SECTION 26 32 13
ENGINE GENERATORS

PART 1 – GENERAL

1.1 DESCRIPTION

A. This section specifies the furnishing, complete installation, connection and testing of the of the low-voltage 1750 KW/2188 kVA for 277/480 volt three phase, 4 wire, 60 HZ, 1800 RPM engine generator system. This includes: air filtration, starting system, generator controls, paralleling switchgear, instrumentation, lubrication, fuel system, cooling system and exhaust system.

B. Generator control panel shall include necessary interface for paralleling and controls at the generator low voltage paralleling switchgear location at electrical room.

C. The engine generator system shall meet the requirement of NFPA 70 and 110.

D. The engine generator system shall be fully automatic and shall constitute a unified and coordinated system ready for operation.

E. The engine generator system shall include, but not be limited to the following:
   1. Diesel Engine.
   2. Lubrication Oil System.
   3. Fuel Oil System.
   4. Cooling System.
   5. Intake and Exhaust Air Systems.
   6. Starting System.
   7. Generator.
   8. Controls, Supervision and Distribution.
   11. Spare Parts.

   This section includes equipment and services necessary for the design, manufacture, factory testing, installation, and site testing of a complete and operable on-site emergency generator unit including radiator, exhaust silencer, double-contained fuel piping, sub-base fuel tank, leak-detection system, control panel, battery and charger enclosed in an outdoor weatherproof, sound attenuated and rodent resistant enclosure.

1.2 RELATED WORK

A. Section 03 30 00, CAST-IN-PLACE CONCRETE: Requirements for concrete equipment pads.

B. Section 13 05 41, SEISMIC RESTRAINT REQUIREMENTS FOR NON- STRUCTURAL COMPONENTS: Requirement for seismic restraint for nonstructural components.

C. Section 26 05 11, REQUIREMENTS FOR ELECTRICAL INSTALLATIONS: Requirements that apply to all sections of Division 26.

D. Section 26 05 19, LOW-VOLTAGE ELECTRICAL POWER CONDUCTORS AND CABLES: 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 23 05 41, NOISE AND VIBRATION CONTROL FOR HVAC PIPING AND EQUIPMENT: Requirements for pipe and equipment support and noise control.

G. Section 23 10 00, FACILITY FUEL SYSTEM

H. Section 26 05 73, OVERCURRENT PROTECTIVE DEVICE COORDINATION STUDY: Short circuit and coordination study, and requirements for a coordinated electrical system.

I. Section 23 07 11, HVAC, PLUMBING, AND BOILER PLANT INSULATION: Requirements for hot piping and equipment insulation.

J. Section 25 10 10, ADVANCED UTILITY METERING: Requirements for electrical metering.

K. Section 26 23 15, GENERATOR LOW-VOLTAGE PARALLELING SWICHGEAR.

L. Section 26 36 23, AUTOMATIC TRANSFER SWITCHES: Requirements for automatic transfer switches for use with engine generators.

1.3 QUALITY ASSURANCE

A. The supplier of the diesel-engine generator set 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 in regards to coordinating, engineering, testing and supervising. Each of these installations shall have been in successful operation for three or more years. Prior to review of submittals, the Department of Veterans Affairs reserves the right to:
   1. Have the manufacturer submit a list of locations of similar installations.
   2. Inspect any of these installations and operations of engine-generator set, and question the user concerning the installations without the presence of the supplier.

B. Factory authorized representative shall be capable of providing emergency maintenance and repairs at the project site within 24 hours maximum of notification.

C. Engine generator and auxiliary components shall be supplied from a single manufacturer.

D. Noise level developed by the generator set shall be as herein specified.

E. Factory Test: The Government shall have the option of witnessing the following tests at the factory. The Government will pay all expenses for the Government representative's trip to witness these tests. Contractor shall notify the COTR 15 days prior to date of testing. Manufacturer shall furnish load banks, testing instruments and all other equipment as necessary to perform these tests.
   1. Load Test: Shall include six hours of continuous operation; two hours while the set is delivering 100 percent of the specified KW and ten hours while delivering 85 percent 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 set to develop specified voltage, frequency and KW load from a standstill condition.

3. The manufacturer shall furnish fuel, load banks, testing instruments, and all other equipment necessary to perform these tests.

1.4 SUBMITTALS

A. Submit in accordance with Section 26 05 11, REQUIREMENTS FOR ELECTRICAL INSTALLATIONS.
B. Shop Drawings:
   1. Sufficient information, clearly presented, shall be included to determine compliance with drawings and specifications.
   2. Data shall be submitted in the following form:
      a. Technical data sheets (TDS): These include published performance, rating and derating curves, published ratings, catalog cuts, pictures, manufacturer's specifications, material composition, and gauge thickness.
      b. Description of operation (DO): Manufacturer's literatures and, if suitable, diagrams.
      c. Calculations (CALC): Detailed engineering calculations with all equations, graphs, assumptions, and approximations shown, and data sources referenced.
      d. Certification (CERT): Written confirmation as to the document's accuracy, and genuineness.
      e. Shop Drawings (SD): Scaled drawings showing plan views, side views, elevations and cross sections.
      f. Diagrams (DGM): These include control system diagrams, elementary diagrams, control sequence diagrams or table, wiring diagrams, interconnections diagrams (between local control cubicles, remote annunciator panels, remote derangement panels, remote monitoring panels, remote exercising panel and underground fuel storage tanks), wireless connection diagrams, illustrative diagrams, flow diagrams, and other like items.
   3. Prior to fabrication, submit for approval the following data for each engine-generator set, transfer device and control and supervisory equipment:
      a. Engine generator set: TDS, SD including subtransient reactance and short-circuit current capacity.
      b. Engine jacket water heaters: TDS
      c. Muffler assembly: TDS, SD
      d. Motor-operated damper assembly: TDS
      e. Day tank and pumps or integral sub-base fuel tank: TDS, CALC
      f. Batteries, racks and charger: TDS, CALC

g. Torsional Vibration: CERT
h. Control and Supervisory Equipment: TDS, DGM, DO, SD
i. Performance:
   1) Voltage regulating equipment: TDS
   2) Frequency regulating equipment: TDS
   3) Voltage and frequency dips and recovery times due to specified motor loading: CALC
   4) Antifreeze derating: TDS
   5) Ambient derating: TDS
k. Fuel oil system: DGM
m. Vibration isolators: TDS, CALC
o. 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.

C. Manuals:
1. Submit, simultaneously with the shop drawings, companion copies of complete maintenance and operating manuals of the engine generator set and auxiliaries including technical data sheets, wiring diagrams, and information, such as telephone number, fax number, and web sites, for ordering replacement parts.
2. Two weeks prior to the final inspection, submit four copies of the updated maintenance and operating manual to the Resident Engineer:
   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 items 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. Complete lists of spare parts and special tools recommended for two years of normal operation of the complete system.

D. Certifications:
1. Prior to fabrication of the engine-generator set, submit the following for approval, to the Resident Engineer:
   a. A certification in writing that a diesel engine of the same model and configuration, with the same bore, stroke, number of cylinders, and equal or higher BMEP and RPM ratings as the proposed diesel engine has been operating satisfactorily, with connected loads of not less than 75 percent of the specified KW/KVA rating, for not less 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 auxiliary electrical power system during operation of the diesel engine-generator set at speeds other than the rated RPM while performing maintenance. Include thorough descriptions with submittal of any precautions, which will be necessary to protect the voltage regulator and other components of the system during operation of the diesel engine-generator set at speeds other than the rated RPM.

2. Prior to installation of the engine-generator set at the job site, submit four copies of the following to the COTR:
   a. Certified test data, alternator temperature rise test and strip chart recordings, and photographs showing test setup and equipment.
3. Two weeks prior to the final inspection, submit four copies of the following, to the COTR:
   a. Certified test report by the manufacturer of the engine-generator set that the auxiliary electrical power system conforms to the requirements of the drawings and specifications.
   b. Certified report of field tests from the contractor that the engine-generator set and major auxiliaries have been properly installed, adjusted and tested.

   c. A certificate by the manufacturer that the engine-generator set, accessories, and components will withstand the seismic forces (Z=4) and that the set will be fully operational after the seismic event at the project site.

E. Submittals shall also include:

A. Shop Drawings:

1. Electrical characteristics and connection requirements.
2. Plan and elevation views of unit including overall dimensions.
3. Electrical and Fuel Oil piping interconnection point with dimensions.
4. Fuel consumption rate curves at various loads.
5. Ventilation and combustion air requirements.
6. Electrical schematic and interconnection diagrams.
7. Sub-base fuel tank details and dimensions.
8. Overall unit dimensions and seismic anchoring points with dimensions.

9. Enclosure sound rating.
10. Emissions report.

B. Product Data:

1. Submit data showing dimensions, weights, ratings, interconnection points, and internal wiring diagrams for engine-, generator, control panel, battery, battery rack, battery charger, exhaust silencer, vibration isolators, sub-base fuel tank, and radiator.
2. Submit two (2) sets of product data, certification, test reports and other necessary information, for engine-generator unit and sub-base fuel tank, to the local Fire Marshall for approval and permit. Contractor shall be responsible for obtaining fire marshal approval for the sub-base fuel tank assembly.
3. Submit calculations and enclosure pad-mount anchoring method (anchor bolt size, embedment and assembly details) to meet California seismic Zone 4 requirements.

C. Certification and Test Reports:

1. Provide Certification for the Protected Sub-Base fuel tank.
2. Provide results of manufacturer’s certification of performance testing. Certification and Test Reports (Includes inspections, findings, and recommendations).
3. Certification that the Engine-Generator unit is designed to meet emission limits and operate correctly for the application.

1.5 STORAGE AND HANDLING

A. Equipment shall withstand the mechanical stresses caused by rough handling during shipment 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 COR.

1.6 JOB CONDITIONS

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

B. Unless specified otherwise, each component of the engine-generator system shall be capable of operating as specified herein at 334 meters (1000 feet) above sea level in a ventilated room which will have average ambient air temperatures ranging from a minimum of 4degrees C (40 degrees F) in winter to maximum of 49 degrees C (120 degrees F) in summer.

1.7 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):

C37.50-07 .....Low-Voltage AC Power Circuit Breakers Used In Enclosures-Test Procedures

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

American Society of Testing Materials (ASTM):

A53/A53M-10.....Standard Specification for Pipe, Steel, Black, and Hot–Dipped, Zinc Coated Welded and Seamless

B88-09 .....Specification for Seamless Copper Water Tube

B88M-11 .....Specification for Seamless Copper water Tube (Metric)

D975-11b .....Diesel Fuel Oils

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

C37.13-08 .....Low Voltage AC Power Circuit Breakers Used In Enclosures

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

D. International Code Council (ICC):

IBC-12.....International Building Code

E. National Electrical Manufacturers Association

(NEMA): ICS 6-06.....Enclosures
ICS 4-10.....Application Guideline for Terminal Blocks

MG 1-11.....Motor and Generators

MG 2-07.....Safety Standard and Guide for Selection, Installation and Use of Electric Motors and Generators

PB 2-11.....Dead-Front Distribution Switchboards

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

F. National Fire Protection Association (NFPA):

30-12.....Flammable and Combustible Liquids Code

37-10.....Installations and Use of Stationary Combustion Engine and Gas Turbines

70-11.....National Electrical Code (NEC)

99-12.....Health Care Facilities

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

G. Underwriters Laboratories, Inc. (UL):

50-07.....Enclosures for Electrical Equipment

142-06.....Steel Aboveground Tanks for Flammable and Combustible Liquids

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

1236-06.....Battery Chargers for Charging Engine-Starter Batteries

2085-97.....Insulated Aboveground Tanks for Flammable and Combustible Liquids

2200-98.....Stationary Engine Generator Assemblies

PART 2 - PRODUCTS

2.1 DIESEL ENGINE-GENERATOR SET

A. The engine generator system shall be in accordance with NFPA, UL, NEMA and ANSI, and as specified.

B. Provide a factory-assembled, wired, (except for the field connections), complete, fully automatic diesel engine-generator system, as well as all associate equipment and devices intended for the operating, control, monitoring, and remote manual stop functions.

1. For installations with engine driven radiator fan: Per Manufacturer recommendation.

C. Engine Generator Parameter Schedule:

1. Power Rating: Mission Critical output available with varying load for the duration of the interruption of the normal source power. Average power output is 85% of the mission critical power rating. Typical peak demand up to 100% of mission critical rated ekW for 5% of the operating time. Typical operation is 200 hours per year, with maximum expected usage of 500 hours per year.
2. Voltage: 277/480V
3. Rated Power: 1750 ekW/2188kVA mission critical rating and 1478 CKW continuous power average.
4. Power Factor: 0.8lagging
5. Engine Generator Application: parallel with other generators on an isolated bus.
6. Fuel: diesel
7. Voltage Regulation: + 2% (maximum) (No Load to Full Load) (standalone applications)
8. Phases: 3 Phase, Wye, 4 wire.
9. Each component of the engine generator system shall be capable of operating at 100 meters above sea level in a ventilated room which will have average ambient air temperature ranging from a minimum of 5 °C in winter to

maximum of 40°C in summer.

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.

F. Coordinate the components of the system and their arrangements, electrically and mechanically.

G. Connections between components of the system shall conform to the recommendations of the manufacturer of the diesel engine-generator set.

H. 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.

I. Generator set and cooling system shall be furnished with extended life antifreeze solution to protect the system from freezing at all times.

J. Generator set shall have the following features:
   1. Factory-mounted on a common, rigid, welded, structural steel base.
   2. Engine generator shall be statically and dynamically balanced so that the maximum engine-generator set vibration in the horizontal, vertical, and axial directions shall be limited to 0.15mm with an overall velocity limit of 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. Automatic start, accelerate to the specified RPM and deliver the specified KW/KVA output at 60 Hz within 10 seconds after a single pole contact closes in a remote device.
   5. Recover rapidly from instantaneous changes between no load and the specified KW/KVA rating, and the reverse changes of load, without damage.
   6. Shall be capable of operating satisfactorily as specified for not less than 10,000 hours between major overhauls.

7. Engine-generator set shall be statically and dynamically balanced at the factory in order to comply with the maximum vibration velocity specified in paragraph 3.1.D.
8. Emissions Permit: Contractor shall complete the attached Bay Area Air Quality Management District (BAAQMD) permit forms and procure a permit to construct prior to generator installation. Procure a permit to operate prior to job completion. Complete the following BAAQMD forms, and provide the appropriate plans per BAAQMD permit application instructions. Provide two (2) copies of the permit application documents to the government for their records.
   1.Bay Area Air Quality Management District forms:
   (a) P-101B,
   (b) ICE,
   (c) HRSA

K. Each engine generator specified for parallel operation shall be configured for automatic parallel operation.

2.2 DIESEL ENGINE

A. Coupled directly to a generator.
B. Minimum 4-cylinders.
C. Operating speed shall be 1800 RPM.
D. BMEP for the diesel engine, while the engine-generator set is delivering 100 percent of its specified output, shall not exceed the following maximum limits:
E. The minimum cubic inch displacement of the engine shall not be less than the value calculated from the following equation:

$$\text{Displacement} = \frac{\text{BHP\_x\_K\_}}{\text{BMEP x RPM}}$$

$$\text{Where BHP} = \frac{\text{Specified KW}}{0.746 \times G} + R$$

K = 396,000 for 2-cycle engines
K = 792,000 for 4-cycle engines
BMEP = Values per manufacturer recommendation.
RPM = 1800
G = generator efficiency expressed as a decimal
R = horsepower of radiator fan

R = O, when electric motor driven radiator fan is herein specified

F. The engine shall be able to start in a 4.5 degrees C (40 degrees F) ambient temperature while using No. 2 diesel fuel oil without the use of starting aids such as glow plugs and ether injections.
G. Fuel oil consumption of the engine rate shall not exceed 0.44 pounds of fuel oil per BHP per hour when it delivers 100 percent of its specified KW rating.
H. Equipped with electric heaters for maintaining the engine's coolant temperature in the range of 32-38 degrees C (90-100 degrees F) 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 level.

2.3 GOVERNOR

A. Isochronous; electronic type.
B. Steady-state speed band at 60 Hz shall not exceed plus or minus 1/3 of one percent.
C. At 60 Hz, when load changes equal to 25 percent of the specified KW/KVA rating, frequency change shall not exceed two percent and it shall recover to 60 Hz within three seconds.
D. At 60 Hz, when load changes equal to 100 percent of the specified KW/KVA rating, frequency change shall not exceed eight percent and it shall recover to 60 Hz within two seconds.
E. While the engine is running, manual speed adjustments may be made.

2.4 LUBRICATION OIL SYSTEM

A. Pressurized type.
B. Positive-displacement pump driven by engine crankshaft.
C. Full-flow strainer and full-flow or by-pass filters.
D. 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.
E. Extend lube oil sump drain line passing out through the skid base and terminate it with a drain valve and plug.
F. Provide a 120-volt oil heater for exterior generator set.

2.5 FUEL OIL SYSTEM

A. Main fuel storage tank(s) shall comply with the requirements of Section 23 10 00, FACILITY FUEL SYSTEMS.
B. Shall comply with NFPA 37 and NFPA 30, and have the following features:
   1. Injection pump(s) and nozzles.
   2. Plungers shall be carefully lapped for precision fit and shall not require any packing.
   3. Filters or screens, which require cleaning or replacement, will not be permitted in the injection system assemblies.
   4. Return surplus oil from the injectors to the main storage tank by gravity or a pump.
   5. Filter System:
      a. Dual primary filters shall be located between the main fuel oil storage and day tank.
      b. Secondary filters (engine mounted) shall be located so the oil will be thoroughly filtered before it reaches the injection system assemblies.
      c. Filters shall be cleanable or replaceable type and shall entrap and remove water from oil as recommended by the engine manufacturer.
C. Day Tank:
   1. Each engine generator shall be provided with a welded steel integral day tank with double-wall fuel containment.
   2. Each day tank shall have capacity 660 gallons to supply fuel to the engine for a 4-hour period at 85% rated load without being refilled, including fuel that is returned to the main fuel storage tank. The calculation of the capacity of each day tank shall incorporate the requirement to stop the supply of fuel into the day tank at 90% of the ultimate volume of the tank.2. Shall be welded steel, UL approved.
   3. Secure, pipe and connect the tank adequately for maximum protection from fire hazards, including oil leaks.
   4. Incorporate a vent, drain cock, shutoff cocks and gauge glass. Terminate the vent piping outdoors with mushroom vent cap.
   5. Incorporate a float switch on the day tank to control the fuel oil transfer pump and to actuate an alarm in the engine generator control cubicle when the oil level in the tank drops below the level at which the transfer pump should start to refill the tank.
      a. The float switch contacts, which control the fuel oil transfer pump, shall be set to energize the pump when the liquid level in the tank reaches 1/3 of the total volume of the tank.

b. The float switch contacts, which actuate the low fuel oil day tank alarm device, shall be set to alarm and energize the second fuel transfer pump when the liquid level in the tank reaches 1/4 of the total volume of the tank.

6. Day tank and engine supply line elevations shall be below the elevation of the injector return outlet on the engine.

D. Fuel Oil Transfer Pump-Main Storage Tank to Day Tank(s).
1. Electric motor-driven, duplex arrangement, close-coupled, single-stage, positive-displacement type with built-in pressure relief valves. When the fuel is used for cooling components of the fuel injection system, the engine's fuel return line shall be returned to the main storage tank, rather than tothe day tank.
2. Include a heavy-duty automatic alternator and H-0-A switch to alternate sequence of pumps and allow maintenance. Pumps shall be controlled with the float switch on the day tank and H-O-A selector switch so the day tank will be refilled automatically when the oil level lowers to the low limit for the float switch. The H-0-A selector switches shall enable the pumps to be operated manually at any time.
3. For all engines, each transfer pump and its electrical and plumbing connections shall be sized to provide a flow rate of at least four times the engines' fuel pumping rate.
4. Provide electric rotary-type transfer pump connected in parallel with the electric motor-driven transfer pumps so that oil can be pumped to the day tank while the electric motor-driven pumps are inoperative. Pump to be able to be connected to a portable generator.

E. Piping System: Black steel, standard weight, ASTM A-53 pipe and necessary valves and pressure gages between:
1. The engine and the day tank as shown on the drawings.
2. The day tank and the supply and return connections at the underground storage tank as shown on the drawings. Connections at the engine shall be made with flexible piping suitable for the fuel furnished.

2.6 ENGINE COOLING SYSTEM

A. Liquid-cooled, closed loop, with radiator mounted on the engine generator set and integral engine driven circulating pump.

B. Cooling capacity shall not be less than the cooling requirements of the engine-generator set and its lubricating oil while operating continuously at 100 percent of its specified rating.

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 percent ethylene and 50 percent soft water, with corrosion inhibitor additive as recommended by the manufacturer.

E. Fan shall be driven by shaft connected to the engine and shall have a 0.5 inches static pressure capability to draw the air and discharge it through the silencer and louvers.

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. Motor-Operated Dampers:

1. Dampers, which are provided under Section 23 31 00, HVAC DUCTS AND CASINGS, shall be two-position, electric motor- operated.

2. Dampers shall open simultaneously with the starting of the diesel engine and shall close simultaneously with the stopping of the diesel engine.

2.7 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. Where a turbocharger is required, they shall be engine-mounted, driven by the engine gases, securely braced against vibration and adequately lubricated by the engine's filtered lubrication system.

2. Exhaust Muffler: Shall be equipped with and passive diesel particle filters to meet the required emission limits mandated by the State of California and the Bay Area Quality Control Board (BAAQCB).

3. 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

4. Pressure drop in the complete exhaust system shall be small enough for satisfactory operation of the engine-generator set while it is delivering 100 percent of its specified rating.
5. 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.
6. 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 75 mm (3 inches) 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 0.4 mm (0.016 inch) thick. The jacket is to be held in place by bands of (0.38 mm) (0.015 inch) thick by 15 mm (0.5 inch) 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 ounce 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 150 mm (6 inch) wide spiders welded to the exhaust pipe.

G. Vertical exhaust piping shall be provided with a hinged, gravity-operated, self-closing rain cover.

2.8 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: 12 volt or 24 volt electric, sized as recommended by engine manufacturer, with the following features:
   1. Batteries shall be nickel-cadmium high discharge rate type.
   2. Each battery cell shall have minimum and maximum electrolyte level indicators, and flip top flame arrestor vent cap.
   3. Batteries shall have connector covers for protection against external short circuits.
   4. With the charger disconnected, the batteries shall have sufficient capacity so that the total system voltage does not fall below 85 percent of the nominal system voltage with the following demands:
      a. 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).
   5. Battery racks shall be metal with an alkali resistant finish and thermal insulation, and secured to the floor. Provide polyethyne plastic battery cases with lockable lid and bolt-on mounting system for secure installation on the floor.
   6. Battery shall operate continuously for 12 hours and be able to provide the cranking power described in 2.8.B.3 without charging.
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 maintain one percent voltage regulation from no load to full load for line voltage variation of 10 percent and frequency variation of ± 3 Hz from 60 Hz.
4. The charger shall maintain a nominal float voltage of 1.4 vdc and a nominal equalizing voltage of 1.6 vdc.
5. 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 250, Type 1 enclosure. The charger shall have a hinged front door and all components shall be accessible from the front.
6. 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.
7. The charger shall be capable of recharging the fully discharged battery in 12 hours and simultaneously power the Supervisory and Control panel.
8. The charger shall have fused AC input and DC output protection, and shall not discharge the batteries when AC power fails.
9. 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.

2.9 LUBRICATING OIL HEATER

A. Provide a thermostatically-controlled electric heater to automatically maintain the oil temperature within plus or minus 1.7 °C (3 °F) of the control temperature.

2.10 JACKET COOLANT HEATER

A. Provide a thermostatically-controlled electric heater mounted in the engine coolant jacketing to automatically maintain the coolant

within plus or minus 1.7 °C (3 °F) of the temperature recommended by the engine manufacturer to meet the starting time specified at the minimum winter outdoor temperature.

2.11 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 at the construction site.
C. Integral poles and spider, or individual poles dove-tailed to the spider.
D. Insulation shall be as required for the ambient temperature and other requirements designated in the paragraph, DIESEL ENGINE-GENERATOR SET, in this section.
E. Designed for sustained short circuit currents in conformance with NEMA Standards.
F. Designed for sustained operation at 100 percent of the RPM specified for the generator set without damage.
G. Telephone influence factor shall conform to NEMA MG 1.
H. Furnished with brushless excitation system or static-exciter-regulator assembly.
I. 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.
J. Furnished with anti-condensation alternator winding space heater unit mounted.
K. The grounded (neutral) conductor shall be electrically isolated from equipment ground and terminated in same junction box as the phase conductors.

2.12 GENERATOR OVERCURRENT AND FAULT PROTECTION

A. Generator circuit breaker shall be insulated-case, electronic-trip type; 100 percent rated; complying with UL 489. Tripping characteristics shall be adjustable long-time and short-time delay and instantaneous. Provide shunt trip to trip breaker when engine generator is shut down by other protective devices.

B. Overcurrent protective device cubicle shall contain terminations for neutral and equipment grounding conductors as necessary.

2.13 EQUIPMENT FOR CONTROLS, SUPERVISION AND DISTRIBUTION

A. Shall include Engine Generator Controls required for the safe operation of the engine generator and ancillary equipment and for control interface with the generator low voltage paralleling switchgear.
B. Paralleling controls shall be located at the Generator Low-Voltage Switchgear specified in Section 26 23 15.
C. Shall include Engine Generator Control Cubicle(s), Master Control Cubicle, Remote Annunciator Panel, Exercising Control Panel, Remote Monitoring Panel to be located at the Boiler House, and VA Police Desk. Engineering Control Center is located in the Boiler House.
    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. Cubicles shall be in accordance with UL 891.
    4. Incorporate all of the items required to fulfill the requirements in the specifications and on the drawings.
    5. Components:
        a. Shall be heavy duty, industrial type.
        b. Electrical contacts shall be precious metal surfaced.
        c. Only heavy duty solid-state components will be accepted.
    6. Coordinate controls with the generator low-voltage paralleling switchgear and automatic transfer devices as shown on the drawings so that the systems will operate as specified.
    7. Cubicles and Panels:
        a. Code gauge steel; manufacturer's recommended heavy gauge steel with factory primer and light gray finish.
        b. Doors shall be gasketed and be attached with concealed or semi-concealed hinges, and shall have a permanent means of latching in closed position.
        c. Panels shall be wall mounted or incorporated in other equipment as indicated on the drawings or as specified.
        d. Cubicle design shall be of frame construction free standing sheet metal cabinet, floor supported with front and rear access openings for air circulation.

e. Door locks for panels and cubicles shall have identical keying to operate from a single key.
f. Panel installation shall be suitable for convenient maintenance and operation. Overall heights of the cubicles shall not exceed 2.5 meters (90 inches).

8. Wiring: Insulated, rated at 600 volts, UL approved.
   a. Install the wiring in vertical and horizontal runs, neatly harnessed.
   b. Terminate all external wiring at heavy duty, pressure type, terminal blocks.
9. Clearly and permanently label the equipment, wiring terminals and wires.
10. Laminate or mount under plexiglass appropriate wiring diagrams and mount them within the frame on the inside of the cubicles and panels.
11. The system shall be designed and manufactured employing the most modern technology to insure maximum reliability and longevity. It shall be arranged for automatic and manual starting, and stopping, and paralleling of diesel generator sets.
12. The cubicles shall be arranged into a switchboard lineup:
    a. Bus shall be copper with maximum current density of 1000 amps per square inch. All joints shall be plated.
    b. Bus shall be adequately braced to withstand the maximum short circuit current available. Minimum bracing level shall be not less than 100,000 amps RMS symmetrical.
13. All indicating lamps and switches shall be accessible and mounted on the cubicle doors.
14. Electronic governor control panel, voltage regulator, control panel, motorized voltage adjusting potentiometer, and associated components shall be shipped to the generator control switchboard manufacturer for assembly, mounting and/or interwiring in the switchboard. Detailed drawings outlining proper interconnection and physical mounting data shall also be furnished to the generator switchboard manufacturer to facilitate proper design and interfacing. The engine generator set supplier shall furnish these items as soon as possible.
15. All meters shall be solid-state switchboard type, 112 mm (4-1/2 inches), 1 percent accuracy transformer rated for 600 volt service. Ammeters and voltmeters shall be furnished with phase selector switches. Metering shall include necessary current and potential transformers and instrument fuses.
16. The repetitive accuracy of the monitors shall be as stated over an environmental temperature range of 0 to 45 degrees C (32 to 113 degrees F)

and voltage range of 70 to 110 percent of nominal. The accuracy shall not exceed the following limits:

Voltage Monitors	+ 2 percent of set point
Current Monitors	+ 3 percent of set point
Frequency Monitors	+ 0.2 Hz.
Power Monitors	+ 3 percent of set point

17. The manufacturer shall coordinate the interfacing, interconnection, and programming of the generator control systems with all related equipment supplied, including the generator low-voltage paralleling switchgear, in accordance with other sections of the project specification.

D. Engine Generator Control Cubicle
   1. Starting and Stopping Controls:
      a. A three-position, maintained-contact type selector switch with positions marked "AUTOMATIC", "OFF" and "MANUAL". Provide flashing amber light for "OFF" and "MANUAL" positions.
      b. A momentary contact pushbutton switch with positions marked "MANUAL START" and "MANUAL STOP".
      c. Selector switch in "AUTOMATIC" position shall cause the engine to start automatically when a single pole contact in a remote device closes. When the generator's output voltage increases to not less than 90 percent of its rated voltage, and its frequency increases to not less than 58 Hz, the remote devices shall transfer the load to the generator. An adjustable time delay relay, 0 to 15 minute range, shall cause the engine generator set to continue operating without any load after completion of the period of operation with load. Upon completion of the additional 0 to 15 minute (adjustable) period, the engine generator set shall stop.
      d. Selector switch in "OFF" position shall prevent the engine from starting either automatically or manually. Selector switch in "MANUAL" position shall cause the engine to start when the manual start pushbutton is also depressed momentarily.
      e. With selector switch in "MANUAL" position, depressing the "MANUAL STOP" pushbutton momentarily shall stop the engine after a cool down period.

f. A maintained contact, red mushroom head pushbutton switch marked "EMERGENCY STOP" will cause the engine to stop without a cool down period independent of the position of the selector switch.

2. Engine Cranking Controls:
   a. The cranking cycles shall be controlled by timer that will be independent of the battery voltage fluctuations.
   b. 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 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.
3. 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.
      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.
      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 and the engine shall stop.
      3) Difference between the first and second stage temperature settings shall be approximately -12 degrees C (10 degrees F).
      4) Permanently indicate the temperature settings near the associated signal light.

5) When the coolant temperature drops to below 21 degrees C (70 degrees F), the "LOW COOLANT TEMPERATURE" signal light and the audible alarm shall be energized.

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.

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.
   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.
   3) Difference between the first and second stage pressure settings shall be approximately 15 percent of the oil pressure.
   4) The pressure settings near the associated signal light shall be permanently displayed 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.

f. Low Fuel - Day Tank:
   1) When the fuel oil level in the day tank decreases to less than the level at which the fuel oil transfer pump should start to refill the tank, the "LOW FUEL DAY TANK" light and the audible alarm shall be energized.

g. Low Fuel - Main Storage Tank:
   1) When the fuel oil level in the storage tank decreases to less than 1/3 of total tank capacity, the "LOW FUEL-MAIN STORAGE TANK” signal light and audible alarm shall be energized.

h. Reset Alarms and Signals:
   1) Overcrank, Coolant Temperature, Coolant Level, Oil Pressure, Overspeed, and Low Fuel signal lights and the associated audible alarms shall require manual reset. A momentary-contact silencing

switch and pushbutton shall silence the audible alarm by using relays of solid state devices to seal-in the audible alarm in the de-energized condition Elimination of the alarm condition shall automatically release the sealed-in circuit for the audible so that it will be automatically energized again when the next alarm condition occurs. The signal lights shall require manual reset after elimination of the condition, which caused them to be energized. Install the audible alarm just outside the generator room in a location as directed by the COR. The audible alarm shall be rated for 85 dB at 3 meter (10 feet).

i. Generator Breaker Signal Light:
   1) Molded case circuit breaker and contactor: A flashing green light shall be energized when the generator circuit breaker is in either the "OPEN" or "TRIPPED" position.
   2) Power circuit breaker: A flashing green light shall be energized when the generator circuit breaker is in the "OPEN" or "TRIPPED" position.
   3) Simultaneously, the audible alarm shall be energized.

4. Monitoring Devices:
   a. Electric type gauges for the cooling water temperatures and lubricating oil pressures. These gauges may be engine mounted with proper vibration isolation.
   b. A running time indicator, totalizing not less than a 9,999 hour, heavy duty and an electric type tachometer.
   c. Voltmeter, ammeter, and their selector switches, frequency meter, kilowatt meter, manual adjusting knob for the output voltage and the other items shown on the drawings shall be mounted on the front of the generator control panels.
   d. Install potential and current transformers as required.
   e. Individual signal lights:
      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) GENERATOR BREAKER
      9) OVERSPEED
      10) LOW FUEL - DAY TANK

11) LOW FUEL – MAIN STORAGE TANK

f. Lamp Test: "Lamp Test" momentary contact switch shall momentarily actuate the alarm buzzer and all the indicating lamps.

5. Power switching and overcurrent protection shall be accomplished with molded case circuit breakers.
   a. Power Circuit Breakers shall have the following features:
      1) Shall be low voltage, airbreak, AC power type, dead front, 100 percent rated, stored energy, with solid-state trip devices. Arcing contacts shall be renewable.
      2) Shall be in accordance with Section 26 23 00, LOW-VOLTAGE SWITCHGEAR.
   b. Molded Case Circuit Breakers shall have the following features:
      1) Solid state adjustable trip type circuit breakers.
      2) Shall be in accordance with UL 489 and NEMA AB-1.
      3) Trip units shall have field adjustable tripping characteristics as follows:
         a) Ampere setting (continuous).
         b) Long time band.
         c) Short time trip point.
         d) Short time delay.
         e) Instantaneous trip point.
         f) Ground fault system for circuit breakers rated 480 volt, equal to or greater than 1000 amperes. The system shall alarm but not trip the circuit breaker.
      4) Trip setting shall be as shown on the electrical system protective device study by Designer of Record.
      5) Shall be 100 percent rated.
      6) Electrically and mechanically trip free.
      7) Manual operating handle with lock-open padlocking provisions, and position indicators on the front of the breaker.
      8) Rear stud connection for both line and load sides.
      9) Shall include type "a" and "b" auxiliary contacts for interfacing with controls.
6. Automatic Voltage Regulator:
   a. Shall maintain the generator's output voltage within plus or minus one percent for load variations between no load and full load.
   b. Shall correct voltage fluctuations rapidly and restore the output voltage to the predetermined level with a minimum amount of hunting.
   c. Shall include voltage level rheostat located inside the control cubicle.

   d. Provide a 3-phase automatic voltage regulator immune to waveform distortion.
7. The voltage regulator and other components of the auxiliary electrical power system shall be protected during operation of the diesel engine-generator set at speeds other than the rated RPM while performing maintenance by a power monitoring system which monitors single phase and three phase faults. A time-delay relay shall shut down the engine when the alternator thermal capacity is exceeded.
8. Reverse Power Monitors: Solid-state reverse power monitors shall be furnished to sense motorizing of a failing engine-generator set. Upon detection of a reverse power flow, the monitor shall signal the alarm circuit for immediate power disconnect of the generator and actuation of load dumping circuits, and energize the audible and visual alarm signals. Monitors shall automatically reset open generator disconnect from the bus. An induction disc type reverse power relay with equivalent performance may be submitted for approval. The monitor shall have the following features:
   a. Accurate operation at power factors down to 0.2 lagging or leading.
   b. Minimum 10 amperes output contacts rated at 480 volts.
   c. Circuitry arranged to continually sense the output power of the generator for magnitude and direction.
   d. Operate accurately over voltage range of 70 percent to 110 percent of rated voltage.
   e. Adjustable dial for trip power range.
   f. Test switch to simulate reverse power for periodic testing. Switch shall be arranged to cause sensing circuitry to measure a reverse power.
9. Synchronizing Monitors: A solid-state generator-synchronizing monitor shall sense voltage, frequency and phase angle of the unit to be paralleled. The monitor shall compare the voltage of the bus with that of the unit to be paralleled and initiate corrective action to cause the voltage difference to be reduced to less than 5 percent of nominal. Voltage adjustment shall be achieved by a motorized voltage adjusting potentiometer, as furnished by generator set manufacturer. The monitor shall compare the frequency of the bus with that of the unit to be paralleled, and shall control the governor to cause the frequency of the unit to be paralleled to match within 0.2 Hz. The monitor shall also compare the phase angle of the bus with that of the unit to be paralleled and reduce the phase angle of the unit to be paralleled to a maximum of five electrical degrees at the instant the connection is made to the bus. Upon achievement of the appropriate phase angle the generator

circuit breaker shall close to parallel the unit. The monitor shall be mounted remotely in the control cabinet. Solid-state circuitry shall be used for all sensing and control functions. Interface circuits for control of voltage adjustment and circuit breaker closing shall be through enclosed electromagnetic relays

11. Generator Neutral Grounding Equipment:
    Install generator neutral equipment and neutral grounding reactor in one enclosure or alternatively install generator neutral equipment in the generator terminal box and neutral grounding equipment in a separate enclosure.
    a. Generator Neutral Equipment: Provide indicated number of current transformers conforming to IEEE C57.13, insulated three-phase to neutral junction point, and necessary cable terminations.
    b. Neutral Grounding Reactor: Provide an indoor, dry type, current limiting, neutral grounding reactor conforming to IEEE Std 32 with clamp-type lugs or connectors. Design and construct reactors to limit ground fault current to less than the three-phase fault current of the generator, for a fault on the generator terminals, without damage from heat or mechanical stresses.

2.14 REMOTE MANUAL STOP STATION

A. Shall be provided per NFPA 101, and shall be a red mushroom-head push-button switch.

B. Shall have remote manual stop button for each generator.

C. Shall be connected to the main generator control panel to provide emergency shutdown of the generator.

D. Shall be located outside the room housing the generator at the three locations as shown on the drawings.

E. Shall have permanent label reading “EMERGENCY STOP”.

2.15 RESISTIVE PERMANENT AUTOMATIC LOAD BANK

A. Rating
    1. The total capacity of the load bank shall be rated 2000 KW at 480 Volts, 3-Phase, 3-Wire, 60 Hertz, 2404 Amps per Phase at unity Power Factor and 50 KW minimum load step resolution.
    2. The load bank shall be designed for continuous duty cycle operation with no limitations. The load bank shall operate in an ambient temperature of -28°C to 49°C (-20°F to 120°F).

B. Material and Construction

1. The load bank shall be outdoor weatherproof construction, suitable for installation on a concrete pad or structural base. All exterior fasteners shall be stainless steel. The load bank shall include forklift channels in the base for lifting.
2. The load bank shall be constructed of heavy gauge aluminized steel per ASTM A463. Aluminized steel provides superior corrosion protection and extended service life, with a better tolerance to high heat exposure compared to the more common Galvanized steel.
3. The main input load bus, load step relays, fuses and blower/control relays shall be located within the load bank enclosure. A thermostatically controlled heater shall be located within the control section to provide protection to the control devices from the effects of moisture and condensation.
4. Airflow throughout the load bank shall be vertical. Ambient intake cooling air shall be drawn in at the base of the unit and heated air exhausted out the top. Intake openings shall be designed to prevent objects greater than 0.50″ diameter from entering the unit.
5. The load bank exhaust hood(s) shall be angled and include interior baffle plates to direct falling rain from the interior of the load bank. The exhaust hood(s) shall be constructed of non-corrosive aluminized steel or aluminum.
6. The load bank enclosure shall have a baked polyester powder coated finish with a film thickness of 2.8 +/- 0.4 Mils per coat.
7. Load elements shall be contained in multiple resistor cases or trays. Each can be removed in it’s entirety as a unit for inspection or service.

C. Resistive Load Elements
1. Load elements shall be Avtron Helidyne™, helically wound chromium alloy rated to operate at approximately ½ of maximum continuous rating of wire. Elements must be fully supported across the entire length within the air stream by segmented ceramic insulators on stainless steel rods. Element supports shall be designed to prevent a short circuit to adjacent elements or to ground.
2. The change in resistance due to temperature shall be minimized by maintaining conservative watt densities.

3. The overall tolerance of the load bank shall be –0% to +5% KW at rated voltage. A –5%, +5% rating allows the load bank to deliver less than rated KW and shall not be used. The load bank must deliver full rated KW at rated voltage.

D. Cooling
   1. The load bank shall be cooled by integral TEFC or TEAO motor(s) which is direct coupled to the cooling fan blade. The fan motor must be electrically protected against overload using a motor overload device and short circuit protected using three (3) current limiting fuses with an interrupting rating of 200K A.I.C.
   2. The fan blade is to be an airfoil design constructed from aluminum or non-corroding material.
   3. An integral control power transformer shall be provided to supply 120V, 1 phase, 60 Hz to the load banks control and motor starter circuitry. Transformer primary and secondary control circuits shall be fuse protected.

E. Protective Devices
   1. A differential pressure switch(s) shall be provided to detect air loss (one for each stack). The switch(s) shall be electrically interlocked with the load application controls to prevent load from being applied if cooling air is not present.
   2. An over-temperature switch shall be provided to sense the load bank exhaust in each vertical heater case assembly. The switch shall be electrically interlocked with the load application controls to remove load from being applied in the event of an over temperature condition.
   3. To provide for major fault protection, branch fuses shall be provided on all three phases of switched load steps above 50KW. Branch fuses shall be current limiting type with an interrupting rating of 200K A.I.C.
   4. The exterior of the load bank shall have appropriate warning/caution statements on access panels.

F. Control Panel
   1. The control panel shall be a remote 19″ rack mounted panel housed in a NEMA 4 type wall mount enclosure. The control panel shall contain the following manual controls:
      a. Power ON/OFF switch

b. Blower START/STOP pushbuttons.
c. Master load ON/OFF switch.
d. Load step switches for ON/OFF application of individual load steps.

2. Control panel visual indicators shall be as follows:
   a. Power ON indication light.
   b. Blower ON light.
   c. Blower/Air FAILURE light.
   d. OVERTEMPERATURE light.
3. A standard remote load dump circuit shall be provided as part of the load bank control circuit. Provisions shall be provided to remove the load bank off-line from the operation of a remote normally closed set of auxiliary contacts from a transfer switch or other device. In the event of the remote contact opening, all load is removed.
4. A Normal (Utility) Power Loss Sensing Relay circuit shall be provided as part of the load bank control circuit. In the event of normal (utility) power loss, the load bank shall be set off-line and all load is to be removed from the generators.
5. An Automatic Load Step Controller shall be provided for maintaining a minimum of 30% load on each generator set during all generator operations. The controller shall monitor the connected downstream loads and will automatically add or subtract load steps in response to building load changes as to maintain a minimum 30% load level on all the generator sets during all generator operations. The controller includes an initial time-delay circuit, and automatic time delayed load step application circuit. A remote contact closure is required for activation and transfer of control. A separate current transformer shall be supplied loose for mounting and sensing of downstream loads.
6. The load bank shall have a digital monitoring system with real-time data logging software. The monitoring system shall provide a 3-line extra-bright LED display of Voltage, Current, Frequency and Power Measurements. System shall utilize communicator EXT type software which provides PC based real- time monitoring and also automated data acquisition from an optical IrDA port. An

IrDA/USB adapter shall be provided for plug and play convenience.

2.16 SPARE PARTS

A. For each engine-generator set:
   1. Six lubricating oil filters.
   2. Six primary fuel oil filters.
   3. Six secondary fuel oil filters.
   4. Six intake air filters.

B. For each battery charger:
   1. Three complete sets of fuses.
   2. One complete set of indicating lamps.

C. For each control and supervisory panel:
   1. Three complete sets of fuses.
   2. One complete set of indicating lamps.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install concrete bases of dimensions shown on the drawings.

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

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

D. Engine generators shall be adequately anchored and braced per details on structural contract drawings to withstand the seismic forces at the location where installed.
E. Balance:
   1. The vibration velocity in the horizontal, vertical, and axial directions shall not exceed 16.25 mm (0.65 inch) 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.
   2. Balance the engine-generator set statically and dynamically at the factory in order to comply with the maximum specified vibration velocity.
F. Connect all components of the essential electrical power system so that they will continue to be energized by the auxiliary electrical power system during failures of the normal electrical power supply system.
G. Install piping between diesel engine and remote components of cooling, fuel and exhaust systems.
H. Flexible connection between radiator and exhaust shroud at the wall damper:
   1. Install noncombustible flexible connections made of 20-ounce neoprene-coated fiberglass fabric approximately 150 mm (six inches) wide.
   2. Crimp and fasten the fabric to the sheet metal with screws 50 mm (two inch) on center. The fabric shall not be stressed, except by the air pressure.
I. 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 1093 degrees C (2000 degrees F) insulating cement before applying the outer covering.
   3. The installation shall be neat, 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 diesel engine-generator set manufacturer to inspect field-assembled components, and equipment installation and supervise the field tests.

B. When the complete engine generator system has been installed and prior to the final inspection, tests all components of the system in the presence of the COR for proper operation of the individual components and the complete system and to eliminate electrical and mechanical defects.
C. Furnish fuel oil, lubricating oil, anti-freeze liquid, water treatment and rust inhibitor and load bank for testing of the diesel engine-generator set.
D. Visual Inspection: Visually verify proper installation of engine generator and all components per manufacturer's pre-functional installation checklist.
E. Set engine generator circuit breaker protective functions per Section 26 05 73, OVERCURRENT PROTECTIVE DEVICE COORDINATION STUDY.
F. Field Tests for the Diesel Engine-Generator Set:
    1. Perform manufacturer's after-starting checks and inspections.
    2. Test the engine generator set for eight hours of continuous operation as follows:
        a. First two hours while the set is delivering 100 percent of its specified KW rating.
        b. Ten hours while the set is delivering 85 percent of its specified KW rating.
        c. If during the 8-hour continuous test an engine generator failure occurs, either the diesel engine shuts down or the full KW rating of the load bank is not achieved and maintained, the test is null and void. The test(s) shall be repeated until the satisfactory results are attained at no additional cost to the government.
    3. Record the following test data at 30-minute intervals:
        a. Time of day, also reading of running time indicator.
        b. KW.
        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 diesel engine.
        l. Average ambient temperature in the vicinity of the starting batteries.
    4. Demonstrate that the generator set will attain proper voltage, frequency and will accept 100 percent block load within 10 seconds from a cold start after the closing of a single contact.

5. Furnish a resistance type load for the testing of the generator:
   a. Test loads shall always include adequate resistance to assure stability of the loads and equipment during all of the testing operations. The test load KW rating:
      1) Shall not be less than 100 percent of the specified KW rating of the engine generator set.
      2) Shall not be less than 35 percent of the sum of the specified KW ratings of the all generator sets in a paralleling system.

G. Battery and Starting System Test:
   1. Demonstrate that the batteries and cranking motor are capable of 5 starting attempts of 10 second cranking each at 10 second intervals with the battery charger turned off.

H. Test local and remote panels: Simulate engine failures while checking for proper operation of each indicating lamp, alarm device and reset button. (It is recommended that one VA inspector be located in the generator room and another at the site of remote panels. By means of telephone or walkie-talkies, the inspectors should be assured of proper operation and coordination of these panels.)

I. Remote Annunciator Panel and Remote Manual Stop Tests:
   1. Simulate conditions to verify proper operation of each visual or audible indication, interconnecting hardware and software, and reset button. Simulate emergency stop of the generator by initiating the remote manual stop station, while the generator is in operation.

J. Fuel systems shall be flushed and tested per Section 23 10 00, FACILITY FUEL SYSTEMS: Fuel supply and storage requirements.

K. Automatic Operation Tests:
   1. Test the engine generator and associated automatic transfer switches to demonstrate automatic starting, loading and unloading. The load for this test shall be the actual connected loads. Initiate loss of normal source and verify the specified sequence of operation. Restore the normal power source and verify the specified sequence of operation. Verify resetting of controls to normal.

L. Parallel Operation Test:
   1. Test the capability of each engine generator to parallel and share load with other engine generators, individually and in all combinations. During operations, record load-sharing characteristics of each engine generator in parallel operation. Provide multiple load banks as required. 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 rated kW, 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, 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 rated kW.
   d. Increase the load in steps until each engine generator is loaded to approximately 50% of its rated kW. 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 rated kW of one engine generator.
   f. Transfer a load equal to the rated kW 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 rated kW, until all multiple combinations of parallel operations have been achieved.

M. At the completion of the field tests, fill the underground storage tank with fuel of grade and quality as recommended by the manufacturer of the engine.

N. 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 Resident Engineer, at no additional cost to the Government.
O. Provide test and inspection results in writing to the COR.

3.3 INSTRUCTIONS AND FINAL INSPECTIONS

A. Laminate or mount under Plexiglass a set of operating instructions for the system and install instructions within a frame mounted on the wall near the diesel engine-generator set at a location per the COR.
B. At the final inspection in the presence of a VA representative, demonstrate that the complete auxiliary electrical power system operates properly in every respect.
C. Furnish the services of a competent, factory-trained engineer or technician for five, 4-hour periods for instructions to VA personnel in operation and maintenance of the equipment, on the dates requested by the COR.
D. Notify the COR seven days in advance prior to any inspections and testings activity.

END OF SECTION 26 32 13