SECTION -16208

DIESEL ENGINE-GENERATOR SET

PART 1 - GENERAL

1.1 APPLICABLE PUBLICATIONS: The publications listed below form a part of this specification to the extent referenced. The publications are referred to in the text by the basic designation only.

1.l.l Federal Specifications (Fed. Spec.):

VV-F-800D (1)	Fuel Oil, Diesel
WW-T-799F	Tube, Copper, Seamless, Water (for use with Solder-, Flared-, or Compression-Type Fittings)

1.1.2 Military Specifications (Mil. Spec.):

MIL-T-152B (Notice 1)	Treatment, Moisture-and-Fungus-Resistant, of Communications, Electronic, and Associated Electrical Equipment
MIL-V-173C (Notice 1)	Varnish, Moisture-and-Fungus-Resistant (for Treatment of Communications, Electronic, and Associated Equipment)
MIL-T-5544B (Notice 2)	Thread Compound, Anti-Seize, Graphite Petroleum
MIL-T-5624M	Turbine Fuel, Aviation, Grades JP-4 and JP-5
MIL-V-12003F(1)	Valves, Plug, Cast-Iron or Steel, Manually Operated
MIL-S-16165E	Shielding, Harnesses, Shielding Items and Shielding Enclosures for Use in the Reduction of Interference from Engine Electrical Systems
MIL-C-17596E(l)	Compressor, Reciprocating or Rotary, Power Driven (EMD), Air, Base Mounted, 10 KP to 300 KP
MIL-P-l7608C	Pump, Rotary, Power Driven, Viscous Liquids
MIL-G-17713C	Gauge, Liquid Level Measuring, Tank
MIL-V-l8436F	Valves, Check, Bronze, Cast-Iron, and Steel Body
MIL-V-18634B	Valve, Safety, Relief, and Safety-Relief
MIL-T-22361(1)	Thread Compound, Antiseize, Zinc Dust- Petrolatum

MIL-I-24092B(1) Insulating Varnish, Electrical, Impregnating, Solvent Containing

MIL-T-83133B Turbine Fuel, Aviation Kerosene Type, Grade JP-8

1.1.3 Military Standard (MIL-STD):

461C Electromagnetic Emission and Susceptibility Requirements for the Control of Electromagnetic Interference

1.1.4 Code of Federal Regulations (CFR):

CFR 29 Chap. XVII Operational Safety and Health Administration, Department of Labor

1.1.5 American National Standards Institute, Inc. (ANSI) Publications:

B 1.01-82 & Supp. B1-1-84 Unified Inch Screw Threads (UN and UNR Thread Form)

B15.01-84 Mechanical Power Transmission Apparatus

B16.01-75 Cast-Iron Pipe Flanges and Flanged Fittings Class 25, 125, 250, and 800

B16.03-85 Malleable Iron Threaded Fittings

B16.05-81 Pipe Flanges and Flanged Fittings

B16.09-86 Factory-Made Wrought Steel Buttwelding Fittings

B16.11-80 Forged Steel Fittings, Socket-Welding and Threaded

B16.39-86 Malleable Iron, Threaded Pipe Unions Classes 150, 250, and 300

B18.02.1-81 Square and Hex Bolts and Screws Inch Series Including Hex Cap Screws and Lag Screws

B31.01-86 Power Piping

C37.13-81 Low-Voltage AC Power Circuit Breakers Used in Enclosures

C37.16-80 Preferred Ratings, Related Requirements, and Application Recommendations for Low-Voltage Power Circuit Breakers and AC Power Circuit Protectors

C37.17-79 Trip Devices for AC and General Purpose DC Low-Voltage Power Circuit Breakers

C39.01-81	Electrical Analog Indicating Instruments
C57.13-78	Instrument Transformers

1.1.6 American Society of Mechanical Engineers (ASME) Publications:

PTC 26-62	Speed-Governing Systems for Internal Combustion Engine-Generator Units
SEC 8-D-l-86	Pressure Vessels - Division 1

1.1.7 American Society for Testing and Materials (ASTM) Publications:

A53-87	Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless
A126-84	Gray Iron Castings for Valves, Flanges, and Pipe Fittings
A1811A181M-85	Forgings, Carbon Steel, for General-Purpose Piping
A193/A193M-87	Alloy-Steel and Stainless Steel Bolting Materials for High-Temperature Service
A194/A194M-87	Carbon and Alloy Steel Nuts for Bolts High - Pressure and High-Temperature Service
A234/A234M-87	Piping Fittings of Wrought Carbon Steel and Alloy Steel for moderate and Elevated Temperatures
A307-86	Carbon Steel Bolts and Studs, 60,000 psi Tensile Strength

1.1.8 Diesel Engine Manufacturers Association (DEMA) Publications:

(Sixth Edition Stationary Diesel and Gas Engines 1972)

1.1.9 Institute of Electrical and Electronics Engineers (IEEE) Publications:

115-83	Test Procedures for Synchronous Machines
126-59(R83)	Speed Governing of Internal Combustion Engine - Generator Units
421-86	Definitions for Excitation Systems for Synchronous Machines

1.1.10 Instrument Society of America (15A) Publication:

518.1-79(R85)	Annunciator Sequences and Specifications

1.1.11 International Conference of Building Officials (ICBO) Publication:

Uniform Building Code - (Latest Edition)

1.1.12 Manufacturers Standardization Society of the Valve and Fittings Industry (MSS) Publications:

SP 70-84	Cast-Iron Gate Valves, Flanged and Threaded Ends
SP 80-87	Bronze Gate, Globe, Angle and Check Valves
SP 83-76	Carbon Steel Pipe Unions, Socket-Welding and Threaded
SP 85-85	Cast Iron Globe and Angle Valves, Flanged and Threaded Ends

1.1.13 National Electrical Manufacturer's Association (NEMA) Publications:

250-87	Enclosures for Electrical Equipment (1,000 Volts Maximum)
AB1-75(R81)	Molded Case Circuit Breaker
ICS6-83(R86)	Industrial Controls and Systems
MG1-78(R85)	Motors and Generators
PB2-84	Deadfront Distribution Switchboards
SG3-81	Low-Voltage Power Circuit Breakers

1.1.14 National Fire Protection Association (NFPA) Publications:

30-84	Flammable and Combustible Liquids Code
37-84	Stationary Combustion Engines and Gas Turbines
70-87	National Electrical Code

1.1.15 Underwriters' Laboratories, Inc. (UL) Publications:

429-82(R85)	Electrically Operated Valves
489-86	Molded-Case Circuit Breakers and Circuit Breaker Enclosures
891-84 (R 86)	Dead-Front Switchboards
1236-86	Battery Chargers

1.2 GENERAL REQUIREMENTS: Section "Electrical General Requirements" applies to this section with the additions and modifications specified herein.

1.3 EXPERIENCE REQUIREMENTS: Engines installed shall meet all of the operating experience requirements listed below.

a. Only electric generation service is considered as equivalent experience. Engines driving pumps or compressors, or those in marine propulsion or railroad service, are not acceptable.

b. Only experience for the same engine model is acceptable. Engine model is considered to be a given series or class with identical bore and stroke and of the same type of engine, such as In-line or Vee. In-line and Vee engines with identical bore and stroke are considered as two separate models of engines.

c. Only experience at the identical or higher rotative speed as that which is specified is acceptable.

d. Only experience at the identical or higher brake mean effective pressure (BMEP) as that which is specified is acceptable.

e. Only experience with diesel-fueled engines is acceptable.

1.4 SUBMITTALS:

1.4.1 Certificates of Operating Experience: Furnish certificate(s) within 30 days after award certifying that not less than two engines of identical number of cylinders and cylinder size, identical or higher rotative speed up to a maximum of 1,800 rpm, and ideentical or higher BMEP, and of the same basic configuration (In-line or Vee) as the engine to be provided, shall have driven generators which have produced, in satisfactory operation, not less than 1,000 kilowatt-hours of electricity for each kW of generator nameplate capability within a 2-year period. Certificate(s) shall include:

a. A list of at least two engine-generator set installations meeting the experience requirements set forth in the paragraph "Experience Requirements".

b. Owner and location of each such installation.

c. Date of initial operation of each such installation.

d. Number of kWh produced per kin of generator net rated capacity of each engine installation.

e. Horsepower rating, kW rating, and rotative speed of each set.

f. Brake mean effective pressure rating of each engine.

g. Design characteristics of each unit, such as bore and stroke, number of cylinders, and configuration (In-line or Vee)

1.4.2 Manufacturer's Data: Submit the following data pertaining to each engine and to the auxiliary equipment proposed to be furnished:

1.4.2.1 Engine-Generator. Set Data:

a. Manufacturer of engine
b. Type or model of engine
c. Gross bhp rating of engine
d. Net bhp rating of engine
e. Strokes per cycle
f. Number of cylinders
g. Bore and stroke, inches
h. Engine speed, rpm
i. Maximum piston speed, fpm
j. BMEP at full load (psig)
k. kin rating of generator
I. kVA rating of generator and power factor
m. Gross kW rating of engine-generator set
n. Net kin rating of engine-generator set
o. Make of turbocharger(s)
p. Altitude basis for ratings
q. Maximum safe lubricating oil temperature from engine

Gross rating shall be the total rated power output before deducting power requirements of any electric motor-driven equipment. Net ratings shall be equal to gross ratings minus the total power requirements of electric motor-driven accessories normally constituting part of "Engine Assembly" as defined in DEMA publication "Standard Practices for Stationary Diesel and Gas Engines" and hereinafter referenced as DEMA requirements. Net ratings shall include a deduction in power output for the following examples of parasitic loads:

a. Scavenging blower with auxiliary equipment for two-cycle engines only.

b. Lubricating oil pumps for lubricating oil circulation and piston cooling service.

c. Fuel oil booster pump.

d. cooling system power requirements including pumps, radiator fans, and any other power consuming devices required to provide engine cooling as specified. Some of these devices may be either electric motor-driven or engine-driven. Engine net output rating shall be reduced by the horsepower required to operate the engine-driven devices where not already done so by. the engine manufacturer. Corrections shall be made to engine output (or generator output) for

the electric motor-driven devices to determine the net rating of the engine-generator set. It may not be possible to estimate engine-driven loads for a manufacturer's standard plant test. In this case the net rating shall be further reduced by applying corrections for the cooling system provided to obtain a net power output exclusive of all parasitic loads.

1.4.3 Factory Tests: Submit certified factory test report within 15 days after completion of the tests. Provide in accordance with the requirements set forth in the paragraph "Factory Test and Inspection Requirements" for the following:

a. Engine Tests.
b. Generator Tests.

1.4.4 Shop Drawings: Submit shop drawings as listed below.

1.4.4.1 Submit drawings pertaining to the engine-generator set and auxiliary equipment, including the following:

a. Certified outline plan, general arrangement (setting plan), and anchor bolt details. Drawings shall show the total weight and center of gravity of the assembled equipment on the structural steel subbase.

b. General arrangement, size, and location of all electrical interface points and detailed elementary, schematic, wiring, and interconnection diagrams of the generator, exciter, governor, and other integral devices.

c. Dimensional drawings or catalog cuts of exhaust and intake silencers, intake filters, pumps, tanks, oil filters, starting equipment, and other auxiliary equipment.

d. General arrangement or assembly drawings showing location of major auxiliary equipment in relation to the engine-generator set.

e. Heat balance diagrams of the coolant system and operating temperature levels.

f. Piping schematics for fuel oil and engine coolant showing pipe sizes and valve' locations.

g. Engine-generator control panel.

1.4.5 Plan for Acceptance Test a: Furnish a written acceptance test plan at least 10 days prior to the acceptance test date. The plan shall delineate the inspections and testing procedures required to demonstrate compliance with the requirements specified in the paragraph titled "Engine-Generator Set Acceptance Tests". The test plan shall indicate how the system is to be tested, what variables will be monitored during test, names of individuals performing tests, and what criteria for acceptance should be used.

1.4.6 Government Approval: Government approval is required for the diesel engine-generator set.

1.4.7 Tools, Testing Equipment, and Spare Parts: Submit a recommended list for each item of equipment. Include all special tools and wrenches required for the installation or erection, maintenance, and operation of the equipment. Include part number, drawing number, current unit prices, and source of supply.

1.4.8 Posted Operating Instructions: Submit proposed operating instructions which shall be laminated between matte-surface thermoplastic sheets and be suitable for placement adjacent to applicable equipment. After approval, operating instructions shall be returned to the Contractor for installation where directed.

1.4.9 Manuals: Provide five sets of operation and maintenance manuals for equipment as listed. Identification symbols for all replaceable parts and assemblies shall be included. Information in manuals shall be comprehensive and specific and provide, but not be limited to, all data submitted previously.

a. Engine-generator sets and associated equipment, including governor, voltage regulator, and control panel. Manual shall include fuel adjustment procedures.

1.4.10 Field Test Reports: Submit test and inspection reports for all work required under the paragraph "FIELD TESTS AND INSPECTIONS".

1.5 FACTORY TESTS AND INSPECTIONS: Perform and report on factory tests prior to shipment. Provide certified copies of all manufacturer’s test data and results. Notify Contracting Officer before performing tests. Contracting Officer or his representative reserves the right to witness all tests. Test procedures shall conform to ASME, IEEE, and ANSI Standards, and the DEMA requirements on testing, as appropriate and applicable. Equipment necessary for test shall be provided by the manufacturer performing the tests, and all measuring and indicating devices shall be certified correct or correction data furnished for the device. Tests shall indicate satisfactory operation and specified performance. If satisfactory, equipment tested will be given a tentative approval. Contractor shall not ship equipment without approval of the factory test reports.

1.5.1 Engine Tests: Perform customary commercial factory tests on each engine, including, but not necessarily limited to, the following:

a. Perform hydrostatic test on water jackets and piping to ensure that water seals and water jackets are water tight. Test report shall indicate pressure at which test was made and the results.

b. Place engine-generator set in continuous operation without stoppage for a period of not less than 8 hours. Operate not less than one hour at each load point (1/2, 3/4, and full load). If stoppage becomes necessary during this period, repeat the 8-hour run. Record the following data for all sets at the start, at 15-minute intervals, and at the end of each load run: Fuel consumption; exhaust temperatures; engine coolant temperatures; lubricating oil temperatures and pressures; and any other data of importance.

1.5.2 Generator Tests: Temperature tests on one generator's windings shall be performed by the manufacturer of the generator in his own plant. Temperature tests shall be in accordance with IFEE 115. Generator tests shall include insulation resistance and dielectric resistance. Prototype tests for generators that are physically and electrically identical to those provided under the Contract are acceptable. Calculations of the subtransient reactance shall be included in the test report.

1.5.3 Test for Radio Frequency Interference (RFI): Conduct test in accordance with Mil. Spec. MIL-S-16165 and MIL-STD-461. All testing equipment, instruments, personnel for making the tests, the test location which shall be reasonably free from radiated and. conducted interference, and other necessary facilities shall be furnished by the Contractor. Tests for RFI will not be required for items that are physically and electrically identical to those that have previously met the requirements of the above specifications.

1.6 SAFETY REQUIREMENTS: Design and install devices to comply with the following requirements:

a. Power Transmission Apparatus: Guard in accordance with ANSI B15.1.

b. Electrical Installations: Conform to NFPA 70.

c. Operator Protection: Guard in accordance with CFR 29 as follows:

(1) Fan Blades: Fart 1910.212(a)(5).

d. Mercury: Use of mercury in instruments, contacts, and manometers is not permitted.

1.7 DELIVERY AND STORAGE: The equipment specified herein shall be delivered on pallets or blocking and with each entire unit or palletized unit wrapped in heavy-duty plastic wrapping, sealed to protect all parts and assemblies from moisture and dirt. All piping, conduit, exhaust, and air intake openings shall be plugged and sealed shut. Batteries shall be protected and prepared for shipment as recommended by the battery manufacturer. All equipment and allied equipment shall be stored at the site

in covered enclosures, protected from atmospheric moisture, dirt, and ground water. Each package shall be properly identified on the exterior of the wrapping as to the identity of the enclosed equipment, contract number, manufacturer, and purchaser. The manufacturer's standard practice in product protection and identification, meeting the above requirements, will be acceptable.

1.8 SITE CONDITIONS: The components of the engine-generator set, including cooling system components, pumps, fans, and similar auxiliaries, shall be suitable and capable of the specified outputs in the following environment:

a. Site Location: [_____.]

b. Site Elevation: [_____] feet above mean sea level.

c. Ambient Temperatures:

(1) Maximum [_____] F dry bulb [_____] F wet bulb.
(2) Minimum [_____] F dry bulb.

d. Seismic zone: [____] as defined by [the Uniform Building Code] [_____].

e. Design Wind Velocity: [_____] mph.

f. Prevailing Wind Direction: [_____]

g. Atmospheric Conditions: Moist.

NOTE: ADD OTNER SITE CONDITIONS WHICH IMPACT SET CHARACTERISTICS.

1.9 MANUFACTURER'S REPRESENTATIVE: Furnish the service of one or more Diesel-Generator representative or technicians, experienced in the installation and operation of the type of systems being provided, to supervise the installation, testing, adjustment of the system, and to instruct Government personnel.

PART 2 - PRODUCTS

2.1 MATERIALS: Use materials and equipment essentially the standard catalogued products of manufacturers regularly engaged in production of such materials or equipment, and the manufacturer's latest standard design that complies with specification requirements. Where two units of the same class of equipment are required, these units shall be products of a single manufacturer; however, component parts of the system need not be products of the same manufacturer. Each major component of equipment shall have the manufacturer's name, address, and model and serial number on a nameplate securely affixed in a conspicuous place; nameplate of the distributing agent will not be acceptable. Nameplates shall not be painted.

2.2 ENGINE-GENERATOR SET: Provide engine-generator set correctly coordinated by the engine-generator manufacturer to assure an installed rating in the environment described in the paragraph "Site Conditions". The set shall consist of a diesel engine direct-connected to an alternating-current generator having a brushless excitation system, and shall be provided with all necessary accessories, auxiliaries, appurtenances, control equipment, and cooling systems, resulting in a complete set and, except for external service connections, ready for operation. Engine-generator set shall be mounted on a structural steel subbase sized to support the engine; generator-exciter, engine-generator control panel; lubricating oil filters, heat exchangers and pump; fuel oil filters, fuel tank, and pumps; jacket coolant heat exchangers and pumps; and interconnecting piping and wiring for all systems. Engine unit-mounted radiators and auxiliaries shall also be mounted on the engine-generator set subbase. The engine-generator set shall include the electric starter, controls, and related wiring for electric starting. The batteries, battery racks and charger assembly shall be mounted on the set subbase. The structural subbase shall be provided with vibration isolators suitable for the loads and lateral forces involved in seismic zones. Isolators shall be as recommended by the engine-generator set and isolator manufacturer to suit the specific equipment involved. Electrical and mechanical field connections shall be made with flexible connectors. Engine and generator shall be factory aligned on the subbase and securely bolted into place in accordance with the manufacturer's standard practice. The engine-generator set, after assembly, shall be painted overall with [the manufacturer's standard paints and colors] [_____]. After tests and before shipping, the set shall be thoroughly cleaned and the painting retouched as necessary to provide complete protection to the set. The manufacturer shall provide one gallon of the identical paint in the paint manufacturer's sealed containers with the engine-generator set. The engine-generator set shall be capable of remote-starting, coming up to synchronous speed, and providing full rated power within 10 seconds after start-up initiation. Engine-generator set shall be' completely housed in a weatherproof enclosure for outdoor installation.

2.2.1 Weatherproof Enclosure: The enclosure shall consist of a roof, underframe, two side walls and two end walls of prepainted aluminum stressed skin construction and shall comply with the following design criteria:

2.2.1.1 Weatherproof, walk-in type enclosure.

2.2.1.2 Rigidity wind test equal to 150 miles per hour.

2.2.1.3 Roof load equal to 50 pounds- per square foot.

2.2.1.4 Floor loading 200 pounds per square foot of equally distributed load.

2.2.1.5 Rain test equal of 5 inches per hour.

2.2.1.6 Flooring: 3/4 inch tongue and groove exterior for plywood subfloor with 1/8 inch diamond plate steel floor.

2.2. 1.7 Personnel Door: Aluminum frame with prepainted aluminum panels fully gasketed.

2.2.2 Equipment Rating and Capability: The engine -generator set shall have a net continuous rating capacity of not less than 600kW at 0.8 power factor and shall be designed to supply 480Y/277 -volt, 60-hertz alternating current output. All auxiliary equipment furnished shall be designed for continuous duty at 100 percent of rated net capacity of the engine -generator set. All cooling system components and auxiliaries shall be properly sized relative to the engine coolant specified under cooling system. The engine-generator set shall be able to start the largest motor load while all other loads are operating with no more than 15 per cent voltage dip at the engine-generator set output terminals.

2.2.3 Critical Speeds: The complete engine -generator set shall be free of critical speeds of either a major or minor order that will endanger satisfactory operation of the set. Satisfactory operation will be considered endangered, if torsional vibration stresses exceed 5,000 psi within 10 percent above or below rated engine speed.

2.3 DESIGN AND CONSTRUCTION: Rotating or reciprocating parts, or other parts that may present a hazard to operating personnel, shall be isolated or shielded to minimize danger.

2.3.1 Space Heaters: Space heaters shall De thermostatically controlled and shall be provided in the enclosures of generators and exciters. Heaters shall be 120-volt AC, single- phase, of ratings as recommended by the manufacturer for the atmosphere specified under the paragraph "Site Conditions".

2.3.2 Diesel Engines: Comply with Mil. Spec. MIL -S-16165 relative to radiated radio interference. For generators and other devices capable of producing radio interference comply with MIL -5TD-461 relative to radiated and conducted radio interference.

2.3.3 Fungus Control: For electrical components, fungus control is required as follows:

a. Electrical components such as switches, fuses, contacts, and heater elements shall not be treated. Other materials and components which are inherently fungus -resistant or are protected by hermetic sealing need not be treated.

b. Circuit elements, not covered above and which have a temperature rise of not more than 75 degrees. F when operating at full load, shall be coated with a fungus -resistant varnish conforming to Mil. Spec. MIL-V-173. The method of treatment shall be in accordance with Mil. Spec. MIL-T-152. Circuit elements include, but are not limited to, cable, wire, terminal and junction blocks, junction boxes, capacitors, and coils.

c. Circuit elements, such as motor coils, generator and transformer windings, and similar electrical components, which have a temperature rise exceeding 75 degrees F when operating at full load, shall not be coated with a fungitoxic compound. Instead, such components shall be given two initial coats of varnish and one seal coat 9f varnish, all conforming to Mil. Spec. MIL-I-24092, Class 220, Type M. The coats shall be applied by the vacuum-pressure immersion, centrifugal, pulsating pressure, or built-up method so as to fill all interstices in the coils and preclude the entrapment of air or moisture.

2.4 DIESEL ENGINES AND ACCESSORIES: Engine shall be four-cycle, turbocharged and not intercooled or turbocharged and intercooled; vertical In-line or vertical Vee type; designed for continuous duty, stationary service. Design and construct the engine so as to eliminate undue heating, vibration, and wear and be efficient and trouble free in operation. Engine shall be capable of operating on diesel fuel oil conforming to Fed. Spec. VV-F-800 (Grade DF-2) [and] [Mil. Spec. MIL-T-5624 (Grade iP-4)] [Mil. Spec. MIL-T-5624 (Grade JP-5)] [Mil. Spec. MIL-T-83133 (JP-8)]. [If fuel additives are required in order to safely operate on Grade JP-4, a conspicuous warning shall be permanently attached to the engine-generator set. The warning shall state the requirement for additive(s) in minimum 1 inch high lettering. In addition, a warning shall be permanently attached to the fuel filler cap.] Limiting characteristics of the engines shall be as follows:

a. Maximum brake mean effective pressure, psi:

Turbocharged Not Intercooled	Turbo charged And Intercooled
150	185

b. Maximum engine speed, RPM: 1,800.

2.4.1 General Construction: Engine shall be constructed to withstand sudden changes from no load to rated load, and to preserve alignment of integral components under all conditions of operation. The design shall incorporate pressure lubrication of bearings and wrist pins, and the bearing journals shall be hardened or chromium plated to provide a hand shock-resistant surface with ductile core. Crankshafts shall be counterbalanced to reduce vibration to a minimum. Crankshaft and connecting rod bearings shall be the replaceable precision sleeve type. Cylinders shall be provided with replaceable liners. The piston rings shall be constructed of a heat-resisting alloy steel or chromium plated cast-iron. Camshafts shall be gear driven, and shall be high wear- resistant, at cams and journals. Timing marks shall be clearly indicated on the crankshaft and

gears. Valves shall have removable stem guides and seat inserts. The flywheel shall be balanced, and shall be capable of being rotated 50 percent above the maximum rated engine rotative speed without danger of breaking or exploding. Flywheel housing shall be provided with a drain hole at the lowest point. Means for turning the crankshaft manually shall be provided. The turbocharger lubricating oil system shall not be a separate system, but shall be a part of the engine lubricating oil system.

2.4.2 Assembly: Completely factory-assemble each engine. Mount turbocharger and intercooler and all piping integral with the engine, on the engine.

2.4.3 Engine Speed Governing System (ANSI Device 65): Provide each engine with a speed governing system and an independently driven overspeed limiting engine shutdown device. The speed governing system shall conform to IEEE 126, Section III, except as modified herein. Provide an adjustable isochronous governor, with suitable speed sensing. The governor shall maintain specified stability without hunting, cycling, or other irregularities. Governor shall include provisions for adjusting speed droop, load limit, and speed while the unit is in operation. Governor characteristics shall conform to the following:

a. Minimum range of speed changer (expressed as a percent of rated speed): minus 15 to plus 5 percent.

b. Observed speed band shall not exceed (expressed as a percent deviation of rated speed): plus or minus 0.25 percent.

c. Transient speed deviation shall not exceed (expressed as a percent of rated speed): plus or minus 3.0 percent.

d. Time to return to limits of b. above must not exceed (after sudden load change of c. above): 3 seconds.

e. Minimum manual speed regulation range adjustment (expressed as a percent of rated speed): 0 percent to 5 percent.

Provide governor with reversible synchronizing, direct-current motor or speed changer suitable for the starting battery voltage. Connect governor to the speed adjusting mechanism by a slip coupling to permit remote manual operation for mechanical governors or equivalent remote operation for electrical governing systems.

2.4.4 Engine Protective Devices: Provide engine with protective devices as follows:

a. Engine Shutdown: Equip engine with shutdown devices listed. These devices shall shut down the engine by shutting off the fuel supply to the fuel injectors. Shutdown devices shall be positive, direct in action and independent of the governor. Shutdown devices shall have factory-set fixed set-points, and shall be equipped with either auxiliary electrical contacts and cranking circuitry, relays or equivalent device. Auxiliary contacts shall be suitable for starting battery voltage. Shutdown shall open the generator main circuit breaker. Provide the following shutdown devices:

(1) Overspeed.device which operates if the engine and turbocharger lubricating oil pressure drop below a preset value.

(2) Pressure switch which operates if the engine and turbocharger lubricating oil pressure drop below a preset value.

(3) Temperature snitch which operates if jacket coolant temperature exceeds a preset value.

(4) Other shutdown devices as recommended or normally provided by the engine manufacturer.

b. Electrical Interlocks and Alarms: Equip throttle valves or starting mechanism with auxiliary contacts for interlocking with the generator main breaker control circuit as determined by manufacturer. Auxiliary contacts shall be suitable for starting battery voltage.

2.4.5 Engine Alarm Contact Devices: Equip each engine with alarm devices, relays, and auxiliary contacts, as required, to actuate alarm system on `the associated engine control panel. Auxiliary contacts shall be suitable for the starting battery voltage. Alarm devices shall have factory-set fixed setpoints. Provide the following alarm contact devices.

a. Throttle valve limit switch or starting mechanism contacts or equivalent device operating to energize a portion of alarm system only when the engine is running and not during cranking or shutdown.

b. Pressure switch in jacket coolant manifold piping at the engine to op rate if jacket coolant pressure drops below a preset value when the engine is running.

c. Pressure switch in engine and turbocharger lubricating oil system piping from engine to operate if pressure drops below a preset value due to failure of engine-driven lubricating oil pump.

d. Temperature switch in the jacket coolant discharge piping from the engine to operate if temperature exceeds a preset value. Device shall have an adjustable range between 100 and 212 degrees F.

e. Temperature switch in lubricating oil piping manifold leaving the engine to operate if temperature exceeds a preset value, or as recommended by the manufacturer.

f. Other alarm devices as recommended by the engine manufacturer.

g. A separate dry contact closure when any one of the alarm conditions listed above exists. The contact shall provide signal to the PCP annunciator in the control house.

2.4.6 Engine Accessories: Provide the following accessories for engine-generator set where recommended by the manufacturer:

a. Piping on engine-generator set to inlet and outlet connections, including all nonstandard companion flanges.

b. Foundation bolts, nuts, isolators, and sleeves for engine - generator set.

c. Level jack screws or shims (if applicable).

d. Chocks and shims for installation and leveling of engine - generator set subbase (if applicable).

e. Provide manually operated barring gear.

f. Indicating thermometer or temperature indicator per manufacturer s standard on engine coolant inlet and outlet and, where it is a separate circuit, provide an indicating thermometer on the turbocharger intercooler outlet.

g. Drilled and tapped holes for attachment of manometer to measure crankcase pressure or vacuum, if standard with the manufacturer.

h. Removable guard or housing, if required, around flywheel, generator, and exciter. Support guard or housing entirely on either the engine or the subbase and to suit manufacturer's standard.

2.4.7 Air Intake and Exhaust Systems: Provide air intake and exhaust system. Air intake system shall be mounted on or supported form the engine subbase assembly. Include piping, fittings, and expansion joints necessary to interconnect equipment with the engine.

a. Air Intake Filters: Provide dry type filter for the engine as standard with the engine manufacturer. Filter shall be capable of removing a minimum of 92 percent of dirt and abrasive 3 microns and larger, from intake air. Size filter to suit engine requirements at 100 percent of rated full load. The unit shall be designed to permit easy access to the filter for maintenance purposes.

b. Exhaust Silencers: Provide an exhaust silencer for engine to reduce the exhaust sound spectrum to, or below, the following listed levels, when measured with a sound level meter conforming to ASA 47, 75 feet from the outlet, under full engine load and clear weather: Silencer shall be complete with handhole openings and all necessary brackets for supporting purposes. Sizing of silencer shall be in accordance with the engine and silencer manufacturer's recommendations. Flanged inlet and outlet connections shall be provided. Silencer shall be mounted above the roof of the outdoor enclosure.

Frequency Range - Hertz			Maximum Sound Level - Decibels
20	to	75	87
75	to	150	77
150	to	300	70
300	to	600	64
600	to	1200	61
1200	to	2400	60
2400	to	4800	60
4800	to	10000	62

c. Expansion (Flexible) Joints: Provide suitable sections of multiple corrugated stainless steel expansion joints with liners in the engine exhaust piping for engine to absorb expansion strains and vibration in the piping. Flexible joints in exhaust piping shall be suitable for continuous operation at 200 degrees F above the normal exhaust gas temperature at 100 percent load. Air intake expansion joints shall be as specified for exhaust piping or may be metal reinforced rubber type suitable for the service. Joints shall be of the same size as the pipe and provided with flanged connections conforming t~ drilling dimensions of ANSI B16.1 for 125 pound flanges. Air intake expansion joints may be for plain end pipe.

d. Air Intake Piping: Conform to the manufacturer's recommendations as to size, type, and connections.

e. Exhaust Piping: Provide piping for engine complete with necessary fittings, flanges, gaskets, bolts, and nuts. Pipe shall be lap-welded, or seamless steel pipe conforming to ASTM A53. Exhaust piping shall be Schedule 40 pipe for sizes 12 inches and smaller and for larger sizes shall have wall thickness not less than 0.375 -inch. Exhaust piping shall slope away from engine. Flanges shall be 150-pound slip-on forged steel welding flanges conforming to ANSI B16.5, with material in accordance with ASTM A181, Grade I. Fittings shall be butt- welding conforming to ASTM A234, with wall thickness same as adjoining piping. Built-up miter welded fittings may be used. Fittings shall be of same material as pipe. Miter angles of each individual section shall not exceed 22.5 degrees' total and not

more than 11.25 degrees relative to the axis of the pipe at any one cut. Gaskets for piping shall be of high temperature asbestos -free material suitable for the service. Bolting materials for exhaust flanges shall be alloy-steel bolt-studs conforming to ASTM Al93, and alloy-steel nuts conforming to ASTM A194. Bolts shall be of sufficient length to obtain full bearing on the nuts and shall project not more than two full threads beyond the nut.

2.5 GENERATORS AND EXCITATION AND VOLTAGE REGULATION SYSTEM:

2.5.1 Generator: Provide 0.80 power factor, synchronous, alternating-current, brushless-excited revolving field, air-cooled, self-ventilated unit conforming to NEMA MG 1 and rated as specified in Paragraph 2.2.2, entitled "Equipment Rating and Capability". Enclosure frame shall be dripproof. Match generator speed to that of the engine. Drive generator directly from the engine crankshaft in a manner approved by both the engine and generator manufacturers. Generator shall be capable of carrying at rated voltage and 0.8 power-factor, a load equal to the net kW rating of the engine without exceeding the temperature limits specified in NEMA MG 1 for continuous duty. For addition of load up to and including 100 percent of rated load, at 0.8 power factor, the transient voltage dip shall not exceed 35 percent of rated voltage. The voltage shall recover to and remain within the steady state band in not more than 5.0 seconds. Winding insulation shall be Class B or F. An amortisser winding shall be provided and the generator and flywheel shall have sufficient flywheel effect to meet the requirements of regulation specified. Generator field. voltage shall be the manufacturer' s standard voltage. The generator neutral and enclosure shall be grounded as indicated.

2.5.2 Excitation and Voltage Regulation Systems: Comply with IEEE 421.

2.5.2.1 Exciter: The exciter shall be integral with the generator and shall be of the synchronous, rotating armature, rotating rectifier type. The rotating rectifier assembly shall be mounted in a manner to provide ready access for inspection and replacement of the rectifier diodes. Semiconductor rectifiers shall have minimum factor of safety of 300 percent for peak inverse voltage, and forward current ratings for all operating conditions, including 100 percent generator output at 40 degrees C ambient. Safety devices for the protection of the rectifiers against overload currents and voltages shall be provided unless the design provides this protection inherently. The acceptable ratio of exciter ceiling voltage to exciter nominal voltage shall be not less than three to two Exciter shall be equipped with surge protection devices. Output of exciter alternator shall be three-phase and shall be rectified by full-wave solid-state rotating rectifier mounted on the generator shaft. Rotating rectifier shall consist of hermetically sealed diodes connected between exciter and generator field without intervening brushes, slip-rings, or commutators. Exciter field shall be stationary.

2.5.2.2 Voltage Regulator (ANSI Device 90): The voltage regulator shall be solid state and shall automatically control the generator field current through action on the exciter. The reference voltage shall be three-phase averaged and shall be obtained from the generator output transformers, if required. The voltage regulator shall enable manual adjustment of the set output voltage, while the set is operating, by potentiometer adjustment at the generator control panel. Provide automatic field flashing using power from the starting battery and suitable means to limit the flashing current to a safe value with controls for the circuit, to be installed in the generator control panel.

a. Mounting: Install instrument transformers and the voltage regulator in the generator control panel along with a manual voltage setting control system consisting of a manual voltage adjusting rheostat or variable autotransformer and a manual-automatic-off switch.

b. Regulation: The voltage regulator/excitation systems shall be capable of voltage regulation within plus or minus 1/2 percent from no-load to full-load, and capable of maintaining a long- time voltage stability of within plus or minus 1 percent. A 5 percent variation in frequency and the effects of field heating shall not affect the units regulation performance. Provide full-field-forcing series boost excitation system supplied as necessary and in conjunction with the voltage regulator to furnish a relatively constant voltage to the regulation power stage during all operating conditions including generator overload and short circuit.

c. EMI Suppression: Provide as an integral part of the regulator, electromagnetic interference (EMI) suppression for conducted and radiation emissions complying with MIL-STD-461, Class C2.

2.6 FUEL OIL SYSTEM: Conform to NFPA 30 and NFPA 37 and the requirements herein.

2.6.1 Fuel Oil Tanks: Provide subbase-mounted tank with a minimum capacity of 350 gallons. Construct tank of not less than 3/16 inch steel plate, with welded joints and necessary stiffeners on exterior of tank and provide an adequately braced structural steel framework support. Provide tank with a level gauge and makeup control valve. Include connections of the indicated sizes for inlet, outlet, overflow, vent, drain, and level controller and high and low level alarm switches.

2.6.1.1 Level Alarm Switches: Provide tank-top mounted or external float cage, single-pole, single-throw type designed for use on fuel oil tanks. Arrange high level alarm switches to close on rise of liquid level, and low level alarm switches to close on fall of liquid level. Mount float cage units, where used, with isolating and drain valves. Contacts shall be suitable for the starting battery voltage.

2.6.1.2 Tank Gauges: Provide tank gauges conforming to Mil. Spec. MIL-G-17713 for the fuel oil tank. Gauges for fuel oil tanks shall be buoyant force type, with dial indicator not less than 4-inch in size and arranged for side mounting. Each reading dial or scale shall be calibrated for its specific tank to read from empty to full, with intermediate points of 1/4, 1/2, and 3/4.

2.6.2 Duplex Fuel Oil Stainer: Provide the type having two straining chambers and arranged to divert the flow from one chamber to the other without interruption at any point of the change over. Design shall allow for cleaning by permitting removal of the strainer basket not in use while the other strainer basket is in use. Construct strainer baskets of corrosion-resistant metal. Strainer mesh, type, and free area shall be as recommended by the engine manufacturer.

2.6.3 Fuel Oil Meters: Provide positive displacement type. Maximum variation from absolute accuracy measurement over entire range of meter shall be not greater than two-tenths of one percent. Provide meters with horizontal setback registers and calibrated to read in gallons and tenths of gallons. Construct meters with cast-iron bodies, with working parts made of corrosion-resistant steel to resist wear, friction, and corrosion and suitable for handling oil containing a small percentage of sulphur.

2.7 LUBRICATING OIL SYSTEM:

2.7.1 Auxiliary Lubricating Oil Pumps: Where recommended by the engine manufacturer, provide one pump suitable for "before-and-after" lubricating and cooling service as required by the engine. Equip pump with a bypass relief valve.

2.7.2 Lubricating Oil Filtration: Provide engine with a pressurized lubricating oil filtration system capable of filtering the full rate of oil flow from the oil pump(s) at the maximum engine speed in accordance with the standard practice of the engine manufacturer. Means shall be provided to ensure delivery of lubricating oil to vital wearing surfaces regardless of the condition of the filter(s) without removing the engine from service. Additionally, the filter(s) must provide means of automatically bypassing the filter if it should become flow-restricting. All filter elements shall be of the throwaway type with filter elements as recommended by the engine manufacturer. Two spare replacement elements in their original containers shall be provided for each filter with each unit.

2.7.3 Lubricating Oil Coolers: If recommended by the engine manufacturer, coolers shall be provided for engine to maintain the lubricating oil within the temperature limits recommended by the engine manufacturer under all operating conditions. The coolant system and components shall be as normally specified by the engine manufacturer for use with the class of engine being provided, and the cooling medium to be used. Engine jacket coolant from the radiator shall be used as cooling medium. Each thermostat used in the oil cooling system shall be of the nonadjustable type and factory set at the temperature recommended by the engine manufacturer.

2.7.4 Thermostatic Control Valves: If recommended and standard practice with the engine manufacturer for the proposed engine, provide a valve installed in the lubricating oil system for each engine to maintain a constant lubricating oil temperature from the engine. Valve shall be as specified in the paragraph "Thermostatic Control Valve". Valve shall be capable of passing the total lubricating oil flow requirement of the engine as determined by the engine manufacturer with a pressure drop across the valve not the exceed 5 psi.

2.8 COOLING SYSTEM: Cooling systems shall be of the type specified. If the engine manufacturer considers that a different arrangement is more suitable for the engine to be installed, the Contractor may submit to Contracting Officer information on the proposed cooling system arrangement. If proposed arrangement is approved by the Contracting Officer, the Contractor shall provide the proposed system at a suitable reduction in contract price. Coolant shall be as specified in the paragraph Radiators

2.8.1 Jacket Coolant Pumps: Provide one pump for each engine driven from engine-generator set unit crankshaft or camshaft. Each pump shall have ample capacity to circulate the required flow of coolant. specified through the system to remove the total heat rejected from the engine and, where provided by design, from the lubricating oil and intercoolers. Heat shall be rejected to the jacket coolant to maintain optimum jacket coolant temperature leaving and entering engine as recommended by the engine manufacturer.

2.8.2 Expansion Tanks: Provide one jacket water expansion - tank. Tank shall be the standard design as provided by the engine manufacturer. If the engine manufacturer has adopted use of a standpipe in lieu of the elevated expansion tank, the standpipe as sized by the engine manufacturer will be acceptable. Provide tank or standpipe with a gauge glass and pet cock assembly.

2.8.3 Radiators: Provide one radiator unit for engine -generator set. Provide engine subbase mounted radiator of the forced draft type with horizontal air discharge as standard with the engine manufacturer.

2.8.3.1 Design Conditions: Radiator unit shall have ample capacity to remove not less than the total Btu per hour of heat rejected by the engine at 100 percent full-rated load to the jacket coolant and lubricating oil system and that necessary for turbocharger intercooler. Radiator capacity shall be rated a-t optimum temperature of coolant leaving the engine and intercooler as recommended by the engine manufacturer, with a dry bulb air temperature of [110] [___] degrees F. Pressure drop through the radiator shall not exceed 6 psi when circulating the maximum required coolant flow, Radiator air velocity shall be a maximum of 900 feet per minute. Coolant solution shall be a mixture of clean water and a commercial standard ethylene glycol based coolant providing protection to [0][___] degrees F. Mixture shall be to the proportions recommended by the engine manufacturer to meet site conditions. Provide an antifreeze solution tester suitable for the solution used.

NOTE: USE TUE MAXIMUM DRY-BULB TEMPERATURE OF THE SITE PLUS 15 DEGREES, BUT NOT LESS THAN 110 DEGREES FOR TUE FIRST TEMPERATURE. USE ZERO DEGREES EXCEPT WHERE MINIMUM DRY-BULB TEMPERATURE PERMITS USE OF A HIGHER TEMPERATURE FOR THE SECOND TEMPERATURE.

2.8.3.2 Engine Subbase-Mounted Radiator Construction: The radiator fan shall direct the air flow from the engine outward through the radiator. The fan may be driven directly from the engine crankshaft through V-belt drive. The radiator shall have sufficient capacity to meet the design conditions against a static restriction of 0.5-inch of water as may be imposed by louvers and ductwork. Cooling section shall have a tube and fin type core. Engine-driven fans shall be the engine manufacturer's standard units, selected for quiet vibration-free operation. Provision shall be made for coolant expansion either by self-contained expansion tanks or separately mounted expansion tanks, as standard with the manufacturer. Provide suitable guards for each fan and drive.

2.8.4 Thermostatic Control Valves: If recommended and standard with the engine manufacturer for the proposed engine, provide a valve installed in the jacket coolant system for the engine to maintain a constant jacket coolant temperature from the engine. Valve shall be capable of passing coolant flow, as determined by the engine manufacturer.

2.8.5 Starting Aids: A factory-installed, electrically-operated, jacket coolant heating system shall be provided to ensure rapid starting. The heater shall be thermostatically controlled at the temperature recommended by the engine manufacturer. Power leads shall be brought to a junction box which shall provide fusing and manual disconnection of the heater. Installation shall include all necessary equipment, piping, controls, wiring, and accessories. Heater shall be 208V., 60 Hz.

2.9 ELECTRIC STARTING SYSTEM: A [24] [___] volt direct-current starting battery installation shall be provided for starting of the engine-generator set utilizing an electric cranking system. The electric cranking system shall be capable of rotating the engine at a speed sufficient for rapid starting in an ambient temperature of [20] [___] degrees F. The signal for starting shall come from the engine- generator set control system.

2.9.1 Cranking: The electric cranking system shall be energized from the starting batteries' negative polarity grounded, direct-current (DC) electrical circuit. The cranking motor(s) shall be of the heavy-duty type with adequate capacity to crank the engine continuously to start the engine. The drive mechanism for engaging the starting motor(s) with the engine flywheel shall be designed to inherently engage and release without binding. When the engine starts, a "stop cranking" switch shall be engine-speed actuated and shall cause disengagement of the starting gearing and the shutdown of the starting motor(s). The automatic cranking panel shall crank the engine as specified under the paragraph "Engine Cranking Relay".

2.9.2 Starting Battery Installation: Lead acid storage batteries shall be provided and shall be of sufficient size and capacity in a fully charged condition to start the engine-generator set six consecutive times. Suitable battery racks or enclosures, properly ventilated shall be provided for the batteries and charger. All necessary cabling shall be provided.

2.9.3 Starting Battery Charger: The battery charger shall be enclosed, automatic, dual-rate, solid-state, constant voltage type having AC voltage compensation, DC voltage regulation, and shall be current limiting. The charger shall employ transistor-controlled magnetic amplifier circuits to provide continuous taper charging. Charger shall have two ranges, float and equalize, with 0 to 24 hour equalizer time, DC cranking relay, silicon diode full-wave rectifiers, automatic surge suppressers, DC ammeter, DC voltmeter, and fused inputs and outputs. Charger shall have a continuous rated output of not less than 10 amperes. Battery charger shall conform to UL 1236.

2.10 PIPING SYSTEMS:

2.10.1 Fuel Oil and Lubricating Oil Piping System: Piping systems shall conform to the following, except that factory-installed piping may conform to the engine-generator set manufacturer's standards:

2.10.1.1 Piping: Provide seamless steel, conforming to ASTM A53, Grade A. Screwed piping, 1-1/2 inch and smaller, shall be Schedule 80; all other piping shall be Schedule 40. The Contractor may substitute Fed. Spec. WW-T-799 Type K copper tubing with wrought copper, high - temperature soldered or threaded fittings, where the use of copper piping is standard with the unit manufacturer. Threaded adapters or flanges shall be used at all valves and equipment connections.

2.10.1.2 Fittings and Flanges: Fittings for steel piping, 1-1/2 inch and smaller, shall be 3,000-pound forged steel socket welding, conforming to ANSI B16.11. Fittings, 2-inch and larger, shall be steel butt-welding, conforming to ANSI B16.9. Flanges shall be per ANSI B16.5 for 150-pound slip-on or welding neck forged steel welding flanges, material conforming to ASTM Al81. Provide flat face flanges for connecting to 125-pound standard cast-iron valves, fittings, and equipment connections.

2.10.1.3 Unions: For steel piping, 1-1/2 inch and smaller, unions shall conform to MSS SP-83 with socket welding ends. For piping 2-inch and larger a pair of flanges may be used in lieu of a union.

2.10.1.4 Plug Valves: Utilize lubricated tapered plug type in conformance with Mil. Spec. MIL-V-12003, 125 pound class. Valves, 4 inch and smaller, shall be wrench-operated. Valves, 1-1/2 inch and smaller, shall have screwed ends. Valves 2 inch and larger, shall have flanged ends.

2.10.1.5 Gaskets: Provide woven nonasbestos fibers with fluorocarbon plastic binder or compressed with nitrile or neoprene binder suitable for either diesel fuel oil or lubricating oil.

2.10.2 Bolts, Studs, and Nuts:

2.10.2.1 For Temperatures Up to 450 Degrees F: Material for bolts or studs shall be ASTM A307, Grade B, and for nuts ASTM A194, Grade 2. Threads and dimensions for bolts or studs shall comply with ANSI B18.2.1 for square head dimensions.

2.10.2.2 For Temperatures over 450 Degrees F: Materials for bolts or studs shall be ASTM A193, Grade B7, and for nuts ASTM A194, Grade 7. Threads and dimensions for bolts or studs shall comply with ANSI B18.2.1 for square head dimensions and with ANSI B1.1 coarse-thread series, for one inch and smaller.

2.11 ENGINE-GENERATOR SET CONTROLS: Provide an engine-generator control panel mounted on the engine-generator set subbase, and a remote alarm panel.

2.11.1 Construction: Provide an enclosed panel fabricated of not lighter than 14-gauge sheet steel in compliance with NEMA 250, Type 3R. Construct cabinet with angle iron framework, if required, for proper stiffness and support. Size the cabinet to accommodate the equipment specified herein when arranged in an orderly and approved manner. Factory-mount panel on the engine unit subbase. Use isolation mounting material between the subbase and the panel to isolate the panel from engine vibrations. Provide all panel-mounted, devices with suitable nameplates of laminated black gloss-finished plastic with white engraved lettering. Provide all connecting piping, tubing, and wiring installed in conduit where not otherwise enclosed.

2.11.1.1 Engine Control Panel: Provide devices of the type standard with the manufacturer utilizing minimum 2 inch nominal diameter gauges. Instruments subject to rapid pressure surges shall be provided with dampening devices to give a steady reading. Provide the following panel-mounted devices as a minimum:

a. Engine Controls: Engine controls shall be installed on the generator control panel, except provide an emergency stop switch on the engine control panel

b. Engine Instrumentation:

(1) Fuel oil pressure gauge.
(2) Lube oil pressure gauge.
(3) Coolant temperature gauge.
(4) Elapsed time meter.
(5) Lube oil temperature gauge.
[(6) _____.]

c. Engine Safety Circuit Devices: Provide the following devices to stop the engine-generator set and to simultaneously open its main circuit breaker. The stop switch may be connected to this safety circuit if so recommended by the manufacturer. Source of energy for the engine safety circuit shall be the starting battery.

(1) Overcranking.
(2) Over speed.
(3) Excessive coolant temperature.
(4) Dangerously low lubricating oil pressure.

2.11.1.2 Generator Control Panel: Install these controls in the engine-generator control panel. Generator controls and instrumentation shall be provided as follows:

a. Generator Controls:

(1) Generator circuit breaker (ANSI Device 52).
(2) Voltage regulator and associated controls.

b. Generator Instrumentation:

(1) Voltmeter and control switch.
(2) Ammeter and control switch.
(3) Three current and three voltage (potential) transformers.
(4) Frequency meter.

c. Engine Starting and Stopping Controls and Protective Equipment

(1) Engine starting switch.
(2) Engine cranking relay.
(3) Engine shutdown relay.
(4) Surge arrester and capacitor assembly.

d. Remote Alarm Panel: Provide a remote alarm panel suitable for operation on the starting battery voltage. The panel shall consist of a factory-installed annunciator complying with 15A S 18.1. The annunciator shall be of the back lighted nameplate windows modular relay type. Relays shall be hermetically sealed of plug-in construction and nameplate windows shall be nominally 2 inch high by 3 inch wide and equipped with two long-life lamps per window audible alarm shall be a single-bell projector type having a noise level of not less than 95 decibels at 10 feet and provided with silencing switch. Provide the following alarms with prealarms provided only for temperature and pressure conditions and shutdown alarms for all conditions:

(1) High jacket coolant temperature
(2) High lubricating oil temperature
(3) Low lubricating oil temperature
(4) Low fuel oil pressure
(5) Engine shutdown due to overspeed
(6) Engine starting failure
(7) Normal voltage supply failure
(8) Restoration of normal supply voltage
(9) Control battery summary alarm
(10) Other engine-generator set abnormal conditions as recommended by the manufacturer

2.11.3 Generator Control Panel Devices: Conform to the following requirements for each device.

2.11.3.1 Generator Circuit Breaker (ANSI Device 52): Provide a circuit breaker having a solid-state tripping device with adjustable long-time and short-tine tripping characteristics. Provide a stored- energy closing mechanism for rapid and safe closing of the circuit breaker against fault currents within the short-time rating of the circuit breaker independent of the operator's strength or effort in closing the handle. Size the circuit breaker for the 100 percent full- load capacity of the engine-generator set and provide lugs for the indicated electrical connection.

a. Type: Provide a molded-case circuit breaker conforming to NEMA AB1 and UL 489 and having 100-percent rating. Switchboard construction shall conform to NEMA PB2 and UL 891.

b. Operation: All circuit breakers shall be manually operated.

2.11.3.2 Generator Voltage Adjustment: Install the manual voltage setting control system as specified under the paragraph Voltage Regulator

2.11.3.3 Governor Remote Control: Provide a governor "raise-lower" control switch to manually operate the electric motor or pneumatic speed changer specified under the paragraph "Engine Speed Governing System".

2.11.3.4 Instrument and Control Switches: Utilize rotary-enclosed, rear-mounted switches having positive means of maintaining contacts, which shall be silver-to-silver type, identifying escutcheon plates, and handle targets to indicate switch position. Utilize knurled handles for instrument switches, standard pistol grip handles for circuit breaker and governor control switches. Provide red and green indicating lights for circuit breaker control switches.

2.11.3.5 Indicating Lights: Provide front removable, low drain, push-to-test, indicating lights equipped with dropping resistors suitable for 120-volt AC service, as required and color caps as specified.

2.11.3.6 Instruments: Provide semiflush-mounted, rectangular, switchboard instruments with rear connecting terminals and conforming to ANSI C39.1. Construct with taut-band suspension movement and 250-degree scales in' a nominal 4.5-inch square case. Design and calibrate for vertical or horizontal mounting, as required. Elapsed time meters shall totalize engine running time to 9999.9 hours total.

2.11.3.7 Instrument Transformers: Provide indoor, dry-type conforming to ANSI C57.13.

2.11.3.8 Engine Starting Switch: The switch shall be a four-position rotary, enclosed rear mounting type. The switch shall be the maintained-position type. The switch positions shall be "Remote Start", "Off", "Test", and "Manual". The control wiring shall be coordinated with the Transfer Switch to provide the following:

a. In the "Remote Start" position, the engine-generator set shall start in response to remote start station signal.

b. In the "Off" position, the engine-generator set starting circuits shall not function.

c. In the "Test" position, the engine may be started and brought up to speed, but the engine-generator set cannot be put on line.

d. In the "Manual" position, the switch shall start and bring the engine-generator set up to speed.

2.11.3.9 Engine Cranking Relay: Provide to operate as follows:

a. When actuated, device shall close contacts to actuate the engine starting system.

b. - Should the engine fail to start at once, cranking shall continue for 25 seconds (adjustable) after which a 10-second "off" period (adjustable) shall occur, followed by a 7-second starting period (adjustable) and another 7-second "off" period (adjustable). Durations of cranking and "off" periods listed above may be modified in accordance with the engine manufacturer's recommendations.

c. The above cranking cycle shall be repeated for three starting attempts.

d. If the engine still fails to start, the cranking device shall lock out further starting attempts until it is manually reset. When the cranking relay locks out, an alarm light shall be energized on the panel and remain lighted until it is manually reset.

2.11.3.10 Engine Shutdown Relay: Provide and actuate by the engine protective devices as specified in the paragraph "Engine Safety Circuit Devices". Shutdown relay shall disable all engine starting circuits until manually reset. Provide reset pushbutton.

2.11.3.11 Surge Arrester and Capacitor Assemblies: Surge arrester and capacitor assemblies shall be installed and shall be designed for the engine-generator set voltage level. Surge arresters shall be of the metal-oxide type designed for a maximum 10-kiloampere discharge. Surge capacitors shall be specifically designed for use with the associated surge arrester. Capacitors for generators shall be provided with built - in resistors and shall be specifically designed for rotating machine protection.

2.12 MOTORS: Provide continuous-duty electric motors complying with NEMA MG1, unless motors are specified to be engine driven. Nameplate horsepower ratings shall be as required to drive associated equipment under the maximum specified conditions of operation without consideration of service factor. Provide induction motors with Class B insulation. Motors shall have general purpose drip-proof enclosures or shall be totally enclosed fan-cooled as specified or shown. Motors shall have sleeve bearings or grease-lubricated ball bearings.

2.12.1 Three-phase Motors: Provide single- or two-speed motors as specified or shown, squirrel cage type rated at the engine-generator set voltage level for 1/2 horsepower and larger units.

2.12.2 Single-Phase Motors: Provide motors rated 115 volts, 60-hertz for 1/3 horsepower and smaller units.

2.13 MOTOR CONTROL: Comply with the requirements specified in Section entitled "Interior Wiring Systems".

2.14 MISCELLANEOUS ENGINE SYSTEM REQUIREMENTS:

2.14.1 Flange Connections: Where not otherwise indicated, flange piping connections in accordance with ANSI B16.l for 125 pound flanges.

2.14.2 Thermostatic Control Valves: Valves shall be modulating type utilizing self-contained thermostats without the use of external bulbs, and equipped with three-way valve action. Provide valves with one or more interchangeable thermostatic elements. Thermostat shall be nonadjustable type, and the operating temperature shall be factory-set at the temperature recommended by the engine manufacturer. Design the valve to failsafe, permitting flow through the engine. Provide flanged connections in accordance with the paragraph "Flange Connections".

PART 3 - EXECUTION

3.1 INSTALLATION: Installation shall be in strict accordance with manufacturer's instructions. The Contractor shall provide all labor, tools, equipment, etc., for erection and installation of the equipment. Use cribbing and shoring as required to protect construction from moving-in damage.

3.1.1 Installation of Engine-Generator Set: Install engine- generator set on a concrete foundation as indicated. Provide vibration isolators to isolate vibrations from the engine-generator set to the foundation. Type, number, and arrangement of the isolators shall be as recommended by the manufacturer of the engine-generator set.

3.1.2 Piping: Piping connecting to engine and equipment mounted on the engine-generator subbase shall be factory installed and shall conform to the manufacturer's standards for the set sizes involved. All piping extensions from the engine-generator and subbase to fuel oil system shall comply with Division 15 Mechanical Specifications.

3.2 FIELD TESTS AND INSPECTIONS: Perform and report on all field tests and trial operations, and conduct all field inspections (except final field inspection). Provide all labor, calibrated and approved test equipment, including inductive load bank(s), recording volt, amp, and frequency meters of sufficient accuracy for the tests, and other incidentals required for the. tests. Contracting Officer will witness all field tests and trial operations and will conduct final field inspections. Give the Contracting Officer 5 working days notice of the dates and times scheduled for tests, trial operations, and inspections. All deficiencies found shall be rectified and work affected by such deficiencies shall be completely retested at the Contractor's expense.

3.2.1 Preliminary Operation: Make all necessary alignment and adjustments to equipment to assure proper operation as instructed by the manufacturers of the equipment. Lubricate equipment prior to operation in accordance with the manufacturer's instructions. Upon approval by the Contracting Officer or his authorized representative, operate engine-generator sets at varying loads throughout the load range for a sufficient time to demonstrate that operation is proper and that all pressures and temperatures are normal and within the specified limits. Operate engines for a period of time sufficient to assure that the units are ready to carry the test loads specified in paragraph "Engine- Generator Set Acceptance Tests" without damage to any of the engine parts. During this preliminary operation, check the operation of all auxiliary equipment furnished under this contract to determine that it is functioning properly, and make necessary adjustments to all equipment to place it in first-class operating condition in conformance with the contract requirements.

3.2.2 Electrical Equipment and Materials Tests:

a. Phase Relationship Tests: Check connections to all equipment for proper phase relationship. During such check, disconnect all devices which could be damaged by the application of voltage or reversed phase sequence.

b. Control Panel Tests: Test and adjust meters and relays in accordance with the applicable referenced -specifications.

c. Insulation Resistance Tests: Test all cables and equipment furnished. Minimum acceptable values of insulation resistance of circuits and equipment shall be as recommended by the manufacturer.

3.2.3 Engine-Generator Set Acceptance Tests: When installation is complete and in operating condition, notify the Contracting Officer in writing that the engine-generator set and auxiliary equipment are ready for final field tests. The Contracting Officer or his authorized representative will witness final acceptance tests. Conduct fuel consumption tests on the engine-generator sets to determine compliance with the specification requirements. Perform such other tests as necessary or desirable to make certain that all equipment is functioning properly. Test shall include the following:

a. A test to determine generating unit speed regulation under a gradual change from zero to full load.

b. A test to determine generating unit instantaneous speed change with 25 percent load on or off.

c. A test to assure proper functioning of the overspeed trip.

d. An individual test of each alarm device.

e. A test to assure that the generating unit can start the largest motor load while all other loads are operating and that the resulting voltage dip at the unit output terminals is no more than 15 per cent.

f. A continuous operation test for not less than one hour at 25, 50, 75 and 100 per cent of full load. Record the following data at the start, at 15-minute intervals, and at the end of each load run: engine coolant temperatures, lubricating oil temperatures and pressures; and any other data of importance.

3.2.3.1 Test Reruns: If the specified performance is not indicated by these tests, make such adjustments and changes, as necessary, and conduct additional tests, as necessary, to further check the performance of the equipment. Contractor shall bear all costs of such additional tests, including cost of fuel used.

3.2.3.2 Failure to Meet Requirements: In the event any of the equipment fails to meet specified performance or fails to operate satisfactorily, the Government shall have the right to operate the equipment until the defects have been corrected. Any equipment proved to be faulty or inadequate for the service specified will be rejected, but the Government shall have the right to operate the rejected equipment until such time as new equipment is provided by the Contractor to replace the equipment rejected.

-- END OF SECTION --