SECTION 11500 - ENGINE - GENERATOR

City of San Diego, CWP Guidelines

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NTS: This Section is intended to be used for continuously running engine-generators in treatment plants, for dual fuel service with natural gas and digester gas. The Specifier must carefully edit the text, add any necessary items, and delete all non-applicable material shown in square brackets, to suit the specific application.

If the engine-generator is intended to operate in conjunction with a heat recovery system, the system must be individually engineered and the Specifier shall select and add all necessary accessories to provide a complete, functional system.

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PART 1 -- GENERAL

1.1 WORK OF THIS SECTION

A. The WORK of this Section includes providing [one] complete [sludge/natural gas,] [dual fuel] engine-generator unit mounted on a structural steel base on a vibration isolated concrete foundation block, with engine-mounted generator control panel, starting and control equipment, exhaust piping, intake air cleaner and piping, oil pumps, lubricating oil [and engine jacket water heater], and all other parts, instruments, and auxiliary equipment necessary to make a complete unit.

The engine-generator shall be a heavy-duty, industrial type, suitable for a 24-hours/day, 7 days/week, continuous operation under the conditions indicated, electric motor started, with engine-mounted radiator. The generator shall be a 4- or 6-pole, revolving field, brushless, synchronous type.

The engine shall be started and stopped in both manual and automatic modes by means of control signals from the engine-generator switchboard control section. The engine-generator set shall also automatically switch between the two fuel sources. The unit shall have a 2-hour overload rating of 110 percent of the continuous rating.

The engine-generator, piping, and all accessories shall be coated with the manufacturer's standard finish.

[B. The design and building layout was based on an engine-generator manufactured by [Waukesha] and therefore all pipe routing connections, trench location and positions of other engine accessories may not be identical to units from other manufacturers. If substituting equipment is submitted and approved by the CONSTRUCTION MANAGER, the CONTRACTOR shall be responsible for making modifications required to complete the installation without additional cost to the OWNER.]

C. The WORK also requires that one single manufacturer be made responsible for furnishing the WORK of this Section but without altering or modifying the CONTRACTOR'S responsibilities under the Contract Documents. The CONTRACTOR shall furnish a written, notarized certification signed by an officer of the manufacturing corporation, stating that the unloading, installation, testing, and inspection of the materials of all major equipment components and instrumentation meet or exceed the values indicated in these Specifications and in the referenced standards.

1.2 RELATED SECTIONS

A. The WORK of the following Sections applies to the WORK of this Section. Other Sections of the Specifications, not referenced below, shall also apply to the extent required for proper performance of this WORK.

1. Section 11000 Equipment General Provisions
2. Section 16400 Low Voltage Electrical Service and Distribution
3. Section 16485 Local Control Panels

1.3 SPECIFICATIONS AND STANDARDS

A. Except as otherwise indicated, the current editions of the following apply to the WORK of this Section:

1.	NEMA MG-1	National Electrical Manufacturers Associations Standards Publication No. MG-1
2.	API Standard 670	Noncontacting Vibration and Axial Position Monitoring System
3.	ASME PTC 17	American Society of Mechanical Engineers, Reciprocating Internal Combustion Engines Performance Test Codes
4.	NFPA 37	National Fire Protection Association Standard 37, Standard for the Installation and Use of Stationary Combustion Engines and Gas Turbines
5.	SAE J431	Society of Automotive Engineers; Automotive Gray Iron Casting
6.	SAE J435C	Society of Automotive Engineers; Automotive Steel
7.	SAE J438B	Society of Automotive Engineers; Tool and Die Steels

1.4 SHOP DRAWINGS AND SAMPLES

A. All of the material required for submittal under this Section shall be furnished in one complete package. The package shall be submitted in accordance with Section 01300. The CONTRACTOR shall submit the proposed factory testing program to the CONSTRUCTION MANAGER for review and comment at least 60 days before testing is scheduled to begin.

In addition to the items required in Section 11000, submittal data shall be required as follows:

1. General:

    a. An affidavit attesting to the identity of the supplier having unit responsibility, as indicated above.

    b. Outline installation drawings (plans and sections) for complete engine-generator set showing the location, size and other pertinent details of each piping, electrical and monitoring connection.

    c. Details of plans for shipment of the equipment to the project site.

    d. Weight of complete unit.

    e. Weight of heaviest part.

    f. Foundation plan with anchor bolt details and dimensions.

    g. Torsional analysis

    h. Exhaust emission analysis for the engine-generator set to satisfy air pollution control requirements.

    i. Vibration isolators for accessories.

    j. All flexible connectors.

    k. Piping, cooling air and exhaust connections.

    l. Exhaust silencer.

    m. Electrical starting system, including batteries and battery rack.

    n. Fuel gas system, including controls and automatic switch-over.

    o. Legends for all devices on all diagrams.

    p. A certified performance rating for each fuel used from the engine manufacturer with the generator set equipped with all auxiliary equipment as needed and when installed at the altitude of [ ] feet.

    q. Information on at least one successfully performing engine-generator unit of comparable size and complexity constructed in the recent past with names, telephone numbers, and addresses of owners.

2. Engine:

    a. Torque, brake horsepower and fuel consumption curves for the indicated conditions and various loads.
    b. Engine weight.
    c. Complete fuel piping schematics showing the relative position of all valving and appurtenances.

    d. Details of governing system.
    e. Catalog data.
    f. Ventilation and combustion air CFM requirements.

3. Generator:

    a. Weight.
    b. Stator and field ratings including temperature rise at full and overload conditions.
    c. Complete description of insulation system.
    d. Complete wiring diagrams for the generator, engine control system, voltage regulation and excitation systems, showing wiring and terminal identification systems.
    e. Generator impedances: Xd, Xq, Xd', Xd'', X2, Xo, Xp, ra, r1, r2
    f. Catalog data.

4. Control Panel and Automatic Controls:

    a. Panel enclosure layout drawings.

    b. Complete step-by-step functional description of the operation of each control circuit.

    c. Complete elementary, connection and circuit diagrams, including interconnection wiring diagrams for all equipment, and automatic system logic diagram.

    d. Conduit stubout locations.

1.5 OWNER'S MANUAL

A. The following shall be included in the OWNER'S MANUAL in compliance with Section 01300:

1. Operation and maintenance information as indicated for each separate subassembly and separately furnished item of equipment provided under this Section. Additionally, the following items--startup, operating, and preventive maintenance procedures and overhaul instructions--shall be specific to the entire engine generator furnished under this Section.

2. Copies of all factory engine tests, in quintuplicate, certified by an officer of the manufacturing corporation.

3. Copies of all generator test documentation, in quintuplicate, certified as above.

4. Point-to-point wiring diagrams for all controls.

5. Details of the engine starting system, including electrical schematics.

1.6 REGULATORY REQUIREMENTS

A. The engine shall be specifically designed to minimize the discharge of gaseous pollutants to the atmosphere and meet all of the County of San Diego, Air Pollution Control District (APCD) standards. The manufacturer shall furnish a certificate attesting to the fact that the unit furnished will be in compliance with requirements of the APCD. Fuel control system shall be specifically designed to operate on digester or natural gas.

B. Specific pollutant limitations, applicable at all loads, shall be as follows:

Pollutant	Maximum Emission Rate, pounds per hour
Oxides of nitrogen	[ ]
Carbon monoxide	[ ]
Non-methane hydrocarbons	[ ]

1.7 SERVICES OF MANUFACTURER

A. **Inspection, Startup, and Field Adjustments**: An authorized service representative of the manufacturer shall visit the site for not less than [4] days provided in three site visits and witness the following:

1. Unloading and placement.
2. Installation.
3. Inspection, checking and adjusting.
4. Startup and field testing for proper operation.

B. **Instruction of OWNER's Personnel**: The authorized service representative shall also instruct the OWNER's personnel in the operation and maintenance of the system including step-by-step troubleshooting procedures with necessary test equipment for not less than [4] days, provided in two site visits.

[C. The manufacturer shall submit a written training program to the CONSTRUCTION MANAGER for approval. Training shall include 8 hours of classroom time instruction and 4 hours of equipment-demonstration time. Training shall not commence until 30 days after written approval by the CONSTRUCTION MANAGER. All trainees, minimum 5, shall receive a training manual specific to their trade, as follows:

1. Mechanics
2. Electricians
3. Instrument Machinery
4. Operators

The training manuals will be retained by the trainees and not returned to the manufacturers.]

1.8 FACTORY TESTING

A. The CONTRACTOR shall be responsible for all costs associated with inspection and testing of materials, products, or equipment at the place of manufacture. This shall include costs for travel, meals, lodging, and car rental for [two] OWNER-designated inspectors for [ ] days required to complete such inspections or observations exclusive of travel days, if the place of manufacture, fabrication and factory testing is more than fifty (50) miles outside the geographical limit of the City. The CONTRACTOR shall not be responsible for salary or salary-related costs of the inspectors. The CONTRACTOR shall comply with the requirements of Section 01400.

B. Prior to delivery to the job site, the products shall be tested at the factory and witnessed by the CONSTRUCTION MANAGER'S representative. The test shall verify that products are free of any defects, and verify guaranteed performance.

C. The engine-generator set shall be subject to both static and operating tests as described below:

1. Static Testing. The entire unit, including control panels and accessories, shall be set up and tested, using static methods to ensure that all safety devices and control circuits are properly installed, aligned, and connected. All trim piping shall be pressure tested, and all regulators and solenoid valves shall be tested for proper function.

2. Operating Tests. The complete unit shall be set up in a test cell and operated to determine its characteristics under various loads. The engine tests shall be conducted in accordance with applicable portions in ASME RTC 17. The generator tests shall be conducted in accordance with applicable portions of the test procedure in NEMA MGI, through the use of dry type load banks.

The engine-generator test shall include both full load and overload operating test of at least 8 hours with not less than 4 hours at full load, followed by 2 hours overload and 2 hours at full load from zero load.

Records, in addition to the information required by ASME TPC 17 and NEMA MGI, shall be as follows: Average starting time for not less than 19 cold starts. Records shall include test cell temperatures and number of cranking cycles before successful start.

1.9 SHIPMENT

A. The equipment to be furnished under this Section shall be shipped to the site with weathertight covers on all piping and electrical connections. All shaft housing penetrations shall be sealed in a manner which shall protect against damage from the elements and deterioration of the equipment due to moisture, corrosive gases, dirt and debris. Additionally, each individual shipment shall be packaged in a manner designed to protect the equipment against damage caused by sudden acceleration or deceleration.

1.10 QUALIFICATIONS

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NTS: In the paragraph below, define the terms "comparable size and complexity" for the equipment or system specified. Requiring experience of more than one successful project requires sound justification and prior written approval from the City Project Manager.

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A. **Manufacturer**: Manufacturer specializing in engine-generators with a minimum of one successfully performing installation of comparable size and complexity constructed in the recent past. Equipment of comparable size and complexity shall have the following characteristics: [ ].

1.11 SPECIAL WARRANTY

A. The WORK of this Section shall be guaranteed for [2] years from the date of final acceptance of the project.

PART 2 -- PRODUCTS

2.1 ENGINE, IDENTIFICATION NUMBER: [ ]

A. **General**: The engine shall be sludge/natural gas drive, where the heat value will be approximately [550 BTU/cubic foot for sludge gas] and [1000 BTU/cubic foot for natural gas. The engine shall have a continuous power rating, at [ ] rpm and with all necessary equipment connected to drive the generator at a continuous load, of not less than [ ] kw after [deduction of radiator fan loss, and] correction for altitude of elevation [ ] feet using sludge gas or natural gas as fuel. The engine shall be a reciprocating, [4-cycle] [turbo charged and intercooled] lean burn model, with minimum displacement of [ ] cubic inches. [The engine-generator shall be suitable for operation in a Class 1, Division 2 area.]

B. **Engine Base**: The engine base shall be of rigid construction with heavy transverse girders formed to support the crankshaft main bearings. The engine frame shall be suitable box shape to provide longitudinal and transverse rigidity . The design shall be of a totally enclosed, dustproof, oiltight type with large oil tight doors fitted on all sides of the frame or a removable automotive type pan to provide complete access to the bearings and running gear.

C. **Crankshaft**: The crankshaft shall be made from a single heat treated forged steel block or of a two-piece design and shall be sized to provide a liberal margin of safety against abnormal strains. Journals shall be hardened and micropolished. The shaft shall be statically and dynamically balanced after fabrication. If of two-piece design the crankshaft shall be machined and balanced as a single unit.

D. **Cylinders**: Cylinders may be cast individually or in one block. If in one block, removable jacket liners shall be provided, fitted with integral water jackets with suitable connections to inlet and outlet to eliminate the presence of water in the cylinder block. All cylinder liners shall be finished to give a straight bore, shall be carefully machined and honed, and shall be chrome-plated, or equivalent, on the water side to reduce cavitation damage.

E. **Pistons**: Pistons shall be of the oil-cooled trunk type, made of close-grained cast iron or aluminum alloy, accurately machined to size. The piston shall be long in proportion to the diameter and shall be provided with a sufficient number of piston rings to ensure maximum compression and to minimize oil consumption.

F. **Valves**: Inlet and exhaust valves shall be precision machined and shall be made of top grade heat-resisting material. Valve seats shall be replaceable, made of heat-resistant high alloy steel. Valves shall be of large diameter to produce the greatest volumetric efficiency and adequate scavenging of the cylinders in order to keep valve maintenance to a minimum. All valve mechanisms shall be constructed so as to provide positive action with utmost rigidity. Renewable hardened steel inserts shall be provided for all valve stem guides. Valve seats shall be replaceable and made of a hardened steel selected specifically for high temperature service.

G. **Exhaust Manifolds**: Exhaust manifolds shall be fully insulated and, if in pairs, shall be joined to provide a single exhaust outlet for the engine.

[H. **Turbocharger**: The engine combustion air shall be pressurized using an exhaust gas driven centrifugal compressor, supplied from a dry-panel type intake air filter with service indicator.]

I. **Materials**: The engine shall be constructed of the following materials:

Component	Material
Base and frame	Cast iron, SAE G3500 or G4500, welded steel, SAE 950C, 945C
Crankshaft	Forged steel, SAE 1046, 4140, or 4340
Connecting rods	Heat treated steel, SAE 4340 or 9840
Flywheel Cast iron	
Cylinders and cylinder heads	Cast iron, SAE G3000, G3500, or heads G4500 for cylinder heads
Pistons	Cast aluminum, SAE 34, 39, 309, 314, 321, or 328
Exhaust manifold	Cast iron, SAE G3000 to G3500 or G4500

2.2 STARTING SYSTEM

A. **General**: The starting system shall be of the electric, automatic starting type, complete with solenoid shift starter, batteries, battery rack, battery cover, cables, and constant voltage charger, capable of at least three 15-second starting attempts in a 30 degree F ambient temperature, without being recharged. Dry contacts shall be provided for remote indication of starting attempts.

B. **Batteries**: Starting batteries shall be the antimony flat plate type designed for heavy-duty natural sludge gas engine starting with molded plastic containers of block design. The 14-cell battery shall be assembled in three units of four cells each plus one 2 cell unit for the required 24 volt nominal system at 1.75 volts per cell. The batteries shall be mounted on the engine-generator skid. The battery shall have an 8-hour nominal capacity of approximately [330] ampere hours, and the 90-second discharge rating shall be [1200] amperes to an end voltage of 1.00 volts per cell at 77 degrees F. Batteries shall be furnished complete with interunit connectors and battery charger.

C. **Battery Rack**: A two-step battery rack shall be provided by the battery manufacturer. The rack shall be constructed to suit the batteries furnished. Rack rails shall be insulated with plastic. Batteries shall be arranged so that all electrolyte levels are easily visible.

D. **Battery Charger**:

1. The battery charger shall be constant potential two-rate type with an output regulation of plus or minus 1 percent from zero to full rated capacity with a maximum input voltage variation of plus or minus 10 percent. The charger shall be capable of operating at the rated output current continuously for an ambient temperature of 40 degrees C. The charger shall be 24 volt DC, [10] amperes maximum output as indicated.

2. The charger shall be equipped with AC input and DC output protection, AC indicating lamp, DC ammeter and voltmeter, each having an accuracy of 2 percent and a minimum scale length of 2-3/8 inches. The charger shall have continuous float voltage adjustment from nominal battery voltage to 20 percent above, automatic surge suppressors, equalizing voltage control with 24-hour timer and automatic current limiting from 40 percent to 110 percent of rated output. Input shall be 120 volts, single phase AC, 60 Hz.

3. The battery charger shall have a low voltage DC alarm relay (adjustable between 0 to 24 volts) and a loss of AC input alarm relay. Contacts from both relays shall be wired to terminals for a remote battery charger failure alarm.

4. The charger shall be convection cooled and provided with a rack for wall mounting. There shall be at least 1/2-inch space between the wall and the charger for free air movement.

2.3 COOLING SYSTEM

A. **General**: A complete, engine-mounted radiator cooling system including radiator, motor-driven fan and circulating pump, bypass thermostats, interconnecting piping and appurtenances shall be provided for the engine. The system shall be designed to utilize a water and glycol solution with a freezing point below minus 15 degrees F. The radiator shall be designed for a maximum bottom tank temperature of 175 degrees F.

B. **Radiator**: The radiator shall be the high capacity copper splitcore, fin and tube type, adequately sized for 110 percent of full load at an ambient temperature of 110 degrees F, to properly cool water from the engine jackets, [aftercooler,] and lube oil cooler under the operating conditions indicated.

C. **Fans**: Fans shall be of the multibladed belt-driven or direct-drive type. Fan blades shall be of adjustable pitch, airfoil design, selected for high efficiency and quiet operation. Fan tip speeds shall be held as low as practicable to reduce fan noise to a minimum.

D. **Pump Belts**: Water circulation pump belts, if any, shall be T wedge type with QD sheaves, rated at 150 percent of running horsepower.

2.4 EXHAUST SYSTEM

A. **Pipe and Coupling**: The engine exhaust coupling shall be stainless steel heavy duty, convoluted pressure hose-type. The flexible coupling shall have an overall length of not less than 16 inches and 150 lb ANSI steel flanges, and it shall be designed for [1250 degrees F] service. All bolts, nuts, and clamps necessary for the installation of the flexible coupling and exhaust piping shall be provided. All parts of the exhaust system, except flanges, shall be of Type 316 stainless steel. Exhaust piping inside of buildings shall be Schedule 20 stainless steel, insulated with [4 inches] of high temperature calcium silicate insulation in 2 layers, staggered, suitable for [1250 degrees F], applied over 3/4-inch corrugated metal, and finished with aluminum lagging secured by metal bands. Ends of insulation shall be neatly finished with [1/2-inch] plate aluminum flanges. The pipe shall be supported by [steel saddles welded to the pipe and extending through the insulation.] [spring hangers.]

B. **Silencer**: The exhaust system shall be equipped with a Type 316 stainless steel hospital type flanged silencer to meet local agency requirements, without exceeding the manufacturer's back-pressure limitations.

The unit shall employ ported tubes in a single or multichamber, nonreactive design selected to achieve the degree of silencing indicated, with inspection ports and drain fittings in each chamber.

[2.5 ENGINE JACKET WATER HEATER

A. A heater shall be installed on each engine, complete with thermostat control in the engine cooling water system to maintain a jacket water temperature of [100 degrees F] at all times, while the engine is not in operation. The heater shall be an electric immersion heater with waterproof enclosure, suitable for 230-volt, single-phase power supply.]

2.6 LUBRICATION SYSTEM

A. **General**: The engine shall be of the wet sump type, provided with a full pressure lubricating oil system arranged to distribute oil to all moving parts of the engine. The lubricating oil pump shall be of the positive displacement type and shall be gear-driven from the engine crankshaft or camshaft. The pump shall have ample capacity to circulate the amount of lubricating and cooling oil required by the engine at all operating speeds.

B. **Oil Filter**: A full flow filter shall be provided. A built-in pressure relief bypass complete with pressure actuated valve and capable of conveying the maximum rate of oil flow shall be provided around each oil filter.

C. **Oil Cooler**: The engine shall be equipped with a lubricating oil cooler, sized to cool the oil as recommended by the manufacturer. Aftercooler water shall be circulated through the water side of the oil cooler.

2.7 GOVERNOR

A. The governor shall be of the hydraulic type, with provision at the engine for manual adjustment of speed, speed droop and load limit.

2.8 ENGINE-MOUNTED PANEL

A. **Gauges**: A vibration-isolated engine panel, NEMA rated in accordance with the area designations of Section 16050, with the following gauges and meters shall be mounted on the engine, with the face of the panel being illuminated.

1. Jacket water temperature gauge
2. Oil temperature gauge
3. Lubricating oil pressure gauge
4. Intake manifold temperature gauges
5. Digital tachometer
6. Operating hour meter
7. Exhaust temperature gauge

B. **Remote Signals**: Remote alarm controls and engine protection shall be provided for the following alarms:

1. Overcrank
2. Low oil pressure
3. Overspeed
4. High water temperature
5. Low water level
6. High winding temperature (generator)
7. High bearing temperature (generator and engine)
8. Excessive vibration (generator and engine)
9. Low oil level
10. High oil level

[11. Excessive fan vibration]

C. **Switches**: The engine shall be provided with the following devices, factory installed and adjusted. Each device shall be suitable for use with the engine's 24 volt DC control power and shall be complete with all necessary conduit and wiring. Leads shall be brought to a common engine-mounted control terminal panel located on the subbase. Protective devices shall include the following:

1. An overspeed switch shall be separate from the governor and shall open at 10 percent above synchronous speed to actuate an alarm contact.

2. A low oil pressure switch which opens when the pressure in the lube oil system is below the permissible operating pressure.

3. A temperature switch, mounted in the lubricating oil system, designed to open when the oil temperature downstream from the oil cooler reaches unacceptable levels.

4. Cooling water float switches located in the radiator. The float switches shall cause the engine-generator to shut down and alarm if the coolant level in the radiator drops below acceptable limits.

D. **Design**: All devices shall be specifically designed for engine service of a type suitable for reliable operation in the presence of continuous vibration. All wiring, conduit, and appurtenances shall be as indicated under Division 16. Conduits shall be routed to provide maximum access to all maintenance points, devices and appurtenances.

E. **Instrument Taps**: The engine shall be provided with suitable taps or connections available for the measurement of the following:

1. Lubricating oil inlet pressure
2. Engine speed
3. Jacket water inlet temperature
4. Aftercooler water inlet temperature

F. **Operation**: The engine control shall be automatically locked out upon safety shutdown. Manual controls shall be provided on the front of the panel to permit manual startup and shutdown of the engine. The safety shutdown of the engine shall initiate an alarm signal for remote annunciation.

The following devices shall be provided on the face of the panel:

1. MANUAL-OFF-REMOTE selector switch
2. EMERGENCY STOP red pushbutton with guard
3. ALARM ACKNOWLEDGE/CANCEL pushbuttons
4. LOCKOUT RESET pushbutton

2.9 FUEL SYSTEM

A. The engine shall have a dual gas carburetor or fuel control valves, gas regulators, prechamber fuel system and control logic. The fuel system shall be provided with automatic change-over valves complete with pressure switches, gas solenoid valves and controls. [In addition, the engine shall be capable of accepting a minimum of [30 psi] of sludge gas or natural gas supply at rated load.]

2.10 FLEXIBLE METAL HOSE

A. Flexible metal hose connectors for jacket water, [aftercooler water,] lube oil, fuel and exhaust piping shall be provided. Water, oil and fuel connectors shall be single braided, Type 316 stainless steel, 150 psig working pressure. Fuel connectors shall bear the Underwriters' Laboratories label. The exhaust connector shall be as indicated above. All connectors shall be selected for a design of not less than 10,000,000 full displacement cycles. Flexible connectors shall be not less than 12 inches long and installed with no visible deflection.

2.11 GENERATOR

A. **General**: The generator shall be of the heavy-duty industrial type, rated [ ] kw continuous when burning [ ], 0.8 PF lagging, 3-phase, 4-wire, 227/480 volt, 105 degrees C rise, 60-Hertz, [ ] rpm, Class F insulation with field windings braced for solid grounding. Each generator shall be suitable for operation at an ambient temperature of [40 degrees C], and [ ] feet elevation. The CONTRACTOR shall provide a larger engine-generator if required to start and run the load indicated. [Some loads are variable frequency drives, which generate some undesirable harmonics.] The generator shall accept a single block application of full rated load with voltage and frequency recovery to normal value within two seconds. The voltage dip shall not exceed 25 percent nor shall the speed regulation exceed 2 percent following block load application. In addition, when the starting load (motor) is applied, the voltage dip shall not exceed 25 percent at any point of the motor starting sequence. The generator excitation system shall consist of a three-phase alternating current exciter, the output of which is directly connected to the main generator field through silicon rectifiers, and shall not have commutator or brushes incorporated in the generator design. The generator shall be a single-bearing machine conforming to applicable NEMA standards and shall have a rigid drip-proof frame with covers to provide easy access to the interior. The generator shall be supplied with a solid state voltage regulator or equal mounted on the machine which will hold the voltage to the set value with not over 2 percent variation from no-load to full-load.

B. **Materials**:

Component	Material
Stators	
Frame	Bar and ring steel
Laminations	Electrical grade sheet steel
Windings	Copper
Rotors	
Laminations	Electrical grade sheet steel
Windings	Copper

2.12 GENERATOR AND POWER SYSTEM PANELS

A. **General**: The CONTRACTOR shall provide a generator control panel, with NEMA rating in accordance with the area designations of Section 16050. The panel shall be an all-steel enclosure in accordance with Section 16485 and [generator] mounted. The panel shall be provided with a hinged door, gasketed and equipped with a lockable handle.

B. **Generator Controls**: The generator controls shall be provided on the generator control panel as indicated.

C. **Power System Panel**: The power system panel shall be provided as indicated. The panel shall be in accordance with Section 16485.

2.13 NAMEPLATES, TOOLS AND SPARE PARTS

A. **Spare Parts**: The WORK includes the following spare parts for each engine-generator unit:

Quantity	Description
[84]	Lube Oil Filter Element Double Length
[6]	Lube Oil Filter Cover O-Ring
[1]	Water Pump Belt Set
[1]	Aux. Water Pump Belt Set
[5]	Thermostat 170E F
[1]	Thermostat 165E F
[6]	Thermostat Seal
[12]	Air Cleaner Element
[96]	Spark Plug
[12]	Rocker Arm Cover Gasket
[2]	Oil Pan Door Gasket
[1]	Thermostat Housing Gasket
[2]	Thermostat Housing Gasket
[4]	Oil Strainer Seal
[4]	Oil Strainer Seal
[2]	Magneto Drive Disc
[12]	Admission Valve Gasket
[24]	O-Ring Admission Valve
[12]	Prechamber Seal
[24]	Spark Plug Carrier O-Ring
[3]	Water Manifold Gasket
[24]	Pre-Filter Air Panel
[1]	Each size and type of relay
[2]	Each size and type of lamp in the control panels
[1]	Throttle actuator, complete
[2]	Complete replacements, engine oil filters
[2]	Complete replacements, air inlet filters
[2]	Engine cover gasket sets
[1]	Complete set timing tools
[1]	Complete set special maintenance tools

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NTS: The above list of spare parts represents the quantity and type of parts required for an 8000 hour period of operation, for a 12 cylinder, Waukesha "lean burn" engine. Due to the variety in type and size of engines and accessories, the Specifier must contact the manufacturer in each case to obtain a meaningful list for each specific unit.

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Spare parts shall be crated, packaged, and stored in metal tool boxes, and identified with the equipment number by means of stainless steel or solid plastic name tags attached to the boxes.

2.14 MANUFACTURERS

A. The equipment shall be manufactured by one of the following (or equal):

1. Engine generator

Waukesha Engine Division; Dresser Industrial, Inc.
Cooper-Superior

[2. Engine jacket water heater

Kim Hotstart Manufacturers Company
Emerson Electric Company]

3. Batteries

Exide Corporation, Model [4LMS-325]

PART 3 -- EXECUTION

3.1 INSTALLATION

A. The engine-generator equipment shall be shipped, unloaded, installed and aligned in accordance with the procedure submitted with the shop drawings and per manufacturer's written recommendation.

3.2 FIELD TESTING

A. The equipment furnished under this Section shall be subject to the following tests, including a final acceptance test to assure compliance with all operation requirements indicated.

The field test shall be conducted by the CONTRACTOR in the presence of the CONSTRUCTION MANAGER. All costs of testing, except fuel, shall be borne by the CONTRACTOR. The test procedure shall be developed by the CONTRACTOR and shall, as a minimum, contain the following features:

1. Static tests of all control and protective circuits.

2. Not less than five cold starts.

3. Not less than 4 hours of transient response tests using loads applied by portable load bank.

4. Not less than 8 hours of continuous operation of which 2 hours shall be at full load, followed by 2 hours at overload, followed by 2 hours at full load.

The CONTRACTOR shall furnish a portable load bank to provide sufficient load to complete the required testing.

** END OF SECTION **