PART 1 GENERAL

1.1 REFERENCES

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.

AMERICAN NATIONAL STANDARDS INSTITUTE (ANSI)

ANSI B18.2.1	(1981; R 1992) Square and Hex Bolts and Screws Inch Series
ANSI C12.10	(1987) Electromechanical Watthour Meters
ANSI C37.16	(1988; Supp. 1994, R 1995) Switchgear - Low-Voltage Power Circuit Breakers and AC Power Circuit Protectors - Preferred Ratings, Related Requirements, and Application Recommendations
ANSI C37.17	(1979; R 1988) Trip Devices for AC and General-Purpose DC Low-Voltage Power Circuit Breakers
ANSI C39.1	(1981; R 1992) Electrical Analog Indicating Instruments
ANSI S1.4 (ASA 47)	(1983; R 1994) Sound Level Meters

AMERICAN PETROLEUM INSTITUTE (API)

API STD 599	(1994) Metal Plug Valves - Flanged and Welded Ends

AMERICAN SOCIETY OF MECHANICAL ENGINEERS (ASME)

ASME B1.1	(1989) Unified Inch Screw Threads (UN and UNR Thread Form)
ANSI/ASME B15.1	(1992; Errata 1992) Mechanical Power Transmission Apparatus
ASME/ANSI B16.1	(1989) Cast Iron Pipe Flanges and Flanged Fittings
ANSI/ASME B16.3	(1992) Malleable Iron Threaded Fittings
ASME/ANSI B16.5	(1988; Errata 1988) Pipe Flanges and Flanged Fittings
ASME/ANSI B16.9	(1993) Factory-Made Wrought Steel Buttwelding Fittings

ASME/ANSI B16.39	(1986; R 1994) Malleable Iron Threaded Pipe Unions Classes 150, 250, and 300
ASME/ANSI B31.9	(1988) Building Services Piping
ASME BPVC SEC VIII D1	(1995) Boiler and Pressure Vessel Code: Section VIII Pressure Vessels, Division 1

AMERICAN SOCIETY FOR TESTING AND MATERIALS (ASTM)

ASTM A 53	(1995) Pipe, Steel, Black and Hot-Dipped, Zinc-Coated Welded and Seamless
ASTM A 126	(1993) Gray Iron Castings for Valves Flanges, and Pipe Fittings
ASTM A 181/A 181M	(1995; Rev. A) Forgings, Carbon Steel, for General Purpose Piping
ASTM A 193/A 193M	(1995) Alloy-Steel and Stainless Steel Bolting Materials for High-Temperature Service
ASTM A 194/A 194M	(1995) Carbon and Alloy Steel Nuts for Bolts for High-Pressure and High-Temperature Service
ASTM A 234/A 234M	(1995; Rev. A) Piping Fittings of Wrought Carbon Steel and Alloy Steel for Moderate and Elevated Temperatures
ASTM A 307	(1994) Carbon Steel Bolts and Studs, 60,000 psi Tensile Strength

CODE OF FEDERAL REGULATIONS (CFR)

29 CFR 1910	Occupational Safety and Health Standards

INTERNATIONAL CONFERENCE OF BUILDING OFFICIALS (ICBO)

ICBO UBC	(1994) Uniform Building Code

INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS, INC. (IEEE)

IEEE 115	(1983; R 1991) Synchronous Machines
IEEE 421.1	(1986) Definitions for Excitation Systems for Synchronous Machines

IEEE C37.2	(1991) Electrical Power System Device Function Numbers
ANSI/IEEE C37.13	(1990) Low-Voltage AC Power Circuit Breakers Used in Enclosures
ANSI/IEEE C57.13	(1993) Instrument Transformers

MANUFACTURERS STANDARDIZATION SOCIETY OF THE VALVE AND FITTINGS INDUSTRY, INC. (MSS)

MSS SP-70	(1990) Cast Iron Gate Valves, Flanged and Threaded Ends
MSS SP-71	(1990) Cast Iron Swing Check Valves, Flanged and Threaded Ends
MSS SP-78	(1987; R 1992) Cast Iron Plug Valves, Flanged and Threaded Ends
MSS SP-80	(1987) Bronze Gate, Globe, Angle and Check Valves
MSS SP-85	(1994) Cast Iron Globe & Angle Valves Flanged and Threaded Ends

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)

NEMA 250	(1991) Enclosures for Electrical Equipment (1000 Volts Maximum)
NEMA AB 1	(1993) Molded Case Circuit Breakers and Molded Case Switches
NEMA MG 1	(1993; Rev. 1-2) Motors and Generators

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 30	(1993) Flammable and Combustible Liquids Code
NFPA 37	(1994) Installation and Use of Stationary Combustion Engines and Gas Turbines
NFPA 70	(1999) National Electrical Code
NFPA 110	(1996) Emergency and Standby Power Systems

UNDERWRITERS LABORATORIES INC. (UL)

UL 429	(1994; Bul. 1994 and 1995) Electrically Operated Valves
UL 489	(1991; Bul. 1992, 1993, 1994, and 1995, R 1995) Molded-Case Circuit Breakers and Circuit-Breaker Enclosures
UL 1236	(1994; R 1995, Bul. 1995) Battery Chargers for Charging Engine-Starter Batteries

1.2 RELATED REQUIREMENTS

Section 16050, "Basic Electrical Materials and Methods," applies to this section with the additions and modifications specified herein.

1.3 DEFINITIONS

a. Intercooling - Cooling of charged air after it leaves turbocharger compressor.

b. IEEE Device Numbers - Described in IEEE Standard IEEE C37.2.

c. Gross and Net Bhp \ Ratings of Engine - Gross rating shall be total rated power output before deducting power requirements of electric motor-driven equipment. Net ratings shall be equal to gross ratings minus total power requirements of electric motor-driven accessories normally constituting part of "engine assembly."

1.4 SUBMITTALS

Submit the following in accordance with Section 01330, "Submittal Procedures."

1.4.1 SD-02, Manufacturer's Catalog Data

a. Engine-generator set

b. Engine-generator unit guarantees

c. Natural Gas engine

d. Generator and exciter

e. Weather proof enclosure

f. Silencer

1.4.1.1 Engine-Generator Set Data

Submit the following data pertaining to each engine-generator set.

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. Piston speed, fpm

j. BMEP at full load psig

k. kW rating of generator set at specified voltage and temperature rise per NEMA MG 1

l. kVA rating of generator and power factor

m. Induction method

n. Intercooler type (air-to-air or jacket water)

o. Governor type, make and model

p. Motor starting kVA of generator set at 35 percent dip for voltage specified

1.4.1.2 Engine-Generator Unit and Auxiliary Equipment

Submit outline and installation drawings or catalog cuts containing installation details.

1.4.1.3 Engine-Generator Unit Electrical Drawings

Submit electrical drawings including elementary, schematic, wiring, and interconnection diagrams.

1.4.2 SD-05, Design Data

a. Torsional vibrations analysis for each unit

1.4.3 SD-08, Statements

a. Natural Gas engine generator successful operation

b. Field welding procedures

1.4.3.1 Natural Gas Engine Generator Successful Operation

Submit certificates within 30 calendar 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 identical or higher brake mean effective pressure (BMEP), and the same basic configuration (In-line or Vee) as the engine to be provided, have each driven generators which have produced, in satisfactory operation, not less than 250 kWh of electricity for each kW of generator nameplate capability within a 2-year period. Certificates shall include:

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

b. Owner and location of each installation.

c. Date of initial operation of each installation.

d. Number of kWh produced per kW of generator net rated capability of each engine installation.

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

f. BMEP rating of each engine.

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

1.4.3.2 Field Welding Procedures (Piping)

Before performing field welding, submit to the Contracting Officer, welding procedure specifications for metals included in the work, with proof of qualification as outlined in ASME/ANSI B31.9.

1.4.4 SD-11, Factory Test Reports

a. Engine-generator set tests

Submit certified factory test report within 15 calendar days after completion of tests. Provide in accordance with requirements set forth in paragraph entitled "Source Quality Control."

1.4.5 SD-12, Field Test Reports

a. Piping tests

b. Preliminary operation

c. Phase relationship tests

d. Control panel tests

e. Engine-generator set acceptance tests

f. Auxiliary equipment test

Submit test and inspection reports for work required under paragraph, "Field Quality Control."

1.4.6 SD-18, Records

a. Posted operating instructions for natural gas engine-generator set

Provide text for each piece of equipment according to paragraph, "Posted Operating Instructions."

1.4.7 SD-19, Operation and Maintenance Manuals

a. Engine-generator unit and auxiliary equipment.

b. Engine speed governing system.

c. Engine-generator set voltage regulator.

d. Engine control panel.

Submit operation and maintenance data in accordance with Section 01781, "Operation and Maintenance Data."

1.5 QUALITY ASSURANCE

1.5.1 Experience Requirements

Engines installed shall meet the following operating experience requirements:

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

b. Only experience on the same engine model is acceptable. Engine model is considered to be a given series or class of 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.

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

d. Only experience at identical or higher BMEP as that specified is acceptable.

e. Only experience with natural gas-fueled engines is acceptable.

1.5.2 Regulatory Requirements

a. Provide devices designed and installed to comply with the following requirements:

(1) Power Transmission Apparatus: Guard in accordance with ANSI/ASME B15.1.

(2) Electrical Installations: Conform to NFPA 70.

(3) Operator Protection: Guard in accordance with 29 CFR 1910 as follows:

(a) Fan blades: Part 1910, Subpart O

(4) Mercury: Use of mercury in instruments, contacts, and manometers is not permitted.

1.6 DELIVERY, STORAGE AND HANDLING

Deliver equipment on pallets or blocking with each entire unit wrapped in heavy-duty plastic wrapping, sealed to protect unit from moisture and dirt. Plug and seal shut piping, conduit, exhaust, and air intake openings.

Protect and prepare batteries for shipment as recommended by battery manufacturer. Store equipment at the site in covered enclosures, protected from atmospheric moisture, dirt, and ground water. Properly label each package on exterior of wrapping to identify enclosed equipment, contract number, manufacturer, and purchaser. Manufacturer's standard practice in product protection and identification meeting above requirements, is acceptable.

1.7 SITE CONDITIONS

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

a. Site location: Artesia, New Mexico.

b. Site elevation: 3320 feet above mean sea level.

c. Ambient temperatures:

(1) Maximum 105 degrees F dry bulb, 65 degrees F wet bulb.

(2) Minimum 10 degrees F dry bulb.

d. Seismic zone: 1 as defined by ICBO UBC.

g. Atmospheric conditions: Dust-laden.

h. Engine-generator set location: Outside, with enclosure.

1.8 EXTRA MATERIAL

1.8.1 Paint

Furnish one gallon of identical paint used on engine-generator assembly in paint manufacturer's sealed container with each engine-generator set.

1.8.2 Filters

Furnish two spare replacement elements in their original containers for each filter with each unit.

1.9 POSTED OPERATING INSTRUCTIONS

Provide operating instructions laminated between matte-surface thermoplastic sheets suitable for placement adjacent to corresponding equipment. Install operating instructions where directed.

PART 2 PRODUCTS

2.1 MATERIALS

Provide materials and equipment of manufacturers regularly engaged in production of such materials or equipment, and the manufacturer's latest standard commercial product 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.

2.2 ENGINE-GENERATOR SET

Provide engine-generator set, correctly coordinated by engine-generator manufacturer to ensure an installed rating in the environment described in paragraph entitled "Site Conditions." Each set shall consist of a water cooled natural gas engine direct-connected to an ac generator having a brushless excitation system, and shall be provided with necessary accessories, auxiliaries, appurtenances, control equipment, and cooling systems, resulting in a complete set and, except for external service connections, ready for operation. Mount each engine-generator set on a steel subbase sized to support the engine; generator-exciter, engine-generator control panel; lubricating oil filter, fuel filter, and interconnecting piping and wiring. Engine unit-mounted radiators and auxiliaries shall be mounted on engine-generator set subbase.

Engine-generator set shall include electric starters, controls, block heaters, and related wiring for electric starting. Batteries, battery racks and charger assembly may be mounted on the set subbase. Provide subbase with vibration isolators suitable for loads and lateral forces involved in seismic zone indicated. Isolators shall be as recommended by engine-generator set and isolator manufacturers to suit specific equipment involved. Make electrical and mechanical field connections with flexible connectors. When standard with the manufacturer, combustion air filter/silencer units and exhaust muffler units may be mounted separately from the set, and connections made to engine with corrosion-resistant flexible connections. Factory align engines and generators on subbase and securely bolt into place in accordance with manufacturer's standard practice. Paint each set, after assembly, with manufacturer's standard paints and colors. After tests and before shipping, thoroughly clean each set and retouch paint as necessary to provide complete protection to the set. Arrange sets for automatic unattended starting in addition to manual start-and-stop by control panel switches. Engine-generator set shall be capable of automatically starting, coming up to synchronous speed, and ready to accept full rated power within 10 seconds after receipt of start signal. House engine-generator set in a weather resistant enclosure for outdoor installation.

2.2.1 Equipment Rating and Capability

Each engine-generator set shall have a net standby rating capacity of not less than 100 kW at 0.8 power factor and shall be designed to supply 480Y/277-volt, 60-Hz ac output. Auxiliary equipment shall be designed for continuous duty at 100 percent of rated net capacity of engine-generator set. Cooling system components and auxiliaries shall be properly sized relative to engine coolant specified under cooling system.

2.2.2 Torsional Vibrations

Each complete engine-generator set shall be free of torsional vibrations that might endanger satisfactory operation of the set. Satisfactory operation will be considered endangered, when torsional vibration stresses exceed 5,000 psi within 10 percent above or below rated engine speed. Analysis of torsional vibrations shall be accomplished by calculations and by tests of a complete representative prototype of the engine-generator set.

2.3 GENERATOR SET DESIGN AND CONSTRUCTION

Isolate or shield rotating or reciprocating parts, or other parts that present a potential hazard to operating personnel.

2.4 NATURAL GAS ENGINES AND ACCESSORIES

Engines shall be four-cycle, naturally aspirated, vertical Vee type; water cooled; designed for continuous standby electrical duty, stationary service. Provide each engine designed and constructed to eliminate undue heating, vibration, and wear and be efficient and trouble free in operation. Engine shall be designed to operate on pipeline natural gas.

a. Maximum engine speed, rpm: 1800

2.4.1 Construction

Construct engine to withstand sudden changes from no load to rated load, and to preserve alignment of integral components under all conditions of operation. Design shall incorporate pressure lubrication of bearings and wrist pins, and bearing journals shall be hardened or chromium plated to provide a hard shock-resistant surface with ductile core. Counterbalance crankshafts to reduce vibration to a minimum. Crankshaft and connecting rod bearings shall be replaceable precision sleeve type. Construct piston rings of heat-resisting alloy steel or chromium plated cast-iron. Clearly indicate timing marks on crankshaft and gears. Valves shall have removable or rebuildable stem guides and seat inserts. Flywheel shall be balanced, and capable of being rotated 50 percent above the maximum rated engine rotative speed without danger of breaking or exploding. Provide means for turning crankshaft manually.

2.4.2 Assembly

Completely factory-assemble each engine.

2.4.3 Engine Speed Governing System, IEEE Device 65. Governor shall be isochronous electronic type.

a. Steady-state governing speedband shall not exceed plus or minus 0.5 percent expressed as a percent deviation from rated speed.

b. Transient speed deviation shall not exceed plus or minus 3.0 percent expressed as a percent of rated speed for any 50 percent load step, on or off.

c. Time to return to limits of observed speedband shall not exceed 4.0 seconds after sudden load change of transient speed deviation.

d. Minus 10 to plus 5 percent minimum range of speed changer expressed as a percent of rated speed.

2.4.4 Engine Protective Devices

Provide each engine with protective devices as follows:

a. Engine Shutdown: Equip engine with shutdown devices listed. 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, relays or equivalent device for shutdown. 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 when engine speed exceeds normal synchronous speed by 18 percent. Device shall require manual reset.

(2) Pressure switch which operates when engine lubricating oil pressure drops below a preset value.

(3) Temperature switch which operates when jacket coolant temperature exceeds a preset value.

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

b. Electrical Interlocks and Alarms: Equip starting mechanism with auxiliary contacts for interlocking with 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 engine with alarm devices, relays, and auxiliary contacts, as required, to actuate alarm system on engine control panel. Auxiliary contacts shall be suitable for starting battery voltage. Alarm devices shall have factory-set fixed set points. Provide following alarm contact devices:

a. Starting mechanism contacts or equivalent device operating to energize a portion of alarm system only when engine is running and not during cranking or shutdown.

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

c. Temperature switch in jacket coolant discharge piping from engine to operate when temperature exceeds a preset value.

d. Other alarm devices as recommended by engine manufacturer.

2.4.6 Engine Accessories

Provide the following accessories for each engine-generator set when recommended by the manufacturer:

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

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

c. Leveling jack screws or shims, when applicable.

d. Chocks and shims for installation and leveling of engine-generator set subbase, when applicable.

e. Indicating thermometer or temperature indicator in accordance with manufacturer's standard for engine coolant.

2.4.7 Air Intake and Exhaust Systems

Provide air intake and exhaust system for engine. Install field piping in accordance with manufacturer's requirements. Mount air intake and exhaust systems on or support from engine subbase assembly. Include piping, fittings, and expansion joints necessary to interconnect equipment with engine. Arrangement of air intake and exhaust systems shall be similar to that indicated and modified, as required, to suit engine furnished, subject to approval of the Contracting Officer.

a. Air intake filters: Provide dry type filter for engine as standard with the engine manufacturer. Size filter to suit engine requirements at 100 percent of rated full load. Unit shall be designed to permit easy access to 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 ANSI S1.4 (ASA 47), Type 1 or 2, 75 feet from the outlet, under full engine load and clear weather. Silencer shall be complete with handhole openings and necessary brackets for supporting purposes. Sizing of silencer shall be in accordance with engine and silencer manufacturer's recommendations. Inlet and outlet connections shall be provided.

Octave Band Center Frequency Hz	Maximum Sound Level Decibels
63 and below	78
125	68
250	60
500	53
1,000	48
2,000	44
4,000	42
8,000	41

c. Expansion (flexible) joints: Provide sections of multiple corrugated stainless steel expansion joints with liners in the engine exhaust piping 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 reinforced rubber type suitable for the service. Joints shall be of the same size as pipe and provided with connections. Air intake expansion joints may be for plain end pipe.

d. Air intake piping: Conform to manufacturer's recommendations for size, type, and connections.

e. Exhaust piping: Provide piping for each engine complete with necessary fittings, gaskets, bolts, and nuts. Pipe shall be steel conforming to ASTM A 53. Exhaust piping shall be Schedule 40 for 12 inch and smaller sizes and for larger sizes shall have wall thickness not less than 0.375 inch. Exhaust piping shall slope away from engine.

2.5 GENERATORS AND EXCITATION AND VOLTAGE REGULATION SYSTEM

2.5.1 Generator

Provide 0.80 power factor, synchronous, ac, brushless-excited, revolving field, air-cooled, self-ventilated unit conforming to NEMA MG 1 and rated as specified in paragraph entitled "Equipment Rating and Capability." Enclosure frame shall be dripproof. Match generator speed to that of engine. Drive generator directly from engine crankshaft in a manner approved by both engine and generator manufacturers. Generator shall be capable of carrying at rated voltage and 0.8 power-factor, a load equal to net kW rating of the engine without exceeding temperature limits specified in NEMA MG 1 for standby duty. Winding insulation shall be Class F or H. An amortisseur winding shall be provided and generator and flywheel shall have sufficient flywheel effect to meet requirements of regulation specified. Generator field voltage shall be manufacturer's standard voltage. Standby generator neutral shall be solidly grounded when 4-pole transfer switch is used and shall not be bonded to ground at the generator when 3-pole transfer switch is used. Ground generator enclosure at two opposite mounting legs.

2.5.2 Excitation and Voltage Regulation Systems

Comply with IEEE 421.1.

2.5.2.1 Exciter

Integral with generator; synchronous, rotating armature, rotating rectifier, brushless or permanent magnet brushless type. Mount rotating rectifier assembly in a manner to provide ready access for inspection and replacement of rectifier diodes. Semiconductor rectifiers shall have minimum factor of safety of 300 percent for peak inverse voltage, and forward current ratings for operating conditions, including 100 percent generator output at 40 degrees C ambient. Provide safety devices for protection of rectifiers against overload currents and voltages unless design provides this protection inherently. Acceptable ratio of exciter ceiling voltage to exciter nominal voltage shall be not less than three to two.

2.5.2.2 Voltage Regulator, IEEE Device 90

Provide a solid state voltage regulator that automatically controls the generator field current through action on the exciter, and provides immunity from SCR tracking. Voltage regulator shall enable manual adjustment of set output voltage, while set is operating, by potentiometer adjustment at generator control panel.

2.6 NATURAL GAS SYSTEM

Conform to NFPA 30 and NFPA 37 and requirements herein.

2.7 LUBRICATING OIL SYSTEM

2.7.1 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 at maximum engine speed in accordance with standard practice of engine manufacturer. Provide means to ensure delivery of lubricating oil to vital wearing surfaces regardless of the condition of filters without removing engine from service. Filter shall provide means of automatically bypassing filter when filter becomes flow-restricting.

2.8 COOLING SYSTEM

2.8.1 Jacket Coolant Pump

Provide a coolant pump for the engine. The pump shall have ample capacity to circulate required flow of coolant specified through the system to remove total heat rejected from the engine. Heat shall be rejected to jacket coolant to maintain optimum jacket coolant temperature leaving and entering engine as recommended by the engine manufacturer.

2.8.2 Radiator

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

a. Design Conditions: The radiator unit shall have ample capacity to remove not less than the total Btu per hour of heat rejected by its respective engine at 100 percent full-rated load to jacket coolant. Radiator capacity shall be rated at optimum temperature of coolant leaving engine as recommended by the engine manufacturer, with a dry bulb air temperature of 120 degrees F.

   Pressure drop through the radiator shall not exceed 6 psi when circulating 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 methoxy-propanol or ethylene glycol coolant providing protection to 0 degrees F. Mixture shall be to proportions recommended by the engine manufacturer to meet site conditions. Provide an antifreeze solution tester suitable for solution used.

b. Engine Subbase-Mounted Radiator Construction: Radiator fan shall direct air flow from the engine outward through the radiator. Fan may be driven directly from engine crankshaft through V-belt drive. Radiator shall have sufficient capacity to meet 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 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 manufacturer. Provide suitable guards for each fan and drive. Provide exhaust duct with flexible connections between radiator and wall louver. Ductwork shall conform to SMACNA DCS.

2.8.3 Thermostatic Control Valves

When recommended and standard with engine manufacturer for 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.

2.8.4 Starting Aids

Provide a factory-installed, electrically operated, jacket coolant heating system to ensure rapid starting. Thermostatically control heater at the temperature recommended by engine manufacturer. Connect power leads to a junction box which shall provide fusing and manual disconnection of the heater. Include necessary equipment, piping, controls, wiring, and accessories.

2.9 ELECTRIC STARTING SYSTEM

Provide a 12-volt dc starting battery installation for starting the engine-generator set utilizing an electric cranking system. 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. Signal for starting shall come from engine-generator set control system (ATS).

2.9.1 Cranking

Energize electric cranking system from negative polarity grounded starting batteries. Provide heavy-duty type cranking motor with capacity to crank the engine continuously to start the engine. Drive mechanism for engaging starting motor with engine flywheel shall be designed to inherently engage and release without binding. When engine starts, starting gearing shall automatically disengage and starting motors shall shut down. Automatic cranking panel shall crank engine as specified under paragraph entitled "Engine Cranking Relay."

2.9.2 Starting Battery Installation

Provide lead acid industrial engine cranking battery designed for spark ignited engine starting of sufficient size and capacity in a fully charged condition to crank engine for four consecutive cycles of 30 seconds cranking followed by 120 seconds rest. Provide battery racks or enclosures, properly ventilated for the batteries and charger. Provide necessary cabling.

2.9.3 Starting Battery Charger

Provide enclosed, automatic, dual-rate, solid-state, constant voltage type battery charger having ac voltage compensation, dc voltage regulation, and current limiting. 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 suppressors, dc ammeter, dc voltmeter, and fused inputs and outputs. Charger shall have continuous rated output of not less than 10 amperes and conform to UL 1236.

2.10 PIPING SYSTEMS

Conform to the following except that factory installed piping may conform to engine-generator set manufacturer's standards:

a. Piping: Provide seamless steel pipe, Schedule 40, ASTM A 53, Grade A.

2.10.1 Lubricating Oil Piping System

Factory installed piping systems shall conform to engine-generator set manufacturer's standards.

2.11 ENGINE-GENERATOR SET CONTROLS

Provide an engine-generator set control panel mounted on the engine-generator set subbase, and a remote alarm panel. Manufacturer's standard electronic control panels may be provided in lieu of those specified below if they accomplish the same functions.

2.11.1 Engine-Generator Control Panel

Provide an enclosed panel fabricated of not lighter than 14-gage sheet steel in compliance with NEMA 250, Type 3R. Construct cabinet with angle iron framework, if required, for proper stiffness and support. Size cabinet to accommodate specified equipment when arranged in an orderly and approved manner. Factory-mount panel on engine unit subbase. Provide isolation mounting material between subbase and panel to isolate the panel from engine vibrations. Provide panel-mounted devices with nameplates of laminated black gloss-finished plastic with white engraved lettering. Provide 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 gages. Provide instruments subject to rapid pressure surges with damping devices to give a steady reading. Provide the following panel-mounted devices as a minimum:

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

b. Engine Instrumentation:

(l) Gas pressure gage.

(2) Lube oil pressure gage.

(3) Coolant temperature gage.

(4) Elapsed time meter.

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

(1) Overcranking.

(2) Overspeed.

(3) Excessive coolant temperature.

(4) Dangerously low lubricating oil pressure.

2.11.1.2 Generator Control Panel

Install controls in engine-generator control panel . Provide generator controls and instrumentation as follows:

a. Generator controls

(1) Generator circuit breaker, IEEE Device 52.

(2) Voltage regulator and associated controls.

b. Generator instrumentation and metering

(1) Voltmeter and control switch.

(2) Ammeter and control switch.

c. Engine starting and stopping controls and protective equipment

(1) Engine starting switch.

(2) Engine cranking relay.

(3) Engine shutdown relay.

d. Local Alarm Panel: Provide manufacturer's standard local alarm panel suitable for operation on the starting battery voltage. Provide with pre-shutdown and shutdown alarms in accordance with NFPA 99. Provide panel with factory-installed annunciator having a noise level of not less than 95 decibels at 10 feet and provide with silencing switch. Provide the following alarms with pre-shutdown alarms 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 pressure

(4) Low gas supply 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

2.11.2 Remote Alarm Panel

Provide pre-shutdown alarms and shutdown alarms in accordance with paragraph entitled "Generator Control Panel".

2.11.3 Generator Control Panel Devices

2.11.3.1 Generator Circuit Breaker, IEEE Device 52

a. Circuit Breaker Type:

(1) Molded-case, 100 percent rated

(a) NEMA AB 1 and UL 489]

(2) Trip ratings

ANSI C37.17

2.11.3.2 Generator Voltage Adjustment

Install manual voltage setting control system as specified under paragraph entitled "Voltage Regulator."

2.11.3.3 Indicating Lights

Provide front removable, low drain, push-to-test, indicating lights equipped with dropping resistors suitable for 120-vac service, as required and color caps as specified.

2.11.3.4 Instruments

Provide manufacturers standard design.

2.11.3.5 Engine Starting Switch

Four-position rotary, enclosed rear mounting, maintained-position type. Switch positions shall be "Automatic," "Off," "Test," and "Manual" and connected to provide the following operation:

a. In "Automatic" position, engine-generator set shall start automatically in response to loss of voltage, remote control contacts in the automatic transfer switch initiating starting and stopping of the generator set.

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

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

d. In "Manual" position, switch shall start and bring engine-generator set up to speed and then connect it to line.

2.11.3.6 Engine Cranking Relay

Provide to operate as follows:

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

b. Should engine fail to start at once, cranking shall continue for 30 seconds (adjustable) after which a 120-second "off" period (adjustable) shall occur. Durations of cranking and "off" periods listed above may be modified in accordance with engine manufacturer's recommendations.

c. Repeat above described cranking cycle for four starting attempts.

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

2.11.3.7 Engine Shutdown Relay

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

2.11.3.8 Automatic Transfer and Bypass Isolation Switch

Section 16410, "Automatic Transfer Switches."

2.12 MISCELLANEOUS ENGINE SYSTEM REQUIREMENTS

2.12.1 Wire and Cable

Provide wire and cable required for a complete electrical system as shown. Comply with requirements specified in Section 16402, "Interior Distribution System."

2.12.2 Weather Resistant Enclosure

Provide a weather resistant enclosure for generator sets. Fabricate from zinc-coated phosphatized and shop primed 16 gage minimum sheet steel in accordance with manufacturer's standard design. Provide enclosure for engine, generator, control panel, excitation equipment, voltage regulator, engine safety control, and accessories. Enclosure shall have sufficient louvered openings to allow entrance of outside air for engine and generator cooling at full load. Louvered openings shall be designed to exclude driving rain and snow. Provide properly arranged and sized hinged panels in the enclosure to allow convenient access to engine, generator, and control equipment for maintenance and operation. Provide lockable,

hinged panels with spring latches to hold panels closed securely and not allow panels to vibrate. Brace housing internally to prevent excessive vibration when generator set is in operation.

2.13 IDENTIFICATION OF EQUIPMENT

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.

2.14 SOURCE QUALITY CONTROL

2.14.1 Engine-Generator Set Tests

Perform customary commercial factory tests on each engine-generator set, including, but not necessarily limited to, the following:

a. Perform hydrostatic test on engine 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, that is **2**, 3/4, and full load. When stoppage becomes necessary during this period, repeat the 8-hour run. Record the following data for sets at the start, at 15-minute intervals, and at end of each load run: Fuel consumption (correct fuel consumption results to guarantee conditions); exhaust temperatures; engine coolant temperatures; lubricating oil temperatures and pressures; and any other data of importance.

2.14.1.1 Generator Tests

Ensure that temperature tests on one generator's windings are performed by manufacturer of generator in manufacturer's own plant. Temperature tests shall be in accordance with IEEE 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 subtransient reactance shall be included in the test report.

PART 3 EXECUTION

3.1 PREPARATION

Use cribbing and shoring as required to protect construction from moving-in damage. Protect flooring and finished surfaces with heavy planking. Obtain approval of methods and materials from the Contracting Officer or the Contracting Officer's authorized representative before moving equipment across shored floors.

3.2 INSTALLATION

Installation shall be in strict accordance with manufacturer's instructions. Provide labor, tools, equipment, and other necessities for erection and installation of equipment. After equipment has been installed, remove shoring and repair damage to floors and other parts of the building. Furnish the services of one or more generator representative or technicians, experienced in installation and operation of the type of systems being provided, to supervise the installation.

3.2.1 Installation of Engine-Generator Sets

Install engine-generator sets on a concrete foundation as indicated.

3.2.2 Equipment Supports and Installation

Provide devices to support equipment not supported on engine-generator structural steel subbase as required. Fabricate required supports of structural steel sections, plates or rods, and arrange to provide rigid and sturdy support. Provide connections and fasteners required between equipment supports and building structures.

a. Batteries and Chargers: When batteries are to be stored during the construction period, follow manufacturer's instructions for charging and protection from environmental damage.

3.2.3 Instruction of Operators

After equipment is ready to be placed in service, Contractor and equipment manufacturer's representative shall fully instruct plant operators in operation and maintenance of the equipment. Posted operating instructions for diesel engine-generator set shall be provided adjacent to the unit.

3.2.4 Piping

Piping connecting the engine and equipment mounted on engine-generator subbase shall be factory installed and shall conform to manufacturer's standards for set sizes involved. Piping extensions from engine-generator and subbase to remote cooling and fuel systems shall conform to ASME/ANSI B31.9 and NFPA 30. Arrange piping to provide a workable arrangement, with convenient access to valves and specialty items. Maintain adequate clearance between runs of piping to permit access around adjacent pipe for dismantling, repair, and maintenance of valves. Piping shall be straight, plumb, and run direct as possible. Do not install piping over electrical equipment.

3.2.4.1 Shop Fabrication

Shop fabricate pipe to greatest extent possible. Plug ends of piping and openings prior to shipment to plant site.

3.2.4.2 Welding

Preparing, bending, cleaning, and welding of piping shall conform to ASME/ANSI B31.9. Welds shall be visually examined and meet acceptance standards of ASME/ANSI B31.9.

3.2.4.3 Field Cleaning

Before placing in position, clean inside of black steel pipe by rapping along its full length to loosen sand, mill scale, and other foreign matter. Pipe 2-inch and larger shall have a wire brush of a diameter larger than that of the inside of the pipe drawn through its entire length several times. Before final connections are made to apparatus, wash out interior of coolant piping with water. Blow out air and fuel lines with 80-to-100 psi dry air or nitrogen.

3.2.4.4 Pickled Piping

Clean steel fuel oil piping and pickle internally by chemical cleaning. Cleaning process shall remove grease, oil, dirt, mill scale, lacquer, and corrosion products. Clean piping either by circulating cleaning solution through completed piping systems or by soaking prefabricated piping sections in a tank of solution. Provide and remove after use pumps, temporary piping connections, tanks, and other equipment required to accomplish cleaning of piping. After cleaning, thoroughly flush, drain, and dry piping and take necessary precautions to prevent rerusting before pipe is used. While cleaning, remove or isolate instrumentation, valves, and equipment installed in piping which contain bronze or brass. Cleaning solution shall not come in contact with bronze or brass. Cleaning solution shall not be circulated through engine piping systems. Provide cleaning solution of the type recommended by engine manufacturer and chemical manufacturer for the specific purpose.

3.2.4.5 Provisions for Expansion

Provide for expansion of piping subject to temperature change by using suitable flexible piping connectors, expansion joints, bends, ball joints, offsets, and loops in a manner that will prohibit development of excessive stresses between anchor points or at equipment connections. Provide bends, loops, and offsets wherever practical to prevent overstressing of piping systems due to thermal expansion and to provide adequate flexibility. A piping system may be cold sprung by an amount no greater than 50 percent of the total linear expansion to alleviate end thrusts and moments. Method of cold springing shall be as approved.

3.2.4.6 Reducing Fittings

Provide for changes in pipe size except where taps are permitted. Use of bushings is prohibited. In horizontal mains containing liquids, provide eccentric reducers.

3.2.4.7 Unions or Flanges

Provide where necessary to permit easy connection of piping and apparatus. Provide unions on valves with screwed ends.

3.2.4.8 Valves

Install in positions accessible for operation and repair. Install stems preferably in a vertical position with handwheels or operators on top, or install in a horizontal position.

3.2.4.9 Connections to Equipment

Make piping connections to equipment shown and provide reducers, unions, and valves to make a complete installation. Make connections to equipment with unions or flanges. Provide valves the same size as piping in which they are installed.

3.2.4.10 Joints

a. Flanged Joints: Face pipe flanges true to line and thoroughly clean before assembly. Gasket faces shall be free of burrs or bruises. Make up flanged joints prior to completing the last weld in connecting piping. Coat bolt threads with a mixture of equal parts of graphite and boiled linseed oil or with an approved commercial coating.

b. Screwed Joints: Provide graphite pipe-joint compound conforming to MIL-T-5544; apply to male threads only. Antiseize zinc compound conforming to MIL-T-22361 may be provided. Piping shall be free of fins and burrs. Ream pipe ends or file out to size of bore; remove chips.

3.2.4.11 Anchors, Guides, and Supports

Anchor and support piping in a manner such that expansion and contraction will take place in the desired direction. Prevent vibration by use of vibration dampers and prevent undue strains on equipment served. Hangers used for supporting piping 2-inches and larger shall be the type permitting adequate adjustment after erection while still supporting the load. Provide supports to adequately carry weight of lines and to maintain proper alignment. Provide inserts and sleeves for supports in concrete where necessary, and in new construction place inserts and sleeves before concrete is poured.

3.3 FIELD QUALITY CONTROL

Perform and report on field tests and trial operations, and conduct field inspections, except final field inspection. Provide labor, calibrated and approved test equipment, and incidentals required for tests. Contracting Officer will witness field tests and trial operations and will conduct final field inspections. Give Contracting Officer 15 days notice of dates and times scheduled for tests, trial operations, and inspections which require the presence of the Contracting Officer. Rectify deficiencies and retest work affected by such deficiencies.

3.3.1 Piping Tests

Test piping system after lines have been cleaned. Test piping systems at a pressure of 1.5 times the design working pressure, and in no case less than 100 psig. Hydrostatically test piping, except for air and fuel, using water not exceeding 100 degrees F. Test air and fuel lines with clean, dry air or nitrogen. For air lines operating at pressure greater than 100 psig, test at design working pressure. During testing, remove gages, traps, and other apparatus which may be damaged by the test pressure, or valve off before conducting tests. Install a calibrated test pressure gage in the system to observe loss in pressure. Brush joints in piping system tested with air with a soapy water solution to check for leaks. Maintain required test pressure for a sufficient length of time to enable inspection of joints and connections. Rectify defects which develop during testing, and retest piping systems until they show no defect or weakness and are tight.

3.3.2 Preliminary Operation

Align and adjust equipment to ensure proper operation as instructed by manufacturers of equipment. Lubricate equipment prior to operation in accordance with manufacturer's instructions. Upon approval by Contracting Officer or the Contracting Officer's authorized representative, operate engine-generator sets varying loads throughout the load range for a sufficient time to demonstrate that operation is proper and that pressures and temperatures are normal and within specified limits. Operate engines for a period of time sufficient to ensure that units are ready to carry test loads specified in paragraph "Engine-Generator Set Acceptance Tests" without damage to engine parts. During this preliminary operation, check operation and ensure proper functioning of auxiliary equipment. Make necessary adjustments to equipment to place auxiliary equipment in operating condition.

3.3.3 Electrical Equipment and Materials Tests

Test procedures, inspections, and sampling shall be as specified and noted below:

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

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

c. Insulation Resistance Tests: Test field installed cables. Minimum acceptable values of insulation resistance of circuits shall be as recommended by the manufacturer.

3.3.4 Engine-Generator Set Acceptance Tests

When installation is complete and in operating condition, notify the Contracting Officer in writing that engine-generator sets and auxiliary equipment are ready for final field tests. The Contracting Officer or Contracting Officer's authorized representative will witness final acceptance tests. Perform tests as necessary to make certain that equipment is functioning properly. Tests 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 50 percent load on or off.

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

d. An individual test of each alarm device.

e. A 6 -hour load test, 2 hours each at 50, 75, and 100 percent load at the highest ambient temperature in the area, to prove cooling system operation in the installed location.

Inspect auxiliary equipment including, but not limited to, pumps, fans, radiators, instruments, and special valves to ensure proper operation. Auxiliary equipment may be field tested at the option of the Contracting Officer. Auxiliary equipment test shall be in accordance with the latest ASME and IEEE performance test codes, when applicable.

Perform tests as prescribed by NFPA-110 and the Contracting Officer. Use plant electrical system load for loading engine-generator set under test. Check oil after tests for presence of metal particles and water.

3.3.4.1 Test Reruns

When specified performance is not met by these tests, make such adjustments and changes, as necessary, and conduct additional tests, as necessary, to further check performance of equipment.

3.3.4.2 Failure to Meet Requirements

In the event equipment fails to meet specified performance or fails to operate satisfactorily, the Government shall have the right to operate equipment until defects have been corrected. Equipment proved to be faulty or inadequate for service specified will be rejected, but the Government shall have the

right to operate rejected equipment until such time as new equipment is provided by the Contractor to replace equipment rejected.

3.3.4.3 Manufacturer's Field Services

Furnish the services of one or more natural gas-generator representative or technicians, experienced in installation and operation of the type of systems being provided, to supervise testing, adjustment of the system, and to instruct Government personnel.

END OF SECTION