5. Battery: Adequate capacity within ambient temperature range specified in Part 1 "Project Conditions" Article to provide specified cranking cycle at least three times without recharging. Battery shall be maintenance free, sealed lead acid type. **[No Wet Cell Or NiCad]**
 6. Battery bank for each cranking motor. **[For Units > 1000 KW]**
 7. Battery Cable: Size as recommended by engine manufacturer for cable length indicated. Include required interconnecting conductors and connection accessories.
 8. Battery Compartment: Factory fabricated of metal with acid-resistant finish and thermal insulation. Include accessories required to support and fasten batteries in place.
 9. Battery-Charging Alternator: Factory mounted on engine with solid-state voltage regulation and 35-A minimum continuous rating.
 10. Battery Charger: Current-limiting, automatic-equalizing and float-charging type. Unit shall comply with UL 1236 and include the following features:
 - a. Operation: Equalizing-charging rate of 10 A 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.

- b. Automatic Temperature Compensation: Adjust float and equalize voltages for variations in ambient temperature from minus 40 deg C to plus 60 deg C to prevent overcharging at high temperatures and undercharging at low temperatures.
- c. Automatic Voltage Regulation: Maintain constant output voltage regardless of input voltage variations up to plus or minus 10 percent.
- d. Ammeter and Voltmeter: Flush mounted in door. Meters shall indicate charging rates.
- e. Safety Functions: Sense abnormally low battery voltage and close contacts providing low battery voltage indication on control and monitoring panel. Sense high battery voltage and loss of ac input or dc output of battery charger. Either condition shall close contacts that provide a battery-charger malfunction indication at system control and monitoring panel.
- f. Enclosure and Mounting: NEMA 250, Type 1, wall-mounted cabinet.
- g. Provide one charger for each battery bank, provide products by La Marche.

2.4 FUEL OIL STORAGE

- A. Comply with NFPA 30, NFPA 37, City of [**Chicago**] [**Evanston**], and State of Illinois Codes.
- B. Skid Base Day Tank: Comply with UL 142, skid base, factory-fabricated fuel tank assembly, with integral, float-controlled transfer pump and the following features:
 1. Tank Capacity: As recommended by engine manufacturer for an uninterrupted period of minimum 24 hours' operation at 100 percent of rated power output of engine-generator system without being refilled. The skid base tank shall not be less than 12 inches in height
 2. Containment: Integral rupture basin with a capacity of 150 percent of nominal capacity of tank.
 - a. Leak Detector: Locate in rupture basin and connect to provide audible and visual alarm in the event of a leak.
 3. Low-Level Alarm Sensor: Liquid-level device operates alarm contacts at 25 percent of normal fuel level.
 4. High-Level Alarm Sensor: Liquid-level device operates alarm and redundant fuel shutoff contacts at midpoint between overflow level and 100 percent of normal fuel level.
 5. The fuel tank shall be equipped with a manual fuel level gauge capable of being seen by the operator to determine the fuel level in the tank.
 6. The tank and all accessories shall be suitable for [**indoor**] [**outdoor**] use.
 7. Pump Capacity: Exceeds maximum flow of fuel drawn by engine-mounted fuel supply pump at 110 percent of rated capacity, including fuel returned from engine.
 8. [**Vandal-resistant fill cap**]. **Outdoor units only**
 9. Piping Connections: Factory-installed fuel supply and return lines from tank to engine; local fuel fill, vent line, overflow line; and tank drain line with shutoff valve. The fuel tank shall be equipped with a manual fuel level gauge capable of being seen by the operator to determine the fuel level in the tank.

2.5 CONTROL AND MONITORING

- A. Automatic Starting System Sequence of Operation: When mode-selector switch on the control and monitoring panel is in the automatic position, remote-control contacts in one or more separate automatic transfer switches initiate starting and stopping of generator set. When mode-selector switch is switched to the on position, generator set starts. The off position of

same switch initiates generator-set shutdown. When generator set is running, specified system or equipment failures or derangements automatically shut down generator set and initiate alarms. Operation of a remote emergency-stop switch also shuts down generator set.

- B. Manual Starting System Sequence of Operation: Switching on-off switch on the generator control panel to the on position starts generator set. The off position of same switch initiates generator-set shutdown. When generator set is running, specified system or equipment failures or derangements automatically shut down generator set and initiate alarms. Operation of a remote emergency-stop switch also shuts down generator set.
- C. Configuration: Operating and safety indications, protective devices, basic system controls, and engine gages shall be grouped in a common control and monitoring pane, microprocessor based, mounted on the generator set. Mounting method shall isolate the control panel from generator-set vibration.
- D. The control panel shall be designed and built by the engine manufacturer.
- E. The control panel shall provide real time digital communications to all engine and regulator controls.
- F. Control panel:
1. The control shall include a backlight graphical display with text-based alarm/event descriptions.
 2. Audible horn for alarm and shutdown with horn silence switch
 3. Remote start/stop control
 4. Local run/off/auto control integral to system microprocessor
 5. Cool-down timer
 6. Speed adjust
 7. Lamp test
 8. Voltage adjust
 9. Voltage regulator V/Hz slope - adjustable
 10. Password protected system programming
- G. Indicating Digital Readouts: As required by NFPA 110 for Level 1 system and the following:
1. AC volts.
 2. AC amps.
 3. AC frequency.
 4. KW
 5. KVA.
 6. KVAR.
 7. Power Factor.
 8. KWH.
 9. Exciter voltage and current.
 10. DC voltmeter (alternator battery charging).
 11. Engine-coolant temperature.
 12. Engine lubricating-oil pressure.
 13. Engine lubricating-oil temperature.
 14. Running-time meter.
 15. Ammeter-voltmeter, phase-selector switches.
 16. Generator-voltage adjusting rheostat.
 17. Fuel tank derangement alarm.
 18. Fuel tank high-level shutdown of fuel supply alarm.

19. Generator overload.
 20. Engine RPM.
- H. Supporting Items: Include sensors, transducers, terminals, relays, and other devices and include wiring required to support specified items. Locate sensors and other supporting items on engine or generator, unless otherwise indicated.
- I. Network Communications: Communication Gateway, discrete I/O module, for each alarm and status indication for data-link transmission of indications to remote data terminals and control network. Generator shall be capable of communicating with Northwestern University's existing SACDA network system.
1. The generator shall be seamlessly compatible with the existing campus generator monitoring Internet-based system.
 2. The network shall be MOD-bus isolated data link through a standard RS-485 connection.
 3. The distributed control, monitoring, and operation shall be connected to the University's SCADA system.
 4. The network media shall be a transformer coupled twisted pair with category 6 transmission capabilities.
 5. The network shall monitor real time generator operating data, status, and alarms.
 6. Provide remote control capability for the generator through the network.
 7. Remote communications: provide devices, wiring, software and equipment for remote communications from the generator to the Building Automation System.
 8. The Controller shall be capable of accepting digital input signals and operate programmable outputs integral to the Controller.
 9. Provide Remote communications to the University's ADT system for the following status:
 - a. Generator "Fail".
 - b. Generator "Running".
 - c. Generator "Fault".
- J. Common Remote Audible Alarm: Comply with NFPA 110 requirements for Level 1 systems. Include necessary contacts and terminals in control and monitoring panel for connection to the SCADA system.
1. Overcrank shutdown.
 2. Coolant low-temperature alarm.
 3. Coolant high-temperature alarm.
 4. Coolant high-temperature shutdown.
 5. Low coolant level.
 6. Loss of coolant shutdown.
 7. Control switch not in auto position.
 8. Battery-charger malfunction alarm.
 9. Battery low-voltage alarm.
 10. Battery high-voltage alarm.
 11. Low oil pressure warning.
 12. Low oil pressure shutdown.
 13. Overspeed shutdown.
- K. Generator Alarm/Shutdown.
1. Generator over voltage.
 2. Generator under voltage
 3. Generator over frequency

4. Generator under frequency
5. Generator reverse power
6. Generator overcurrent

L. Voltage Regulator Alarm/Shutdown

1. Loss of excitation alarm/shutdown
2. Instantaneous over excitation alarm/shutdown
3. Time over excitation alarm/shutdown
4. Rotating diode failure
5. Loss of sensing
6. Loss of PMG

M. Remote Alarm Annunciator: Comply with NFPA 110 requirements for Level 1 systems. An LED labeled with proper alarm conditions shall identify each alarm event and a common audible signal shall sound for each alarm condition. Silencing switch in face of panel shall silence signal without altering visual indication. Connect so that after an alarm is silenced, clearing of initiating condition will reactivate alarm until silencing switch is reset. Cabinet and faceplate are surface- or flush-mounting type to suit mounting conditions indicated. The annunciator shall have the ability to be located up to 800 ft. from the generator set.

N. Generator exerciser:

1. Programmable cycle timer that starts and runs the generator for a predetermined time. The timer shall use 14 user-programmable sequences that are repeated in a 7-day cycle. Each sequence shall have the following programmable set points:
 - a. Day of week
 - b. Time of day to start
 - c. Duration of Cycle.

O. Remote Emergency-Stop Switch: Flush; wall mounted, [**in weatherproof enclosure,**] (**select for outdoor units**) unless otherwise indicated; and labeled. Push button shall be protected from accidental operation.

2.6 GENERATOR OVERCURRENT AND FAULT PROTECTION

A. Quantity of unit mounted output circuit breakers: [**insert number**]

B. Generator Circuit Breaker: [**Molded Case, up to and including 400 A**] [**Insulated-case, above 400 A**], electronic-trip type; complying with UL 489. Circuit breakers 250 Amps and larger shall be rated to carry 100% of their current rating continuously.

1. All breakers shall be fully rated to interrupt the available fault current.
2. Tripping Characteristics: Adjustable long-time, short-time delay and instantaneous.
 - a. Provide bypass switch to defeat instantaneous trip.
3. Trip Settings: Selected to coordinate with generator thermal damage curve.
4. Shunt Trip: Connected to trip breaker when generator set is shut down by other protective devices.
5. Mounting: Adjacent to or integrated with control and monitoring panel.

- C. Ground-Fault Indication: Comply with NFPA 70, "Emergency System" signals for ground-fault. Integrate ground-fault alarm indication with other generator-set alarm indications.

2.7 LOAD CONNECTION BOX

- A. Provide a generator bus tap located in a connection box for connection of cables to a portable load bank. Size the bus tap for 100 percent full load current of the generator, with mechanical lugs for cable connections. Box shall have a bushed opening(s) sized for the cables and a hinged padlockable cover capable of being closed while the cables are connected.

2.8 GENERATOR, EXCITER, AND VOLTAGE REGULATOR

- A. Comply with NEMA MG 1.
- B. Drive: Generator shaft shall be directly connected to engine shaft. Exciter shall be rotated integrally with generator rotor.
- C. Electrical Insulation: Class H or Class F.
- D. Stator-Winding Leads: Brought out to terminal box to permit future reconnection for other voltages if required.
- E. Construction shall prevent mechanical, electrical, and thermal damage due to vibration, overspeed up to 125 percent of rating, and heat during operation at 110 percent of rated capacity.
- F. Enclosure: Drip-proof.
- G. Instrument Transformers: Mounted within generator enclosure.
- H. Voltage Regulator: Solid-state type, separate from exciter, providing performance as specified.
 - 1. Adjusting rheostat on control and monitoring panel shall provide plus or minus 5 percent adjustment of output-voltage operating band.
- I. Strip Heater: Thermostatically controlled unit arranged to maintain stator windings above dew point.
- J. Windings: 0.6667 pitch stator winding and fully linked amortisseur winding.
- K. Sub-transient Reactance: 12 percent, maximum.
- L. Provide minimum motor starting capability of [*insert number*] sKVA at 30% instantaneous voltage dip as defined per NEMA MG 1.

2.9 MOTORS

- A. General requirements for motors are specified in Division 23 Section "Common Motor Requirements for HVAC Equipment."
 - 1. Motor Sizes: Minimum size as indicated. If not indicated, large enough so driven loads will not require motor to operate in service factor range above 1.0.

2. Controllers, Electrical Devices, and Wiring: Electrical devices and connections are specified in Division 26 Sections.

2.10 VIBRATION ISOLATION DEVICES

- A. The isolators shall be of a waffled or ribbed pad. The pads shall be resistant to heat and age, and impervious to oil, water, antifreeze, diesel fuel, and cleaning compounds.

2.11 FINISHES

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

2.12 SOURCE QUALITY CONTROL

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

1. Tests: Comply with NFPA 110, Level 1 Energy Converters and with IEEE 115.

- B. Project-Specific Equipment Tests: Before shipment, factory test engine-generator set and other system components and accessories manufactured specifically for this Project. Perform tests at rated load and power factor. Include the following tests:

1. Test components and accessories furnished with installed unit that are not identical to those on tested prototype to demonstrate compatibility and reliability.
2. Full load run.
3. Maximum power.
4. Voltage regulation.
5. Transient and steady-state governing.
6. Single-step load pickup.
7. Safety shutdown.
8. Provide 14 days' advance notice of tests and opportunity for observation of tests by the Northwestern University's designated representative.
9. Report factory test results within 10 days of completion of test.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine areas, equipment bases, and conditions, with Installer present, for compliance with requirements for installation and other conditions affecting packaged engine-generator performance.
- B. Examine roughing-in of piping systems and electrical connections. Verify actual locations of connections before packaged engine-generator installation.
- C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

- A. Comply with packaged engine-generator manufacturers' written installation and alignment instructions and with NFPA 110.
- B. Install packaged engine generator to provide access, without removing connections or accessories, for periodic maintenance.
- C. Install indoor engine generators on 4-inch- (100-mm-) high concrete base (Evanston: 6" high east of Sheridan Rd.). Secure sets to anchor bolts installed in concrete bases. Construct concrete bases according to Division 3 Sections.
- D. Electrical Wiring: Install electrical devices furnished by equipment manufacturers but not specified to be factory mounted.
- E. Install remote Generator Annunciator Panel(s) (GAP) as indicated. Provide all interconnecting wiring.

3.3 CONNECTIONS

- A. Ground equipment according to Division 26 Section "Grounding and Bonding for Electrical Systems."
- B. Connect wiring according to Division 26 Section "Low-Voltage Electrical Power Conductors and Cables."
- C. Tighten electrical joints, electrical connectors, and terminals according to manufacturer's published torque-tightening values using a calibrated torque wrench. Provide a list of all torqued connections and values.
- D. Provide all communications wiring between generator's remote monitoring and communication modules and the University's SCADA system. Verify that each Generator's address for microprocessor-communication packages corresponds to data network requirements. Include all necessary programming by a factory-authorized service representative to link systems and permit data transfer between generator and SCADA.
- E. Provide all interconnecting wiring between the generator and transfer switches as required for proper operation of system, provide a start circuit from each transfer switch.
- F. Provide all interconnecting wiring between the generator and other equipment or systems as required for proper operation and monitoring of system.
- G. ***(Delete if not required)*** [Provide control circuits from the fire pump controller to start the engine-generator.]
- H. Provide control circuits from the engine-generator to BAS to provide "generator running" and "generator trouble" alarms.
- I. Furnish and install all miscellaneous control and power wiring as required for a complete and functioning system that meets all University, AHJ, and Code requirements.

3.4 IDENTIFICATION

- A. Identify system components according to Division 26 Section "Identification for Electrical Systems."
- B. Emergency Sources: A sign shall be placed at the service entrance equipment indicating the type and location of on-site emergency power sources per NEC Art. 700.

3.5 ADJUSTING

- A. Set engine-generator circuit breaker and relay protective functions.

3.6 FIELD QUALITY CONTROL

- A. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect, test, and adjust components, assemblies, and equipment installations, including connections. Report results in writing.
- B. Perform tests and inspections and prepare test reports.
 - 1. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect components, assemblies, and equipment installations, including connections, and to assist in testing.
- C. This Contractor is responsible for the following tests and inspections:
 - 1. Perform tests recommended by manufacturer and each electrical test and visual and mechanical inspection for "AC Generators and for Emergency Systems" specified in NETA Acceptance Testing Specification. Certify compliance with test parameters.
 - 2. NFPA 110 Acceptance Tests: Perform tests required by NFPA 110 that are additional to those specified here including, but not limited to, single-step full-load pickup test.
 - 3. The diesel generator set shall operate under full load conditions for a minimum of four (4) hours. The generator set shall maintain rated voltage and rated frequency per Specifications for the duration of the full load test. Voltage, amperage and frequency measurements, as well as engine gauge and monitor points, shall be recorded at 15 minute intervals. All doors of the weatherproof housing shall remain closed during testing.
 - 4. Battery Tests: Equalize charging of battery cells according to manufacturer's written instructions. Record individual cell voltages.
 - a. Measure charging voltage and voltages between available battery terminals for full-charging and float-charging conditions. Check electrolyte level and specific gravity under both conditions.
 - b. Test for contact integrity of all connectors. Perform an integrity load test and a capacity load test for the battery.
 - c. Verify acceptance of charge for each element of the battery after discharge.
 - d. Verify that measurements are within manufacturer's specifications.
 - 5. Battery-Charger Tests: Verify specified rates of charge for both equalizing and float-charging conditions.
 - 6. System Integrity Tests: Methodically verify proper installation, connection, and integrity of each element of engine-generator system before and during system operation. Check for air, exhaust, and fluid leaks.

7. Exhaust-System Back-Pressure Test: Use a manometer with a scale exceeding 40-inch wg (120 kPa). Connect to exhaust line close to engine exhaust manifold. Verify that back pressure at full-rated load is within manufacturer's written allowable limits for the engine.
 8. Exhaust Emissions Test: Comply with applicable government test criteria.
 9. Voltage and Frequency Transient Stability Tests: Use recording oscilloscope to measure voltage and frequency transients for 50 and 100 percent step-load increases and decreases, and verify that performance is as specified.
 10. Harmonic-Content Tests: Measure harmonic content of output voltage under 25 percent and at 100 percent of rated linear load. Verify that harmonic content is within specified limits.
 11. Noise Level Tests: Measure A-weighted level of noise emanating from generator-set installation, including engine exhaust and cooling-air intake and discharge, at four locations on the property line, and compare measured levels with required values.
- D. Coordinate tests with tests for transfer switches and run them concurrently.
- E. Leak Test: After installation, charge system and test for leaks. Repair leaks and retest until no leaks exist.
- F. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.
- G. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
- H. Remove and replace malfunctioning units and retest as specified above.
- I. Retest: Correct deficiencies identified by tests and observations and retest until specified requirements are met.
- J. This Contractor shall top off all fuel/oil/coolant tanks at completion of testing. Fill all engine fluids to levels as recommended by manufacturer.
- K. Report results of tests and inspections in writing. Record adjustable relay settings and measured insulation resistances, time delays, and other values and observations.
- L. Infrared Scanning: After Substantial Completion, but not more than 90 days after Final Acceptance, perform an infrared scan of each power wiring termination and each bus connection. Remove all access panels so terminations and connections are accessible to portable scanner. Generator shall be at running temperature under load conditions.
1. Follow-up Infrared Scanning: Perform an additional follow-up infrared scan of each switchboard 11 months after date of Substantial Completion.
- 3.7 DEMONSTRATION
- A. Engage a factory-authorized service representative to train Northwestern University maintenance personnel to adjust, operate, and maintain packaged engine generators. Provide two - 8 hour sessions. Conduct this training concurrently with ATS training, refer to Section 263600.

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FOR: _____
ISSUED: 03/29/2017

END OF SECTION 26 3213