SECTION 26 32 13
ENGINE GENERATORS

PART 1 - GENERAL

1.1 DESCRIPTION

A. This section specifies the furnishing, installation, and testing of the medium-voltage (13.8 kv) natural gas driven reciprocating engine-generator system in weatherproof enclosure. This includes, but is not limited to: air filtration, starting system, generator controls, instrumentation, lubrication, fuel system, cooling system, and exhaust system, piping connections, piping supports remote radiators, batteries, with battery racks and chargers, control/monitoring, communication capabilities, and all data and documentation needed for air quality permit.

B. The engine-generator system shall be fully automatic and shall constitute a unified and coordinated system ready for operation, fully coordinated with paralleling switchgear and controls.

C. System Description

1. Systems provided under this section includes turbocharged engine driven generators complete with controls, fuel and auxiliary equipment. Air cooled remote radiators and exhaust silencers along with flexible piping connections shall be included and designed as an integral part of the engine-generator package.
2. The engine supplier is responsible for engineering, design, layout, control, device selection, materials, run testing, delivery, installation support and start-up services as needed to provide complete and functional systems.
3. Design Criteria:
   a. Site Conditions:
      1) Maximum outdoor temperature……120 degrees F
      2) Minimum outdoor temperature……10 degrees F
      3) Approximate altitude……2300 feet above sea level
   b. Fuel Supply Conditions
      1) Nominal supply main pressure……10 psi at meter, 7-8 psi at regulator, 2-3 psi at generator inlet.
      2) Average fuel main energy content……per Southwest Gas Company
      3) Natural gas supply fuel analysis per Southwest Gas Company

4. Functional Requirements:
   a. Multiple generation systems for production of electrical power in Island Mode with closed transition paralleling capability with each generator and open transition to/from utility source. Engines shall run on pipeline natural gas fuel and controls will be capable of manually-initiated automatic starting, automatic and manual synchronization, load following and continuous operation at fixed output and manually initiated automatic shutdown.
   b. The generation system shall incorporate all safety and operating shutdown and protective devices which the manufacturer requires to preserve system integrity.
   c. Facility loads will be applied in accordance with a defined sequence of operations and will not exceed the maximum load step capabilities of the generation system.
   d. Engine (Prime Rating at Site Conditions, per Engine):
      1) Approximate BHP (continuous, full load, without fan)…2889BHP
      2) Maximum operating speed…….1800rpm
5. Generator (Prime Duty, per Generator)
   a. Minimum power output.....2000ekW after altitude and temperature derate.
   b. Voltage output…….13.8kV, 3-phase, 3-wire.
6. Regulatory Requirements: All materials, assembly, installation, testing and commissioning shall meet the requirements of applicable codes and standards.
   a. ASTM-American Society for Testing and Materials
   b. NETA-National Electrical Testing Association
   c. NFPA 110-Non life safety
   d. UL 508A
7. This section defines performance characteristics of natural gas fueled engine-generator system and accessories designed for operation in Island Mode.
   a. Skid-mounted engine generator sets.
   b. Outdoor weatherproof enclosures. Provide “Best” key 7-pin door locks.
   c. Engine generator supporting equipment and materials including; remote radiators, exhaust silencers, exhaust connections, piping connections.
   d. Engine generator control panels, gauge panels, batteries, battery racks and battery chargers.

8. Provide natural gas fueled reciprocating engine driven electric power generation equipment consisting of:
   a. 2000kW (without fan) island mode rated engine-generator sets (gensets).
   b. Electric motor driven, fan assisted, air cooled, remote radiators (one per genset).
   c. Medium voltage (13.8kV) paralleling switchgear per Section 261300.
9. The proposed power generation system is intended to operate in 'island mode' with closed transition paralleling capability such that:
   a. Upon loss of utility power generator systems will be manually started and serve standby loads.
   b. Natural gas fuelled engines will start and parallel to generator bus.
   c. Distribution breakers will be closed to serve building loads in compliance with the Sequence of Operations.
10. The following uncommon abbreviations and phrases are used in this specification.
   a. Scfd: Standard cubic foot of gas per day
   b. ASL: Above sea level
   c. BMEP: Brake mean effective pressure
   d. FC: Fuel consumption
   e. inWC: Inches of water column
   f. Island Mode: Operation without utility paralleling, but in parallel with other generators.

1.2 RELATED WORK

A. Section 23 05 41, NOISE AND VIBRATION CONTROL FOR HVAC PIPING AND EQUIPMENT: Requirements for pipe and equipment support and noise control.
B. Section 23 10 00, FACILITY FUEL SYSTEMS: Fuel supply and storage requirements.
C. Section 26 05 11, REQUIREMENTS FOR ELECTRICAL INSTALLATIONS: General electrical requirements and items common to more than one section of Division 26.
D. Section 26 05 21, LOW-VOLTAGE ELECTRICAL POWER CONDUCTORS AND CABLES (600 VOLTS AND BELOW): Low voltage conductors.
E. Section 26 05 26, GROUNDING AND BONDING FOR ELECTRICAL SYSTEMS: Requirements for personnel safety and to provide a low impedance path for possible ground fault currents.

F. Section 26 05 71, ELECTRICAL SYSTEM PROTECTIVE DEVICE STUDY: Requirements for protective coordination of a standby and/or essential electrical system.
G. Section 26 13 00, MEDIUM-VOLTAGE SWITCHGEAR: Requirements for medium-voltage switchgear for use with medium-voltage generators.
H. Section 26 13 13, GENERATOR PARALLELING CONTROLS: Requirements for generator paralleling.
I. Section 26 24 19, Low Voltage (600kV) Motor control centers.
J. Section 26 24 11, DISTRIBUTION SWITCHBOARDS: Requirements for secondary distribution switchboards.

1.3 QUALITY ASSURANCE

Refer to Paragraph, QUALIFICATIONS, in Section 26 05 11, REQUIREMENTS FOR ELECTRICAL INSTALLATIONS.

1.4 QUALITY ASSURANCE

A. The supplier of the engine-generator shall be responsible for satisfactory total operation of the system and its certification. This supplier shall have had experience with three or more installations of systems of comparable size and complexity. Each of these installations shall have been in successful operation for three or more years. Prior to review of submittals, the Government reserves the right to:
   1. Have the manufacturer submit a list of locations with similar installations.
   2. Inspect any of these installations and question the user concerning the installations without the presence of the supplier.
B. A factory-authorized representative shall be capable of providing emergency maintenance and repairs at the project site within 2 hours maximum of notification.
C. Gensets, paralleling equipment and auxiliary components shall be provided by a single supplier who shall be responsible for installing, startup, integration testing and commissioning of all components and interconnections.
D. Factory Test: The Government shall have the option of witnessing the following tests at the factory. The tests shall be performed on the specific engine-generator(s) being manufactured for this project regardless of whether or not the government chooses to witness the tests. The Government will pay all expenses for the Government representative's trip to witness these tests. The contractor shall

notify the COTR 30 days prior to date of testing. The manufacturer shall furnish load banks, testing instruments, and all other equipment necessary to perform these tests.

1. Load Test: Shall include six hours of continuous operation; four hours while the engine-generator is delivering 100% of the specified kW and two hours while delivering 110% of the specified kW. During this test record, the following data at 20-minute intervals:

Time	Engine RPM	Oil Temperature Out
kW	Water Temperature In	Fuel Pressure
Voltage	Water Temperature Out	Oil Pressure
Amperes	Oil Temperature In	Ambient Temperature

2. Quick Start Test: Record time required for the engine-generator to develop specified voltage, frequency, and kW load from a standstill condition.
3. Whether or not Government witness' tests, submit initial test report before shipping and formal report before installation.
4. Full load rejection: demonstrate that engine will not shut down when output breaker opens at full load.
5. Block load test: demonstrate the maximum block load that the genset will accept without tripping off line.

1.5 SUBMITTALS

A. In accordance with Section 26 05 11, REQUIREMENTS FOR ELECTRICAL INSTALLATIONS, submit the following:

B. Shop Drawings:
Scaled drawings, showing plan views, side views, elevations, and cross-sections. Drawings and design calculations for concrete genset equipment pads and radiator support columns.

C. Diagrams:
Control system diagrams, elementary diagrams, control sequence diagrams or tables, wiring diagrams, interconnections diagrams (between local control cubicles, remote annunciator panels, remote derangement panels, remote monitoring panels, remote exercising panel, paralleling switchgear, illustrative diagrams, flow diagrams, and other like items.

D. Technical Data:
1. Published ratings, catalog cuts, pictures, and manufacturers' specifications for engine-generator, governor, voltage regulator, radiator, muffler, dampers, batteries and charger, jacket heaters, torsional vibration, and control and supervisory equipment.
2. Description of operation.

3. Short-circuit current capacity and subtransient reactance.
4. Sound power level data.
5. Vibration isolation system performance data from no-load to full-load. This must include seismic qualification of the engine-generator mounting, base, and vibration isolation.
6. Engine Data:
   a. Brake horsepower
   b. Operating speed
   c. Fuel consumption as a function of load
   d. Engine efficiency as a function of load
   e. Derating factors
   f. Emissions data

E. Calculations:
Detailed engineering calculations with all equations, graphs, assumptions, and approximations shown and data sources referenced. Include any calculated performance derations appropriate to installed environment.

F. Manuals:
1. When submitting the shop drawings, submit complete maintenance and operating manuals of the engine-generator and auxiliaries, including technical data sheets, wiring diagrams, and information for ordering replacement parts.
2. Two weeks prior to the final inspection, submit four copies of the updated maintenance and operating manual to the COTR:
   a. Include complete "As Installed" diagrams, which indicate all items of equipment and their interconnecting wiring.
   b. Include complete diagrams of the internal wiring for each of the pieces of equipment, including "As Installed" revisions of the diagrams.
   c. The wiring diagrams shall identify the terminals to facilitate installation, maintenance, operation, and testing.
   d. Include complete lists of spare parts and special tools recommended for two years of normal operation of the complete system.

G. Certifications:
1. Prior to fabrication of the engine-generator, submit the following to the COTR for approval:
   a. A certification in writing that an engine-generator of the same model and configuration, with the same bore, stroke, number of cylinders, and equal or higher kW/kVA ratings as the proposed

engine-generator, has been operating satisfactorily with connected loads of not less than 75% of the specified kW/kVA rating, for not fewer than 2,000 hours without any failure of a crankshaft, camshaft, piston, valve, injector, or governor system.

b. A certification in writing that devices and circuits will be incorporated to protect the voltage regulator and other components of the engine-generator during operation at speeds other than the rated RPM while performing maintenance. Submit thorough descriptions of any precautions necessary to protect the voltage regulator and other components of the system during operation of the engine-generator at speeds other than the rated RPM.

c. A certification from the engine manufacturer stating that the engine exhaust emissions meet the federal, state, and local regulations and restrictions. At a minimum, this certification shall include emission factors for criteria pollutants including nitrogen oxides, carbon monoxide, particulate matter, sulfur dioxide, non-methane hydrocarbon, and hazardous air pollutants (HPAs).

2. Prior to installation of the engine-generator at the job site, submit four copies of certified factory test data to the COTR.

3. Two weeks prior to the final inspection, submit four copies of the following to the COTR:

a. Certification by the engine-generator manufacturer that the equipment conforms to the requirements of the drawings and specifications.

b. A certified report of field tests from the contractor that the engine-generator has been properly installed, adjusted, and tested.

c. A certificate by the manufacturer that the engine-generator, accessories, and components will withstand the design seismic event forces (Z=___) and that the engine-generator will be fully operational after the design seismic event at the project site.

1.6 STORAGE AND HANDLING

A. Equipment shall withstand shipping and handling stresses in addition to the electrical and mechanical stresses which occur during operation of the system. Protect radiator core with wood sheet.

B. Store the equipment in a location approved by the COTR.

1.7 JOB CONDITIONS

Shall conform to the arrangements and details shown on the drawings. The dimensions, enclosures, and arrangements of the engine-generator system shall permit the operating personnel to safely and conveniently operate and maintain the system in the space designated for installation.

1.8 APPLICABLE PUBLICATIONS

A. Publications listed below (including amendments, addenda, revisions, supplements, and errata) form a part of this specification to the extent referenced. Publications are referenced in the text by designation only.

B. American National Standards Institute (ANSI):

C39.1-81 (R1992) .....Requirements for Electrical Analog Indicating Instruments

C. American Society of Testing Materials (ASTM):

A53/A53M-07.....Standard Specification for Pipe, Steel, Black, and Hot–Dipped, Zinc Coated Welded and Seamless.

B88-03.....Specification for Seamless Copper Water Tube

B88M-03.....Specification for Seamless Copper water Tube (Metric)

D. Institute of Electrical and Electronic Engineers (IEEE):

C37.90.1-02.....Surge Withstand Capability (SWC) Tests for Relays and Relay Systems Associated with Electric Power Apparatus

E. National Electrical Manufacturers Association (NEMA):

ICS 6-06.....Enclosures

ICS 4-05.....Terminal Blocks

MG 1-07.....Motor and Generators

MG 2-01.....Safety Standard and Guide for Selection, Installation and Use of Electric Motors and Generators

PB 2-06.....Dead-Front Distribution Switchboards

250-08.....Enclosures for Electrical Equipment (1000 Volts Maximum)

F. National Fire Protection Association (NFPA):

37-05.....Installations and Use of Stationary Combustion Engine and Gas Turbines

70-08.....National Electrical Code (NEC)

99-05.....Health Care Facilities

110-10.....Standard for Emergency and Standby Power Systems

G. Underwriters Laboratories, Inc. (UL):

50-95.....Enclosures for Electrical Equipment

2200-98.....Stationery Engine Generator Assemblies

1236-06.....Battery Chargers for Charging Engine-Starter Batteries
467-07.....Grounding and Bonding Equipment
489-09.....Molded-Case Circuit Breakers, Molded-Case Switches and Circuit-Breaker Enclosures
508-99.....Industrial Control Equipment
891-05.....Switchboards

PART 2 - PRODUCTS

2.1 ENGINE-GENERATOR

A. The engine-generator system shall be in accordance with NFPA, UL, NEMA and ANSI, and as specified herein. All information required by these specifications shall shown on the drawings.

B. Provide a factory-assembled, wired (except for field connections), complete, fully automatic engine-generator and control system.

C. Engine-Generator Parameter Schedule:
Site Power Rating: Prime duty site rating not less than 2000KW. Shall be capable of operating continuous for 24 consecutive hours at 100% of specified rating without damage.
Voltage: 13800V/7970V, 3-phase, 3-wire
Power Factor: 0.8 lagging
Engine-Generator Application: Parallel
Fuel: Natural Gas
Maximum Speed: 1800 RPM
Frequency Bandwidth (steady state): + 0.25
Voltage Regulation: + 2% (maximum) (No Load to Full Load) (standalone applications)
Voltage Bandwidth: 0.5% (steady state)
Frequency: 60 Hz
Phases: 3 Phase, Wye, 3 wire
Minimum Generator Subtransient Reactance: 14.6%
Minimum Step Load Increase: 20% of maximum output—load at 0.8 PF
Transient Recovery Time with Step Load Increase (Voltage): 10 seconds
Transient Recovery Time with Step Load Increase (Frequency): 10 seconds
Maximum Frequency Deviation with 25% Step Load Increase: 10% of rated frequency
Max Step Load Decrease (without shutdown): 100% of maximum output load at 0.8 PF
Max Time to Start and be Ready to Assume Load: 60 seconds
Operation: 10 F

Max Summer Outdoor Temp (Ambient): 120F °
Min Winter Outdoor Temp (Ambient): 10F °
Installation Elevation: 2300 above sea level

D. Assemble, connect, and wire the equipment at the factory so that only the external connections need to be made at the construction site.
E. Unit shall be factory-painted with manufacturer's primer and standard finishes. Contractor to submit on available colors (green color is not recommended) so building and enclosures are reviewed simultaneously.
F. Connections between components of the system shall conform to the recommendations of the manufacturer.
G. Couplings, shafts, and other moving parts shall be enclosed and guarded. Guards shall be metal, ruggedly constructed, rigidly fastened, and readily removable for convenient servicing of the equipment without disassembling any pipes and fittings.
H. Engine-generator shall have the following features:
   1. Factory skid-mounted on a common, rigid, welded, structural steel base.
   2. Engine-generator shall be statically and dynamically balanced so that the maximum vibration in the horizontal, vertical, and axial directions shall be limited to 0.0059 in [0.15 mm], with an overall velocity limit of 0.866 in/sec [24 mm/sec] RMS, for all speeds.
   3. The isolators shall be constrained with restraints capable of withstanding static forces in any direction equal to twice the weight of the supported equipment.
   4. Shall be capable of operating satisfactorily as specified for not fewer than 10,000 hours between major overhauls.
I. Each engine-generator shall be capable of parallel operation with one or more engine-generators on an isolated bus without hunting.
J. Each engine-generator specified for parallel operation shall be configured to automatically load-share with other engine-generators by proportional loading. Proportional loading shall load each engine-generator to within 5% of its fair share. A fair share is its nameplate-rated capacity times the total load, divided by the sum of all nameplate-rated capacities of on-line engine-generators. Load sharing shall incorporate both the real and reactive components of the load.

2.2 ENGINE

A. Coupled directly to a generator.
B. Minimum eight cylinders.
C. The engine shall be able to start in a 20° F [-6.7° C] ambient temperature while using natural gas supply starting aids such as glow plugs and ether injections.

D. Natural gas consumption of each engine rate shall not exceed 3500 SCFM:
E. Equipped with electric heater for maintaining the coolant temperature as recommended by the manufacturer.
   1. Install thermostatic controls, contactors, and circuit breaker-protected circuits for the heaters.
   2. The heaters shall operate continuously except while the engine is operating or the water temperature is at the predetermined set point (adjustable).

2.3 GOVERNOR

A. Isochronous, electronic type.
B. Steady-state speed band at 60 Hz shall not exceed plus or minus one-third of 1%. Specify frequency limitation for load pickup of 2.5%, 15.0% and 100%
C. While the engine is running, manual speed adjustments may be made.

2.4 LUBRICATION OIL SYSTEM

A. Provide a 120-volt oil heater for exterior engine-generator with adjustable set point and circuit breaker.
B. Pressurized type.
C. Positive-displacement pump driven by engine crankshaft.
D. Full-flow strainer and full-flow or by-pass filters.
E. Filters shall be cleanable or replaceable type and shall remove particles as small as 3 microns without removing the additives in the oil. For by-pass filters, flow shall be diverted without flow interruption.
F. Extend lube oil sump drain line out through the skid base and terminate it with a drain valve and plug.

2.5 COOLING SYSTEM

A. Liquid-cooled, closed loop, with fin-tube remote radiator, as shown on the drawings.
B. Cooling capacity shall not be less than the cooling requirements of the engine-generator and its lubricating oil while operating continuously at 110% of its maximum specified rating at maximum ambient temperature.
C. Water circulating pumps shall be the centrifugal type driven by engine. Incorporate pressure relief devices where required to prevent excessive pressure increase after the engine stops.
D. Coolant shall be extended-life antifreeze solution, 50% ethylene glycol and 50% soft water, with corrosion inhibitor additive as recommended by the manufacturer.
E. Fan shall be driven by a totally enclosed electric motor.
F. Coolant hoses shall be flexible, per manufacturer's recommendation.

G. Self-contained thermostatic-control valve shall modulate coolant flow to maintain optimum constant coolant temperature, as recommended by the engine manufacturer.

H. Remote Radiator Enclosure:

1. Shall be rugged, tamperproof assemblies framed with steel channels, angles, and braces. Provide fan shroud, fixed louvers, and bird screens at both air intake and exhaust.
2. Shall be securely bolted together to facilitate future dismantling. Carriage type bolts shall be used with the washers and locknuts on the inside of the enclosures.
3. Door shall be leveled sheet steel attached with concealed or semi-concealed hinges. Include a stop edge around the inside of the door opening and a metal rod stop for 90 degree opening.
4. Anchor the enclosures to concrete column bases with bolts, not less than 0.5 in [15 mm] diameter.
5. Radiator fan motor shall be totally enclosed with guarded V-belt drive and an adjustable mounting base.
6. Coolant piping shall be as recommended by the manufacturer.

2.6 AIR INTAKE AND EXHAUST SYSTEMS

A. Air Intake:

Provide an engine-mounted air cleaner with replaceable dry filter and dirty filter indicator.

B. Exhaust System:

1. Exhaust Muffler:

Shall be critical grade type and capable of the following noise attenuation:

Octave Band Hertz (Mid Frequency)	Minimum db Attenuation (.0002 Microbar Reference)
31	5
63	10
125	27
500	37
1000	31
2000	26
4000	25
8000	26

2. Pressure drop in the complete exhaust system shall be small enough for satisfactory operation of the engine-generator while it is delivering 110% of its specified rating.
3. Exhaust pipe size from the engine to the muffler shall be as recommended by the engine manufacturer. Pipe size from muffler to air discharge shall be two pipe sizes larger than engine exhaust pipe.
4. Connections at the engine exhaust outlet shall be made with a flexible exhaust pipe. Provide bolted type pipe flanges welded to each end of the flexible section.

C. Condensate drain at muffler shall be made with schedule 40 black steel pipe through a petcock.
D. Exhaust Piping and Supports: Black steel pipe, ASTM A-53 standard weight with welded fittings. Spring type hangers, as specified in Section 23 05 41, NOISE AND VIBRATION CONTROL FOR HVAC PIPING AND EQUIPMENT, shall support the pipe.
E. Insulation for Exhaust Pipe and Muffler:
1. Calcium silicate minimum 3 in [75 mm] thick.
2. Insulation shall be as specified in Section 23 07 11, HVAC, PLUMBING, AND BOILER PLANT INSULATION.
3. The installed insulation shall be covered with aluminum jacket 0.016 in [0.4 mm] thick. The jacket is to be held in place by bands of 0.015 in [0.38 mm] thick by 0.5 in [15 mm] wide aluminum.
4. Insulation and jacket are not required on flexible exhaust sections.

F. Roof Sleeves: Pipe sleeves (thimble) shall be Schedule 40 standard weight steel pipe. Flash exhaust pipe thimble through roof with 16 oz soft sheet copper, flanged, and made watertight under built-up roofing and extended up around pipe thimble. The exhaust pipe shall be positioned within the thimble by four 6 in [150 mm] wide spiders welded to the exhaust pipe.
G. Vertical exhaust piping shall be provided with a hinged, gravity-operated, self-closing rain cover.

2.7 ENGINE STARTING SYSTEM

A. Shall start the engine at any position of the flywheel.
B. Electric cranking motor:
1. Shall be engine-mounted.
2. Shall crank the engine via a gear drive.
3. Rating shall be adequate for cranking the cold engine at the voltage provided by the battery system, and at the required RPM during five consecutive starting attempts of 10 seconds cranking each at

10-second intervals, for a total of 50 seconds of actual cranking without damage (the fifth starting attempt will be manually initiated upon failure of a complete engine cranking cycle).

C. Batteries shall be sealed lead-acid high discharge rate type.
   1. Each battery cell shall have minimum and maximum electrolyte level indicators and a flip-top flame arrestor vent cap.
   2. Batteries shall have connector covers for protection against external short circuits.
   3. With the charger disconnected, the batteries shall have sufficient capacity so that the total system voltage does not fall below 85% of the nominal system voltage with the following demands:
      Five consecutive starting attempts of 10 seconds cranking at 10 second intervals for a total of 50 seconds of actual cranking (the fifth starting attempt will be manually initiated upon failure of a complete engine cranking cycle).
   4. Battery racks shall be metal with an alkali-resistant finish and thermal insulation, and secured to the floor.

D. Battery Charger:
   1. A current-limiting battery charger, conforming to UL 1236, shall be provided and shall automatically recharge the batteries. The charger shall be capable of an equalize-charging rate for recharging fully depleted batteries within 24 hours and a floating charge rate for maintaining the batteries at fully charged condition.
   2. An ammeter shall be provided to indicate charging rate. A voltmeter shall be provided to indicate charging voltage.
   3. The charger shall be capable of continuous operation in an ambient temperature of -20 to 60 degrees C (-30 to 104 degrees F) without derating. The charger shall be convection cooled and housed in a NEMA Type 3 gasketed enclosure. The charger shall have a hinged front door and all components shall be accessible from the front.
   4. Provide both AC and DC transient protection. Charger shall be able to recharge a fully discharged battery without tripping AC protective devices. AC circuit breaker shall not trip under any DC load condition including short circuit on output terminals.
   5. The charger shall be capable of recharging the fully discharged battery in 12 hours and simultaneously power the Supervisory and control panel.
   6. The charger shall have fused AC input and DC output protection, and shall not discharge the batteries when AC power fails.

7. The charger shall have the following accessories:
   a. On-off control switch with pilot light.
   b. Hand adjustable 0 to 24 hour equalize charge timer.
   c. AC power failure alarm light.
   d. High DC voltage alarm light.
   e. DC voltmeter – 5 percent accuracy.
   f. DC ammeter – 5 percent accuracy.

2.8 LUBRICATING OIL HEATERS

Provide an adjustable thermostatically-controlled electric heater with circuit breaker to automatically maintain the oil temperature within plus or minus 3° F [1.7° C] of the control temperature.

2.9 JACKET COOLANT HEATERS

Provide an adjustable thermostatically-controlled electric heater with circuit breaker mounted in the engine coolant jacketing to automatically maintain the coolant within plus or minus 3° F [1.7° C] of the temperature recommended by the engine manufacturer to meet the starting time specified at the minimum winter outdoor temperature.

2.10 GENERATOR

A. Synchronous, amortisseur windings, bracket-bearing, self-venting, rotating-field type connected directly to the engine.
B. Lifting lugs designed for convenient connection to and removal from the engine.
C. Integral poles and spider, or individual poles dove-tailed to the spider.
D. Designed for sustained short-circuit currents in conformance with NEMA Standards.
E. Designed for sustained operation at 125% of the RPM specified for the engine-generator without damage.
F. Telephone influence factor shall conform to NEMA Standards.
G. Furnished with brushless excitation system consisting of rotating rectifier assembly, 3-phase AC exciter and a solid state voltage regulator with surge protection for rotating rectifier.
H. Nameplates attached to the generator and exciter shall show the manufacturer's name, equipment identification, serial number, voltage ratings, field current ratings, kW/kVA output ratings, power factor rating, time rating, temperature rise ratings, RPM ratings, full load current rating, number of phases and frequency, and date of manufacture.
I. The grounded (neutral) conductor shall be electrically isolated from equipment ground and terminated in the same junction box as the phase conductors.

2.11 GENERATOR OVERCURRENT AND FAULT PROTECTION

A. Power Circuit

B. Generator circuit breaker shall be medium-voltage vacuum circuit breaker per the requirements of Section 26 13 10, MEDIUM VOLTAGE SWITCHGEAR.

C. Integrate ground-fault indication with other engine-generator alarm indications (two breakers) one load breaker and one load bank breaker. Include two sets of Type “A” and “B” auxiliary contacts for controls and remote monitoring.

D. Include minimum two sets of “a” and “b” breaker auxiliary contacts on each breaker for controls and monitoring.

2.12 CONTROLS

A. Shall include a local Engine Generator Control Panel.

B. General:

1. Control Equipment shall be in accordance with UL 508, NEMA ICS-4, ICS-6, and ANSI C37.90.1.
2. Panels shall be in accordance with UL 50.
3. Coordinate controls as shown on the drawings and specifications so that the systems will operate as specified.

C. Engine-Generator Control Panel: Provide at each engine-generator a digital monitoring, control and display panel for local operator interface and remote system interface.

1. Shall be environmentally sealed and suitable for use within the engine-generator enclosure.
2. True RMS sensing accuracy of 0.5% for voltage and current.
3. Power metering and diagnostics accessible via keypad.
4. Programmable protections and alarms.
5. Automatic, manual, or off mode selections.
6. Manual start/stop and emergency stop control.
7. Indication of AC voltage, AC current, KW, KVA, KVAR, KWH, PF, frequency, DC voltage, oil pressure, fuel pressure, RPM, runtime hours, and system diagnostics.
8. Provide voltage control and cool down timer.
9. Indicate alarms: low oil pressure, low/high fuel pressure, high coolant temperature, overspeed, overcrank, fault shutdown, fault alarms.
10. Provide electronic governor.
11. Provide communication links, protocol software and programming necessary to communicate all data to Master Control system.
12. Engine Cranking Controls:
    a. The cranking cycles shall be controlled by a timer that will be independent of the battery voltage fluctuations.

b. The controls shall crank the engine through one complete cranking cycle, consisting of four starting attempts of 10 seconds each and 10 seconds between each attempt.
c. Total actual cranking time for the complete cranking cycle shall be 40 seconds during a 70-second interval.
d. Cranking shall terminate when the engine starts so that the starting system will not be damaged. Termination of the cranking shall be controlled by self-contained, speed-sensitive switch. The switch shall prevent re-cranking of the engine until after the engine stops.
e. After the engine has stopped, the cranking control shall reset.

13. Supervisory Controls:
    a. Overcrank:
        1) When the cranking control system completes one cranking cycle (four starting attempts), without starting the engine, the OVERCRANK signal light and the audible alarm shall be energized and the Master Controller notified.
        2) The cranking control system shall lock-out, and shall require a manual reset.
    b. Coolant Temperature:
        1) When the temperature rises to the predetermined first stage level, the HIGH COOLANT TEMPERATURE - FIRST STAGE signal light and the audible alarm shall be energized and the Master Controller notified.
        2) When the temperature rises to the predetermined second stage level, which shall be low enough to prevent any damage to the engine and high enough to avoid unnecessary engine shutdowns, the HIGH COOLANT TEMPERATURE - SECOND STAGE signal light and the audible alarm shall be energized, the engine shall stop, and the Master Controller notified.
        3) The difference between the first and second stage temperature settings shall be approximately 10° F [-12° C].
        4) Permanently indicate the temperature settings at the panel.
        5) When the coolant temperature drops to below 70° F [21° C] (adjustable), the "LOW COOLANT TEMPERATURE" signal light and the audible alarm shall be energized and the Master Controller notified.
    c. Low Coolant Level: When the coolant level falls below the minimum level recommended by the manufacturer, the LOW COOLANT LEVEL signal light and audible alarm shall be energized and the Master Controller notified.

d. Lubricating Oil Pressure:
   1) When the pressure falls to the predetermined first stage level, the OIL PRESSURE - FIRST STAGE signal light and the audible alarm shall be energized and the Master Controller notified.
   2) When the pressure falls to the predetermined second stage level, which shall be high enough to prevent damage to the engine and low enough to avoid unnecessary engine shutdowns, the OIL PRESSURE - SECOND STAGE signal light and the audible alarm shall be energized and the engine shall stop and the Master Controller notified.
   3) The difference between the first and second stage pressure settings shall be approximately 15% of the oil pressure.
   4) The pressure settings shall be permanently displayed on the panel so that the running oil pressure can be compared to the target (setpoint) value.

e. Overspeed:
   1) When the engine RPM exceeds the maximum RPM recommended by the manufacturer of the engine, the engine shall stop.
   2) Simultaneously, the OVERSPEED signal light and the audible alarm shall be energized and the Master Controller notified.

f. Low Fuel Pressure:
   When the natural gas supply pressure decreases to less than the minimum level the warning light and the audible alarm shall be energized and the Master Controller notified.

g. Reset Alarms and Signals:
   Overcrank, Coolant Temperature, Coolant Level, Oil Pressure, Overspeed, and Low Fuel signal lights and the associated alarms shall require manual reset. The audible alarm shall be rated for 85 dB at 10 ft [3 M].

14. Monitoring Devices:
   a. Electronic type gauges for the cooling water temperatures and lubricating oil pressures. These gauges may be engine mounted with proper vibration isolation.
   b. An electronic running time indicator, totalizing not fewer than 9,999 hours, and an electronic tachometer.
   c. A voltmeter, ammeter, frequency meter, kilowatt meter, power factor, total harmonic distribution, manual adjusting knob for the output voltage, shall be mounted on the front of the generator control panel.
   d. Install potential and current transformers as required.

e. Individual signal indicators:
1) OVER-CRANK
2) HIGH COOLANT TEMPERATURE - FIRST STAGE
3) HIGH COOLANT TEMPERATURE - SECOND STAGE
4) LOW COOLANT TEMPERATURE
5) OIL PRESSURE - FIRST STAGE
6) OIL PRESSURE - SECOND STAGE
7) LOW COOLANT LEVEL
8) OVERSPEED
9) LOW NATURAL GAS SUPPLY PRESSURE

15. Automatic Voltage Regulator:
a. Shall correct voltage fluctuations rapidly and restore the output voltage to the predetermined level with a minimum amount of hunting.
b. Shall include voltage level manual control.
c. Provide a 3-phase automatic voltage regulator immune to waveform distortion.

2.13 SPARE PARTS

A. For each engine generator:
1. Six lubricating oil filters.
2. Six primary fuel filters.
3. Six secondary fuel filters.
4. Six intake air filters.
5. One set of belt drives.
6. Generator air filter.
7. One set of rotating rectifiers and surge protection for brushless exciter.

B. For each battery charger:
Three complete sets of fuses.

C. For each control panel:
1. Three complete sets of fuses.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install concrete bases of characteristics shown on the drawings and specifications.

B. Installation of the engine-generator shall comply with manufacturer's written instructions and with NFPA 110.

C. Mounting:
1. Support the base of engine-generator on vibration isolators, each isolator bolted to the pad, and the generator base bolted to isolator.

2. Install sufficient isolators so that the pad bearing pressure under each isolator is within the pad loading specification.
3. Install equal number of isolators on each side of the engine-generator's base.
4. Locate isolators for approximately equal load distribution and deflection per isolator. The base of the engine-generator shall be drilled at the factory for the isolator bolts.
5. Isolators shall be shipped loose with the engine-generator.
6. All connections between the engine-generator and exterior systems, such as fuel lines, electrical connections, and engine exhaust system and air exhaust shroud, shall be flexible.

D. Balance:

The vibration velocity in the horizontal, vertical, and axial directions shall not exceed 0.65 in [16.25 mm] per second peak at any specific frequency. These limits apply to main structural components such as the engine block and the generator frame at the bearings.

E. Connect all components of the generator system so that they will continue to be energized during failure of the normal electrical power supply system.

F. Install piping between engine-generator and remote components of cooling, fuel, and exhaust systems.

G. Flexible connection between radiator and exhaust shroud at the wall damper:
1. Install noncombustible flexible connections made of 20-oz neoprene-coated fiberglass fabric approximately 6 in [150 mm] wide.
2. Crimp and fasten the fabric to the sheet metal with screws 2 in [50 mm] on center. The fabric shall not be stressed, except by the air pressure.

H. Exhaust System Insulation:
1. Adhesive and insulation materials shall be applied on clean, dry surfaces from which loose scale and construction debris has been removed by wire brushing.
2. Fill all cracks, voids, and joints of applied insulation material with high temperature 2000° F [1093° C] insulating cement before applying the outer covering.
3. The installation shall be clean and free of debris, thermally and structurally tight without sag, neatly finished at all hangers or other penetrations, and shall provide a smooth finish surface.
4. Insulation and jacket shall terminate hard and tight at all anchor points.

5. Insulate completely from engine exhaust flexible connection through roof or wall construction, including muffler.

3.2 ACCEPTANCE CHECKS AND TESTS

A. Provide the services of a factory-authorized, factory-trained representative of the engine-generator manufacturer to inspect field-assembled components, and equipment installation and supervise the field tests of the complete genset, power and control system.

B. When the complete engine-generator system has been installed and prior to the final inspection, test all components of the system in the presence of the COTR for proper operation of the individual components and the total system in scope of supply and to eliminate electrical and mechanical defects.

C. Furnish lubricating oil, anti-freeze liquid, water treatment, and rust-inhibitor for full output testing of the engine-generator.

D. Visual Inspection: Visually verify proper installation of engine-generator and all components per manufacturer’s pre-start installation checklist.

E. Set relays per this specification. Set engine-generator circuit breaker protective functions per Section 26 05 71, ELECTRICAL SYSTEM PROTECTIVE DEVICE STUDY.

F. Field Tests: Submit test plan 30 days before notification of test readiness. Tests to be timed for availability of natural gas.

1. Perform manufacturer’s after-starting checks and inspections.
2. Test the engine-generator for eight hours of continuous operation as follows (NOTE: load shall be VA electrical distribution system):
   a. First six hours while the engine-generator is delivering 100% of its specified kW rating.
   b. Last two hours while the engine-generator is delivering 110% of its specified kW rating.
   c. If during the 8-hour continuous test, a failure occurs, either the engine shuts down or the full kW rating of the load bank is not achieved, the test is null and void. The test(s) shall be repeated at no additional cost to the Government until satisfactory results are attained.
3. Record the following test data at 30-minute intervals:
   a. Time of day, as well as reading of running time indicator.
   b. kW, Kva.
   c. Voltage on each phase.
   d. Amperes on each phase.
   e. Engine RPM.
   f. Frequency.

g. Engine water temperature.
h. Fuel pressure.
i. Oil pressure.
j. Outdoor temperature.
k. Average ambient temperature in the vicinity of the engine-generator.
l. Total harmonic distortion.

4. Demonstrate that the engine-generator will attain proper voltage, frequency, and will accept the factory tested block load within the specified time limit of one minute from a cold start after the closing of a single contact.
5. Using VA campus loads, load gensets to 110% of KW rating.

G. Starting System Test:
1. Demonstrate that the batteries and cranking motor are capable of five starting attempts of 10 seconds cranking each at 10-second intervals with the battery charger turned off.

H. Simulate conditions to verify proper operation of each indicating lamp, alarm device, meter, interconnecting hardware and software, and reset button.

I. Automatic Operation Tests:
Test the engine-generator to demonstrate automatic starting, loading and unloading. The load for this test shall utilize both load banks and actual loads to be served. Verify resetting of controls to normal. Test local and remote annunciation. Simulate engine failures to demonstrate proper operation of alarm annunciation. Test generator closure to dead bus and manual and automatic synchronizing.

J. Parallel Operation Test:
1. Test the capability of each engine-generator to parallel and stably share load with other engine-generators, individually and in all combinations. During operations, record load-sharing characteristics of each engine-generator in parallel operation. Record the following data:
a. Ambient temperature (at 15-minute intervals).
b. Generator output current (before and after load changes).
c. Generator output voltage (before and after load changes).
d. Power division and exchange between engine-generators.
e. Real power (watts) and reactive power (vars) on each engine-generator.

2. Connect each engine-generator, while operating at no load, in parallel with one other engine-generator in the system, operating at service load, until all possible two-unit-in-parallel combinations have been tested. Verify stabilization of voltage and frequency within specified bandwidths and proportional sharing of real and reactive loads. Document stabilization of voltage, frequency within specified bandwidth, the active power division, active power exchange, reactive power division, and voltage and frequency stability, and transient response in the following steps for each combination.
   a. Divide the load proportionally between the engine-generators and operate in parallel for 15 minutes.
   b. Increase the load in steps until each engine-generator is loaded to its service load.
   c. Decrease the load in steps until each engine-generator is loaded to approximately 25% of its service load.
   d. Increase the load in steps until each engine-generator is loaded to approximately 50% of its service load. Verify stabilization of voltage and frequency within specified bandwidths and proportional sharing of real and reactive load.
   e. Reduce the sum of the loads on all engine-generators to the output rating of one engine-generator.
   f. Transfer a load equal to the output rating of one engine-generator to and from each engine-generator. Verify stabilization of voltage and frequency within specified bandwidths and proportional sharing of real and reactive load.
3. Connect each engine-generator, while operating at no load, in parallel with all multiple combinations of all other engine-generators in the system, while operating at service load, until all multiple combinations of parallel operations have been achieved.

K. At the completion of the field tests, fill all engine fluids to levels as recommended by manufacturer.

L. When any defects are detected during the tests, correct all the deficiencies and repeat all or part of the 8-hour continuous test as requested by the COTR, at no additional cost to the Government.

M. Provide test and inspection results in writing to the COTR.

3.3 FOLLOW-UP VERIFICATION

Upon completion of acceptance checks, settings, and tests, the contractor shall demonstrate that the engine-generator(s) and control and annunciation components are in good operating condition and properly performing the intended function.

3.4 INSTRUCTIONS AND FINAL INSPECTIONS

A. Laminate or mount under acrylic resin a set of operating instructions for the system and install instructions within a frame mounted on the wall near the engine-generator at a location per the COTR.

B. Furnish the services of a competent, factory-trained technician for three 4-hour periods for instructions to VA personnel in operation and maintenance of the equipment, on the dates requested by the COTR.

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