
USACE / NAVFAC / AFCEC / NASA UFGS-26 32 13.00 20 (April 2007)

Preparing Activity: NAVFAC Superseding
UFGS-26 32 13.00 20 (April 2006)

UNIFIED FACILITIES GUIDE SPECIFICATIONS

References are in agreement with UMRL dated January 2015

SECTION TABLE OF CONTENTS

DIVISION 26 - ELECTRICAL

SECTION 26 32 13.00 20

SINGLE OPERATION GENERATOR SETS

04/07

PART 1 GENERAL

- 1.1 REFERENCES
- 1.2 RELATED REQUIREMENTS
- 1.3 SYSTEM DESCRIPTION
 - 1.3.1 Engine-Generator Set Data
 - 1.3.2 Engine-Generator Set Efficiencies
 - 1.3.3 Diesel Engine Data
 - 1.3.4 Generator and Exciter Data
 - 1.3.5 Capacity Calculations for Engine-Generator Set
 - 1.3.6 Calculations for Brake Mean Effective Pressure (BMEP)
 - 1.3.7 Torsional Vibration Stress Analysis Computations
 - 1.3.8 Capacity Calculations for Batteries
 - 1.3.9 Turbocharger Load Calculations
- 1.4 SUBMITTALS
- 1.5 QUALITY ASSURANCE
 - 1.5.1 Drawing Requirements
 - 1.5.1.1 Engine-Generator Set and Auxiliary Equipment
 - 1.5.1.2 Auxiliary Systems
 - 1.5.2 Vibration Isolation System Certification
 - 1.5.3 Fuel System Certification
- 1.6 DELIVERY, STORAGE, AND HANDLING
- 1.7 SITE CONDITIONS
- 1.8 MAINTENANCE
 - 1.8.1 Extra Materials
 - 1.8.1.1 Paint
 - 1.8.1.2 Filters
 - 1.8.2 Posted Operating Instructions

PART 2 PRODUCTS

- 2.1 DIESEL ENGINE-GENERATOR SET
 - 2.1.1 Engine-Generator Set Ratings and Performance
 - 2.1.1.1 Diesel Engine Capacity
 - 2.1.1.2 Diesel Engine Emission Limits
 - 2.1.1.3 Performance Class

- 2.1.1.4 Load Profile
- 2.1.2 Diesel Engines and Accessories
 - 2.1.2.1 Subbase Mounting
 - 2.1.2.2 Assembly
 - 2.1.2.3 Turbocharger
 - 2.1.2.4 Intercooler
 - 2.1.2.5 Crankcase Protection
 - 2.1.2.6 Engine Lubricating Oil System
 - 2.1.2.7 Engine Cooling System
 - 2.1.2.8 Engine Fuel System
 - 2.1.2.9 Engine Intake Filter
 - 2.1.2.10 Engine Starting System
 - 2.1.2.11 Jacket Coolant Heating System
 - 2.1.2.12 Engine Protective (Shutdown) Devices
 - 2.1.2.13 Engine Alarm Devices
 - 2.1.2.14 Miscellaneous Engine Accessories
 - 2.1.2.15 Engine Speed Governor System
- 2.1.3 Generator and Excitation System
 - 2.1.3.1 Generator
 - 2.1.3.2 Excitation System
 - 2.1.3.3 Electromagnetic Interference (EMI) Suppression
- 2.2 ENGINE-GENERATOR SET AUXILIARY SYSTEMS AND EQUIPMENT
 - 2.2.1 Vibration Isolation System
 - 2.2.2 Exhaust System
 - 2.2.2.1 Exhaust Silencers
 - 2.2.2.2 Field Installed Exhaust Piping System
 - 2.2.3 Cooling System
 - 2.2.3.1 Radiators
 - 2.2.3.2 Jacket Coolant Water Piping Systems
 - 2.2.4 Diesel Fuel System
 - 2.2.4.1 Diesel Fuel Piping System
 - 2.2.4.2 Diesel Fuel Day Tank System
 - 2.2.4.3 Fuel Transfer Pump[s]
 - 2.2.4.4 Fuel Oil Solenoid Valve
 - 2.2.4.5 Strainer
 - 2.2.4.6 Fuel Oil Meters
 - 2.2.4.7 Fuel Oil Cooler
 - 2.2.5 Starting Battery System
 - 2.2.5.1 Engine Starting Battery
 - 2.2.5.2 Starting Battery Charger
 - 2.2.6 Engine-Generator Control Panel
 - 2.2.6.1 Control Panel Mounted Devices
 - 2.2.6.2 Crank Cycle/Terminate Relay
 - 2.2.6.3 Engine Cooldown Relay
 - 2.2.7 Remote Alarm Annunciator
 - 2.2.7.1 Storage Battery
 - 2.2.8 Generator Circuit Breaker
 - 2.2.9 Electrical Support Equipment
 - 2.2.10 Weatherproof Enclosure
- 2.3 SPECIAL WRENCHES AND TOOLS
- 2.4 IDENTIFICATION OF EQUIPMENT
 - 2.4.1 Materials
 - 2.4.2 Control Devices and Operation Indicators
 - 2.4.3 Equipment
- 2.5 ASSEMBLED OPERATION AND MAINTENANCE MANUALS
- 2.6 SOURCE QUALITY CONTROL
 - 2.6.1 Engine Tests
 - 2.6.2 Generator Tests
 - 2.6.2.1 Routine Tests

- 2.6.2.2 Design Tests
- 2.6.3 Assembled Engine-Generator Set Tests
 - 2.6.3.1 Initial Stabilization Readings
 - 2.6.3.2 Regulator Range Test
 - 2.6.3.3 Frequency Range Test
 - 2.6.3.4 Transient Response Test

PART 3 EXECUTION

- 3.1 INSTALLATION
- 3.2 GROUNDING
 - 3.2.1 Grounding Electrodes
 - 3.2.2 Engine-Generator Set Grounding
 - 3.2.3 Connections
 - 3.2.4 Grounding and Bonding Equipment
- 3.3 START-UP ENGINEER
- 3.4 PREREQUISITES FOR FUNCTIONAL ACCEPTANCE TESTING
 - 3.4.1 Piping Tests
 - 3.4.2 Performance of Acceptance Checks and Tests
 - 3.4.2.1 Generator Sets
 - 3.4.2.2 Automatic Transfer Switches
 - 3.4.3 Preliminary Operations
 - 3.4.4 Preliminary Assembled Operation and Maintenance Manuals
 - 3.4.5 Functional Acceptance Test Procedure
 - 3.4.6 Test Equipment
- 3.5 FIELD QUALITY CONTROL
 - 3.5.1 Acceptance Checks and Tests
 - 3.5.1.1 Circuit Breakers - Low Voltage Insulated Case/Molded Case
 - 3.5.1.2 Current Transformers
 - 3.5.1.3 Metering and Instrumentation
 - 3.5.1.4 Battery Systems
 - 3.5.1.5 Engine-Generator Set
 - 3.5.1.6 Grounding System
 - 3.5.2 Functional Acceptance Tests
 - 3.5.3 Emissions Tests
- 3.6 DEMONSTRATION
 - 3.6.1 Instructor's Qualification Resume
 - 3.6.2 Training Plan
 - 3.6.2.1 Operating Personnel Training
 - 3.6.2.2 Maintenance Personnel Training

-- End of Section Table of Contents --

USACE / NAVFAC / AFCEC / NASA UFGS-26 32 13.00 20 (April 2007)

Preparing Activity: NAVFAC Superseding
UFGS-26 32 13.00 20 (April 2006)

UNIFIED FACILITIES GUIDE SPECIFICATIONS

References are in agreement with UMRL dated January 2015

SECTION 26 32 13.00 20

SINGLE OPERATION GENERATOR SETS 04/07

NOTE: This guide specification covers the requirements for 1800 rpm diesel engine-generator sets with ratings up to 2000 kW at 0.8 power factor intended for use in low voltage, non paralleling, emergency electrical power systems meeting requirements of NFPA 70, NFPA 99, and MIL-HDBK-1191.

Adhere to UFC 1-300-02 Unified Facilities Guide Specifications (UFGS) Format Standard when editing this guide specification or preparing new project specification sections. Edit this guide specification for project specific requirements by adding, deleting, or revising text. For bracketed items, choose applicable items(s) or insert appropriate information.

Remove information and requirements not required in respective project, whether or not brackets are present.

Comments, suggestions and recommended changes for this guide specification are welcome and should be submitted as a Criteria Change Request (CCR).

NOTE: This guide specification will require modification for applications where automatic transfer switches are not used. When generators are to be operated in parallel with utility or with other generators, and for medium voltage (greater than 600 volt) systems, contact the responsible Facilities Engineering Command (FEC) for determination as to which specification or sample specification is to be used. If Echelon III Reach-back Support form NAVFAC LANT or NAVFAC PAC is required for shop drawing review or field acceptance testing, the FEC technical representative (electrical engineer) editing this document for a specific project must contact the appropriate Capital Improvements Electrical Engineering Office

for consultation during the design stage of the project.

NOTE: On drawings, show:

1. Engine-generator set foundation design and details.
2. Piping for ventilation of engine crankcase to atmosphere where required.
3. Details of exhaust, cooling water, and fuel piping, including penetrations through walls and roofs showing piping sleeves and exterior flashing where applicable.
4. Diesel fuel day tank capacity where applicable.
5. Location of remote alarm annunciator where applicable.
6. Circuiting for the jacket coolant heating system, electric motor driven radiator fan where applicable, diesel fuel day tank system, starting battery charger, remote alarm annunciator storage battery charger where applicable, and generator space heater.
7. Grounding plan. For applications using transfer switches, the transfer switch shall be four pole and the generator shall be grounded as a separately derived system.

PART 1 GENERAL

1.1 REFERENCES

NOTE: This paragraph is used to list the publications cited in the text of the guide specification. The publications are referred to in the text by basic designation only and listed in this paragraph by organization, designation, date, and title.

Use the Reference Wizard's Check Reference feature when you add a RID outside of the Section's Reference Article to automatically place the reference in the Reference Article. Also use the Reference Wizard's Check Reference feature to update the issue dates.

References not used in the text will automatically be deleted from this section of the project specification when you choose to reconcile references in the publish print process.

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

ASME INTERNATIONAL (ASME)

ASME B16.1	(2010) Gray Iron Pipe Flanges and Flanged Fittings Classes 25, 125, and 250
ASME B16.21	(2011) Nonmetallic Flat Gaskets for Pipe Flanges
ASME B16.3	(2011) Malleable Iron Threaded Fittings, Classes 150 and 300
ASME B16.5	(2013) Pipe Flanges and Flanged Fittings: NPS 1/2 Through NPS 24 Metric/Inch Standard
ASME B16.9	(2012) Standard for Factory-Made Wrought Steel Buttwelding Fittings

ASTM INTERNATIONAL (ASTM)

ASTM A126	(2004; R 2014) Standard Specification for Gray Iron Castings for Valves, Flanges, and Pipe Fittings
ASTM A181/A181M	(2014) Standard Specification for Carbon Steel Forgings, for General-Purpose Piping
ASTM A193/A193M	(2014) Standard Specification for Alloy-Steel and Stainless Steel Bolting Materials for High-Temperature Service and Other Special Purpose Applications
ASTM A194/A194M	(2014) Standard Specification for Carbon and Alloy Steel Nuts for Bolts for High-Pressure or High-Temperature Service, or Both
ASTM A234/A234M	(2013; E 2014) Standard Specification for Piping Fittings of Wrought Carbon Steel and Alloy Steel for Moderate and High Temperature Service
ASTM A53/A53M	(2012) Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless
ASTM D975	(2014a) Standard Specification for Diesel Fuel Oils

INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS (IEEE)

IEEE 115	(2009) Guide for Test Procedures for Synchronous Machines: Part I Acceptance and Performance Testing; Part II Test
----------	--

Procedures and Parameter Determination for
Dynamic Analysis

IEEE C2 (2012; Errata 2012; INT 1-4 2012; INT 5-7
2013; INT 8 2014) National Electrical
Safety Code

IEEE C50.12 (2005; R 2010) Standard for Salient Pole
50 HZ and 60 Hz Synchronous Generators and
Generation/Motors for Hydraulic Turbine
Applications Rated 5 MVA and above

INTERNATIONAL CODE COUNCIL (ICC)

ICC UBC (1997; Erratas Vol 1, 2 & 3 01/2001; Vol 1
& 2 03/2001; Vol 2 10/2001) Uniform
Building Code

INTERNATIONAL ELECTRICAL TESTING ASSOCIATION (NETA)

NETA ATS (2013) Standard for Acceptance Testing
Specifications for Electrical Power
Equipment and Systems

INTERNATIONAL ELECTROTECHNICAL COMMISSION (IEC)

IEC 60034-2A (1974; ED 1.0) Rotating Electrical
Machines Part 2: Methods for Determining
Losses and Efficiency of Rotating
Electrical Machinery from Tests (Excluding
Machines for Traction Vehicles)
Measurement of Losses by the Calorimetric
Method

INTERNATIONAL ORGANIZATION FOR STANDARDIZATION (ISO)

ISO 3046 (1986; Am. 1) Reciprocating Internal
Combustion Engines - Performance

ISO 8528 (1993; R 2005) Reciprocating Internal
Combustion Engine Driven Alternating
Current Generator Sets

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

MSS SP-58 (1993; Reaffirmed 2010) Pipe Hangers and
Supports - Materials, Design and
Manufacture, Selection, Application, and
Installation

MSS SP-69 (2003; Notice 2012) Pipe Hangers and
Supports - Selection and Application (ANSI
Approved American National Standard)

MSS SP-70 (2011) Gray Iron Gate Valves, Flanged and
Threaded Ends

MSS SP-71 (2011; Errata 2013) Gray Iron Swing Check

Valves, Flanged and Threaded Ends

MSS SP-80 (2013) Bronze Gate, Globe, Angle and Check Valves

MSS SP-85 (2011) Gray Iron Globe & Angle Valves Flanged and Threaded Ends

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)

NEMA C50.10 (1990) Rotating Electrical Machinery - Synchronous Machines

NEMA ICS 6 (1993; R 2011) Enclosures

NEMA MG 1 (2011; Errata 2012) Motors and Generators

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 30 (2015) Flammable and Combustible Liquids Code

NFPA 37 (2015) Standard for the Installation and Use of Stationary Combustion Engines and Gas Turbines

NFPA 70 (2014; AMD 1 2013; Errata 1 2013; AMD 2 2013; Errata 2 2013; AMD 3 2014; Errata 3-4 2014; AMD 4-6 2014) National Electrical Code

U.S. DEPARTMENT OF DEFENSE (DOD)

MIL-DTL-16884 (2014; Rev N) Fuel, Naval Distillate

MIL-DTL-5624 (2013; Rev V) Turbine Fuel, Aviation, Grades JP-4 and JP-5

MIL-STD-461 (2007; Rev F) Requirements for the Control of Electromagnetic Interference Characteristics of Subsystems and Equipment

U.S. GENERAL SERVICES ADMINISTRATION (GSA)

CID A-A-52557 (Rev A; Notice 1) Fuel Oil, Diesel; for Posts, Camps and Stations

U.S. NATIONAL ARCHIVES AND RECORDS ADMINISTRATION (NARA)

40 CFR 60 Standards of Performance for New Stationary Sources

UNDERWRITERS LABORATORIES (UL)

UL 1236 (2006; Reprint Jul 2011) Standard for Battery Chargers for Charging Engine-Starter Batteries

UL 142 (2006; Reprint Jul 2013) Steel Aboveground

Tanks for Flammable and Combustible Liquids

- UL 429 (2013) Electrically Operated Valves
- UL 467 (2007) Grounding and Bonding Equipment
- UL 489 (2013; Reprint Mar 2014) Molded-Case Circuit Breakers, Molded-Case Switches, and Circuit-Breaker Enclosures

1.2 RELATED REQUIREMENTS

Section 26 00 00.00 20 BASIC ELECTRICAL MATERIALS AND METHODS, and Section 26 08 00 APPARATUS INSPECTION AND TESTING apply to this section except as modified herein.

1.3 SYSTEM DESCRIPTION

1.3.1 Engine-Generator Set Data

Submit data pertaining to the diesel engine-generator set and to the auxiliary equipment including but not limited to the following:

- a. Make of engine.
- b. Type or model of engine.
- c. Gross bhp rating of engine shall be the total rated power output before deducting power requirements of electric motor-driven equipment or engine driven radiator fan.
- d. Net brake power rating of engine shall include deductions for the total power requirements of electric motor-driven or engine-driven accessories as defined in ISO 3046. Net ratings shall include a deduction in power output for cooling media system power requirements including radiator fans and any other power consuming devices required to provide cooling as specified.
- e. Strokes per cycle.
- f. Number of cylinders.
- g. Bore and stroke, mm inches.
- h. Engine speed, rpm.
- i. Piston speed, m/s fpm.
- j. kW power rating of engine-generator set as defined in the paragraph entitled "Engine-Generator Set Ratings and Performance."
- k. Induction method (naturally aspirated, turbocharged).
- l. Intercooler type (air-to-air or jacket water).
- m. Governor type, make, and model.
- n. Make and model of turbochargers.

1.3.2 Engine-Generator Set Efficiencies

**NOTE: Include the bracketed option below for
projects located outside the continental United
States (OCONUS)**

Submit data pertaining to the diesel engine-generator set including but not limited to the following: Loads shall be calculated on basis of rated engine-generator set power.

- a. Fuel consumption at 0.80 power factor, liters per hr gallons per hr.
 1. 1/2 load
 2. 3/4 load
 3. Full load
- b. Generator efficiency at 0.80 power factor (percent)[in accordance with IEC 60034-2A].
 1. 1/2 load
 2. 3/4 load
 3. Full load
- c. Radiator capacity at design conditions.
 1. Coolant shall be antifreeze mixture as specified under paragraph entitled "Cooling System."
 2. L/s gpm of coolant
 3. L/s cfm of air through radiator
 4. kW Btu per hr of heat exchange based on optimum coolant temperature to and from engine.

1.3.3 Diesel Engine Data

Submit data certified by the engine manufacturer including but not limited to the following: Loads shall be calculated on basis of rated engine-generator set power.

- a. Approximate exhaust temperature degrees C F at full load
- b. Weight of exhaust gas at full load kg per hr lb per hr
- c. Weight of intake air at full load kg per hr lb per hr
- d. Total heat rejected at full load kW Btu per hr
 1. To jacket coolant system
 2. To fuel oil cooling system

- e. Emissions (Lbs/hr)(kg/hr) at full load
 - 1. Total Suspended Particulate
 - 2. Particulate matter with an average aerodynamic diameter of 10 microns (PM-10)
 - 3. Sulfur dioxides
 - 4. Nitrogen Oxides (as NO₂)
 - 5. Carbon Monoxide
 - 6. Volatile Organic Compounds
- f. Visible Emissions (percent opacity) at full load

1.3.4 Generator and Exciter Data

Submit data certified by the generator manufacturer including but not limited to the following:

- a. Make and model number of generator
- b. kW rating of generator
- c. Generator reactances
 - 1. Synchronous reactance, X_d
 - 2. Transient reactance, X'_d
 - 3. Subtransient reactance, X''_d
 - 4. Negative sequence reactance, X_2
 - 5. Zero sequence reactance, X_0

1.3.5 Capacity Calculations for Engine-Generator Set

Calculations shall verify that the engine-generator set power rating is adequate for the load described in the paragraph entitled "Load Profile."

1.3.6 Calculations for Brake Mean Effective Pressure (BMEP)

Calculation shall verify that the diesel engine meets the specified maximum BMEP as follows:

- a. kW: Minimum power rating of engine-generator set as defined in the paragraph entitled "Engine-Generator Set Ratings and Performance."
- b. rpm: Engine revolutions per minute.
- c. liters cu. in.: Total engine piston displacement in liters cubic inches.
- d. GEN.EFF.: Generator efficiency.
- e. x: Multiplication sign.

- f. bkW' bhp' : Brake kW horsepower required from diesel engine by generator loaded to full power rating.
- g. bkW' bhp' : $\text{kW/GEN.EFF. kW/(GEN.EFF. times 0.746)}$.
- h. bkW" bhp" : Brake kW horsepower required by diesel engine driven fan for cooling radiator or motor driven fan for cooling radiator.
- i. bkW bhp : $\text{bkW' plus bkW" bhp' plus bhp"}$.
- j. BMEP kPa psi: $(120,000 \text{ times bkW}) (792,000 \text{ times bhp}) / (\text{rpm times liters cu. in.})$.

1.3.7 Torsional Vibration Stress Analysis Computations

Torsional vibrational stresses in the crankshaft and generator shaft of assembled diesel engine and driven generator shall not exceed 34,450 kPa 5000 psi when engine is driving generator at rated speed while assembled unit is loaded to rated engine-generator set power. Computations shall be based on a mathematical model of the assembled generator set provided or based on calculations using measured values from tests on a unit identical to the one provided. Calculations based on models of, or measured data from, the unassembled engine and generator will not be acceptable. Calculations shall include:

- a. A description of the system relating information pertinent to analysis such as operating speed range and identification plate data.
- b. A mass elastic assembly drawing, showing the arrangement of the units in the generator set and dimensions of shafting, including minimum diameters (or section moduli) of shafting in the system.
- c. A labeled line diagram of the mass elastic system indicating values of masses, stiffness, equivalent lengths, and equivalent diameters including basic assumptions and definition of terms.
- d. Sample computations showing procedures used to obtain resulting stress values.
- e. Computations indicating assembled engine-generator speed of 1800 rpm with assembly loaded to rated generator power and the resulting computed critical torsional stress values in the assembled engine crankshaft and generator shaft.

1.3.8 Capacity Calculations for Batteries

Calculation shall verify that the engine starting battery capacity exceeds dc power requirements.

[1.3.9 Turbocharger Load Calculations

NOTE: When the engine-generator set installation includes field installed exhaust system (i.e., the engine-generator set is installed internal to a building in lieu of in a self contained outdoor enclosure), include the following paragraph.

When the proposed exhaust system layout is different from that shown on the contract drawings, submit calculations showing that the external loads from the exhaust system such as weight and thermal expansion do not exceed the engine manufacturer's maximum allowed forces and moments on the turbocharger.

11.4 SUBMITTALS

NOTE: Review Submittal Description (SD) definitions in Section 01 33 00 SUBMITTAL PROCEDURES and edit the following list to reflect only the submittals required for the project.

The Guide Specification technical editors have designated those items that require Government approval, due to their complexity or criticality, with a "G". Generally, other submittal items can be reviewed by the Contractor's Quality Control System. Only add a "G" to an item, if the submittal is sufficiently important or complex in context of the project.

For submittals requiring Government approval on Army projects, a code of up to three characters within the submittal tags may be used following the "G" designation to indicate the approving authority. Codes for Army projects using the Resident Management System (RMS) are: "AE" for Architect-Engineer; "DO" for District Office (Engineering Division or other organization in the District Office); "AO" for Area Office; "RO" for Resident Office; and "PO" for Project Office. Codes following the "G" typically are not used for Navy, Air Force, and NASA projects.

An "S" following a submittal item indicates that the submittal is required for the Sustainability Notebook to fulfill federally mandated sustainable requirements in accordance with Section 01 33 29 SUSTAINABILITY REPORTING.

Choose the first bracketed item for Navy, Air Force and NASA projects, or choose the second bracketed item for Army projects.

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are [for Contractor Quality Control approval.][for information only. When used, a designation following the "G" designation identifies the office that will review the submittal for the Government.] Submittals with an "S" are for inclusion in the Sustainability Notebook, in conformance to Section 01 33 29 SUSTAINABILITY REPORTING. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-02 Shop Drawings

Engine-Generator set and auxiliary equipment; G[, [_____]]

[Auxiliary systems; G[, [____]]]

SD-03 Product Data

Engine-generator set data; G[, [____]]

Engine-generator set efficiencies; G[, [____]]

Diesel engine data; G[, [____]]

Generator and exciter data; G[, [____]]

Diesel engine-generator set; G[, [____]]

Auxiliary systems and equipment; G[, [____]]

Remote alarm annunciator; G[, [____]]

SD-05 Design Data

Capacity calculations for engine-generator set; G[, [____]]

Calculations for brake mean effective pressure; G[, [____]]

Torsional vibration stress analysis computations; G[, [____]]

Capacity calculations for batteries; G[, [____]]

[Turbocharger load calculations; G[, [____]]]

SD-06 Test Reports

Acceptance checks and tests; G[, [____]]

Functional acceptance tests; G[, [____]]

Functional acceptance test procedure; G[, [____]]

SD-07 Certificates

Vibration isolation system certification; G[, [____]]

Fuel system certification; G[, [____]]

Start-up engineer qualification resume; G[, [____]]

Instructor's qualification resume; G[, [____]]

SD-09 Manufacturer's Field Reports

Engine tests; G[, [____]]

Generator tests; G[, [____]]

Assembled engine-generator set tests; G[, [____]]

SD-10 Operation and Maintenance Data

Diesel engine-generator set, Data Package 4; G[, [_____]]

Auxiliary systems and equipment, Data Package 4; G[, [_____]]

Preliminary assembled operation and maintenance manuals; G[, [_____]]

Submit in accordance with Section 01 78 23 OPERATION AND MAINTENANCE DATA and the paragraph entitled "Assembled Operation and Maintenance Manuals."

SD-11 Closeout Submittals

Posted operating instructions; G[, [_____]]

Training plan; G[, [_____]]

1.5 QUALITY ASSURANCE

1.5.1 Drawing Requirements

1.5.1.1 Engine-Generator Set and Auxiliary Equipment

Submit drawings pertaining to the engine-generator set and auxiliary equipment, including but not limited to the following:

- a. Certified outline, general arrangement (setting plan), and anchor bolt details. Show total weight and center of gravity of assembled equipment on the steel subbase.
- b. Detailed elementary, schematic wiring, and interconnection diagrams of the engine starting system, jacket coolant heating system, engine protective devices, engine alarm devices, engine speed governor system, generator and excitation system, and other integral devices.
- c. Detailed elementary, schematic wiring; and interconnection diagrams of the diesel fuel system, starting battery system, engine-generator control panel, generator circuit breaker[, and remote alarm annunciator].
- d. Dimensional drawings or catalog cuts of exhaust silencers, radiator, diesel fuel day tanks, fuel oil cooler, valves and pumps, intake filters, vibration isolators, and other auxiliary equipment not integral with the engine-generator set.

[1.5.1.2 Auxiliary Systems

NOTE: When the engine-generator set installation includes field installed exhaust, air intake, fuel oil cooler, or jacket coolant water systems (i.e., the engine-generator set is installed internal to a building in lieu of in a self contained outdoor enclosure), include the following paragraph.

Submit drawings showing floor plan arrangement of[exhaust,][air intake,][fuel oil cooler,][and][jacket coolant water] systems including arrangement of piping and pipe sizes.

1.5.2 Vibration Isolation System Certification

Submit certification from the manufacturer that the vibration isolation system will reduce the vibration to the limits specified in the paragraph entitled "Vibration Isolation System."

1.5.3 Fuel System Certification

When the diesel fuel system requires a fuel oil cooler as described in the paragraph entitled "Fuel Oil Cooler," submit certification from the engine manufacturer that the fuel system design is satisfactory.

1.6 DELIVERY, STORAGE, AND HANDLING

Deliver equipment on pallets or blocking wrapped in heavy-duty plastic, sealed to protect parts and assemblies from moisture and dirt. Plug piping, conduit, exhaust, and air intake openings. Protect and prepare batteries for shipment as recommended by the battery manufacturer. Store auxiliary equipment at the site in covered enclosures, protected from atmospheric moisture, dirt, and ground water.

1.7 SITE CONDITIONS

Protect the components of the engine-generator set, including cooling system components, pumps, fans, and similar auxiliaries when not operating and provide components capable of the specified outputs in the following environment:

- a. Site Location: [_____]
- b. Site Elevation: [_____] meters[_____] feet above mean sea level
- c. Ambient Temperatures:

**NOTE: Ambient temperatures, design wind velocity,
and prevailing wind direction shall be as defined by
NAVFAC P-89, "Engineering Weather Data," dated 1
July 1978.**

- 1. Maximum [_____] degrees C[_____] degrees F dry bulb, [_____] degrees C[_____] degrees F wet bulb.
- 2. Minimum [_____] degrees C[_____] degrees F dry bulb.
- [d. Design Wind Velocity: [_____] km/h[_____] mph.]
- [e. Prevailing Wind Direction: [_____] .]
- f. Seismic Zone: Zone [_____] as defined by ICC UBC.

1.8 MAINTENANCE

1.8.1 Extra Materials

1.8.1.1 Paint

Furnish 4 liters one gallon of identical paint used on engine-generator set in manufacturer's sealed container with each engine-generator set.

1.8.1.2 Filters

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

1.8.2 Posted Operating Instructions

Provide proposed operating instructions for the engine-generator set and auxiliary equipment laminated between matte-surface thermoplastic sheets and suitable for placement adjacent to corresponding equipment. After approval, install operating instructions where directed.

PART 2 PRODUCTS

2.1 DIESEL ENGINE-GENERATOR SET

Provide diesel engine-generator sets consisting of a water cooled diesel engine direct connected to an ac generator with a brushless excitation system and accessories. Equipment and materials shall be the manufacturer's standard products offered in catalogs for commercial or industrial use.

2.1.1 Engine-Generator Set Ratings and Performance

ISO 8528. Each engine-generator set shall have a power rating of not less than [_____] kW at 0.8 power factor and supply[208Y/120][480Y/277][_____] -volt, three-phase,[60][50]-Hz ac output. Coordinate the engine-generator set to ensure an installed rating in the environment described in paragraph entitled "Site Conditions." The power of the engine-generator set is defined as the power output available at the generator terminals excluding the electrical power absorbed by the essential independent auxiliaries. Essential independent auxiliaries are items of equipment which are essential for the continued or repeated operation of the engine which uses power supplied from a source other than the engine.

2.1.1.1 Diesel Engine Capacity

NOTE: Select the appropriate engine-generator set from three manufacturers that suit the intended application based on power rating (kW) and kind of power (i.e., number of operating hours per year and average power output). Using the specified kW and the total engine piston displacement per the selected engine-generator sets catalog data, calculate the BMEP to be specified in accordance with the paragraph entitled "Calculations for BMEP." A value of 0.9 may be used for generator efficiency.

The diesel engine shall meet the specified maximum BMEP requirements at rated speed as calculated in accordance with the paragraph entitled "Calculations for BMEP." The engine capacity shall be based on the following:

NOTE: Contact the activity to find out fuel type to be used.

- a. Engine burning diesel fuel conforming to[CID A-A-52557, Grade DF-2,][MIL-DTL-16884,][ASTM D975, Grade 2-D,] or [MIL-DTL-5624, Grade JP-5] at an ambient temperature of 29 degrees C 85 degrees F.
- b. Engine cooled by a radiator fan mechanically driven by the diesel engine or remote with a motor driven fan.
- c. Engine cooled by coolant mixture of water and ethylene glycol, 50 percent by volume of each.

Maximum BMEP, kPa psi

	Naturally Aspirated	Turbocharged	Turbocharged and Intercooled
Four-cycle engines	[_____]	[_____]	[_____]
Engine speed, rpm:	[1800] [1500]	[_____]	[_____]

2.1.1.2 [Diesel Engine Emission Limits

NOTE: Include the following paragraph when an air pollution permit is required by local, state, or federal law to install and operate the diesel engine generator set. Contact the engine-generator set manufacturer for achievable limits. Contact the activities environmental department representative to determine permit requirements.

Emissions from the operation of the engine-generator set shall not exceed the following limits at full rated load.

- a. Total Suspended Particulate [_____] Lbs/Hr kg/Hr
- b. Particulate Matter with an [_____] Lbs/Hr kg/Hr average aerodynamic diameter of 10 microns (PM-10)
- c. Sulfur Dioxide [_____] Lbs/Hr kg/Hr
- d. Nitrogen Oxides (as NO₂) [_____] Lbs/Hr kg/Hr
- e. Carbon Monoxide [_____] Lbs/Hr kg/Hr
- f. Volatile Organic Compounds [_____] Lbs/Hr kg/Hr

g. Visible Emissions [_____] percent opacity

2.1.1.3 Performance Class

NOTE: See the following guidelines and table for selecting the appropriate performance class:

1. Select Class G1 where the connected loads are such that only basic parameters of voltage and frequency are needed, e.g., general purpose lighting and other simple electrical loads.
2. Select Class G2 where the demands on voltage characteristics are very much the same as for the commercial power system, e.g., lighting systems, pumps, fans, hoists.
3. Select Class G3 where the connected equipment may make severe demands on frequency, voltage, and waveform characteristics, e.g., telecommunications as thyristor-controlled loads.
4. Select Class G4 where the demands on the frequency, voltage, and waveform characteristics are exceptionally severe, e.g., data processing equipment or computer systems. Performance values for Class G4 shall be determined by the designer and an appropriate table similar to the following table must be inserted into the Specification.

Parameter	Performance Class		
	G1	G2	G3
100 Percent Load Increase Frequency Deviation (Percent)	<-15	<-10	<-7
100 Percent Load Decrease Frequency Deviation (Percent)	<+18	<+12	<+10
100 Percent Load Change Frequency Recovery Time (Seconds)	<10	<5	<3
100 Percent Load Increase Voltage Deviation (Percent)	<-25	<-20	<-15
100 Percent Load Decrease Voltage Deviation (Percent)	<+35	<+25	<+20
100 Percent Load Change Voltage Recovery Time (Seconds)	<10	<6	<4

Parameter	Performance Class		
	G1	G2	G3
Frequency Droop (Percent)	<-8	<-5	<-3
Steady-State Frequency Band (Percent) (plus or minus)	<2.5	<1.5	<0.5
Steady-State Voltage Regulation (Percent) (plus or minus)	<5	<2.5	<1.0

The voltage and frequency behavior of the generator set shall be in accordance with ISO 8528 operating limit values for performance Class[G1][G2][G3][G4 as follows].

2.1.1.4 Load Profile

The diesel engine-generator set shall be of adequate capacity necessary for the following load profile:

- [a. Lighting [_____] kW]
- [b. Computer [_____] kW]
- [c. Uninterruptible power supplies (UPS) [_____] kVA,[3][6][12][24] pulse]
- [d. Variable frequency drives (VFD) [_____] kVA,[3][6][12][24] pulse]
- [e. Motor starting sequence

Starting Order	Size (hp)	Locked Rotor NEMA Code	Starting Method	Maximum Voltage Dip
[_____]	[_____]	[F] [_____]	[Full Voltage] [_____]	[25] [_____] Percent
[_____]	[_____]	[F] [_____]	[Full Voltage] [_____]	[25] [_____] Percent
[_____]	[_____]	[F] [_____]	[Full Voltage] [_____]	[25] [_____] Percent

]

- [f. Other load: [_____] kW at 0.8 p.f.]

2.1.2 Diesel Engines and Accessories

NOTE: As of 8/98 major manufacturers are building only four-cycle engines in order to meet Federal emissions requirements. Two-cycle engines shall not be specified.

ISO 3046. Diesel engines shall be four-cycle naturally aspirated, or

turbocharged, or turbocharged and intercooled; vertical in-line or vertical Vee type; designed for stationary service. Engines shall be capable of immediate acceleration from rest to normal speed without intermediate idle/warm up period or prelubrication to provide essential electrical power. Two-cycle engines are not acceptable.

2.1.2.1 Subbase Mounting

Mount each engine-generator set on a structural steel subbase sized to support the engine, generator, and necessary accessories, auxiliaries and control equipment to produce a complete self-contained unit as standard with the manufacturer. Design the structural subbase to properly support the equipment and maintain proper alignment of the engine-generator set in the specified seismic zone. In addition, provide subbase with both lifting rings and jacking pads properly located to facilitate shipping and installation of the unit. Factory align engine and generator on the subbase and securely bolt into place in accordance with the manufacturer's standard practice. Crankshaft shall have rigid coupling for connection to the generator.

2.1.2.2 Assembly

Completely shop assemble each engine-generator set on its structural steel subbase. Paint entire unit with manufacturer's standard paints and colors. After factory tests and before shipping, thoroughly clean and retouch painting as necessary to provide complete protection.

2.1.2.3 Turbocharger

If required by the manufacturer to meet the engine-generator set rating, provide turbine type driven by exhaust gas from engine cylinders, and direct connected to the blower supplying air to the engine intake manifold.

2.1.2.4 Intercooler

Provide manufacturer's standard intercooler for engine size specified.

2.1.2.5 Crankcase Protection

NOTE: Include details on the drawings for the crankcase ventilation piping and associated penetrations through walls and roofs showing the piping sleeve and exterior flashing when the radiator is remote and the engine-generator set is to be installed inside a building.

Provide manufacturer's standard method of preventing crankcase explosions and standard method of crankcase ventilation. [Provide ventilation of crankcase via piping to the atmosphere as indicated on the drawings.]

2.1.2.6 Engine Lubricating Oil System

Provide each engine with the manufacturer's standard full pressure lubricating oil system arranged to cool the pistons and to distribute oil to moving parts of the engine. Provide oil type and oil filters as recommended by the engine manufacturer.

2.1.2.7 Engine Cooling System

Provide each engine with the manufacturer's standard jacket water pump. Provide a thermostatic control valve in the jacket coolant system for each engine-generator set to maintain a constant jacket coolant temperature to the engine.

2.1.2.8 Engine Fuel System

NOTE: Select the options for duplex filters when changing of the filter will be required while the engine-generator set is operating. Do not provide duplex filters when the engine-generator set is to be installed in an enclosure or provided with an engine-driven radiator.

Provide each engine with the manufacturer's standard fuel system integral with the engine, complete with necessary piping, fittings, and valves for connecting items of equipment which are a part of the system. Provide engine manufacturer's standard hand priming pump. Provide manufacturer's standard[simplex][duplex] filter for each engine, of the throwaway filter element type, consisting of shell filter elements, drains, and necessary connections and fittings. [Arrange duplex filter such that flow may be diverted from one chamber to the other without interruption at any point of the changeover.]

2.1.2.9 Engine Intake Filter

Provide intake filter assemblies for each engine of the oil bath or dry type, as standard with the manufacturer. Filters shall be capable of removing a minimum of 92 percent of dirt and abrasive 3 microns and larger from intake air. Size filters to suit engine requirements at 100 percent of rated full load. Design unit for field access for maintenance purposes.

2.1.2.10 Engine Starting System

Starting shall be accomplished using an adequately sized dc starter system with a positive shift solenoid to engage the starter motor and to crank the engine continuously for 60 seconds without overheating.

2.1.2.11 Jacket Coolant Heating System

Provide a factory-installed,[120][_____] volts ac, jacket coolant heating system to ensure rapid starting. Thermostatically control heater at the temperature recommended by engine manufacturer. Include necessary equipment, piping, controls, wiring, and accessories.

2.1.2.12 Engine Protective (Shutdown) Devices

Equip each engine with devices to shut down the engine by shutting off the fuel supply to the engine via a fuel shutoff solenoid. Auxiliary contacts shall be suitable for activating a remote alarm system. Shutdown shall open the associated generator circuit breaker. Provide the following shutdown devices:

- a. Overspeed device which operates when engine speed exceeds normal synchronous speed by 18 percent or as recommended by manufacturer.

Device shall require manual reset.

- b. Pressure switch which operates when lubricating oil pressure to engine drops below a preset value.
- c. Temperature switch which operates when jacket coolant temperature exceeds a preset value.
- d. Device which operates when the coolant level in the radiator drops below a preset level.
- e. Other shutdown devices as recommended by the engine manufacturer.

2.1.2.13 Engine Alarm Devices

Equip each engine with alarm devices. Auxiliary contacts shall be suitable for activating a remote alarm system. Alarm devices shall have factory-fixed set points. Provide the following alarm contact devices:

- a. Pressure switch which operates when lubricating oil pressure drops below a preset value.
- b. Temperature switch which operates when jacket coolant temperature exceeds a preset value.
- c. Temperature switch which operates when jacket coolant temperature is too low.
- d. Other alarm devices as recommended by the engine manufacturer.

2.1.2.14 Miscellaneous Engine Accessories

Provide the following engine accessories where the manufacturer's standard design permits:

- a. Piping on engine to inlet and outlet connections, including nonstandard companion flanges.
- b. Structural steel subbase and vibration isolators, foundation bolts, nuts, and pipe sleeves.
- c. Level jack screws or shims, as required.
- d. Rails, chocks, and shims for installation of subbase on the foundation.
- e. Removable guard, around fan. Support guard, on engine subbase, to suit manufacturer's standard.

2.1.2.15 Engine Speed Governor System

Provide a forward acting type engine speed governor system. Steady-state frequency band and frequency regulation (droop) shall be in accordance with the operating limit values of the performance class specified in the paragraph entitled "Performance Class."

2.1.3 Generator and Excitation System

2.1.3.1 Generator

NOTE: Use the following guidelines for specifying generators:

1. Select dripproof guarded option for generators without weatherproof enclosures.
2. Select NEMA MG 1, Part 16, standby duty, and temperature rise of 130 degrees C for engine-generator sets which are expected to operate for less than 300 hours per year. Select NEMA MG 1, Part 22, continuous duty, and temperature rise of 105 degrees C for engine-generator sets expected to operate 300 hours or greater per year or rated 300 kW and above.
3. Select 2/3 pitch design option for engine-generator sets rated 300 kW and above.
4. Select 10-12 lead reconnectable for engine-generator sets rated 300 kW to 800 kW.
5. For applications requiring high SCR loading or in harsh environments laden with salts and chemicals, select vacuum pressure impregnation (VPI) insulated coils. When engine-generator sets are rated 800 kW and larger, also select form wound coils.

Provide salient-pole type, ac, brushless-excited, revolving field, air-cooled, self-ventilated, [dripproof guarded,] coupled type, synchronous generator conforming to NEMA MG 1, Part [16] [22], NEMA C50.10, and IEEE C50.12. Generator shall be rated for [standby] [continuous] duty at 100 percent of the power rating of the engine-generator set as specified in paragraph entitled "Engine-Generator Set Ratings and Performance." Temperature rise of each of the various parts of the generator shall not exceed [130] [105] degrees C as measured by resistance, based on a maximum ambient temperature of 40 degrees C. Winding insulation shall be Class H.

- a. Stator: Stator windings shall be [2/3 pitch design] [,] [10-12 lead reconnectable] [with VPI insulated [and form wound] coils].
- b. Rotor: The rotor shall have connected amortiser windings.
- c. Generator Space Heater: Provide [120] [_____] volt ac heaters. Heater capacity shall be as recommended by the generator manufacturer to aid in keeping the generator insulation dry.
- d. Grounding: Provide non-corrosive steel grounding pads located at two opposite mounting legs.
- e. Filters: Provide manufacturer's standard generator cooling air filter assembly.

2.1.3.2 Excitation System

**NOTE: Select all options for engine-generator sets
rated 300 kW and above.**

Provide a brushless excitation system consisting of an exciter and rotating rectifier assembly[, and permanent magnet generator] integral with the generator and a voltage regulator. Insulation class for parts integral with the generator shall be as specified in paragraph entitled "Generator." System shall provide a minimum short circuit of 300 percent rated engine-generator set current for at least 10 seconds. Steady state voltage regulation shall be in accordance with the operating limit values of the performance class specified in the paragraph entitled "Performance Class."

- a. Exciter and Rotating Rectifier Assembly: Rectifiers shall be provided with surge voltage protection.
- [b. Permanent Magnet Generator: Provide a voltage spike suppression device for permanent magnet generator (PMG) excitation systems.
-] c. Voltage Regulator: Voltage regulator shall be solid state or digital, automatic, three-phase sensing, volts per hertz type regulator.[Regulator shall receive its input power from a PMG.] Voltage variation for any 40 degree C change over the operating temperature range shall be less than plus or minus 1.0 percent. Operating temperature shall be minus 40 degree C to plus 70 degree C. Voltage adjust range shall be plus to minus 5.0 percent of nominal. Inherent regulator features shall include overexcitation shutdown.

[2.1.3.3 Electromagnetic Interference (EMI) Suppression

**NOTE: Include electromagnetic interference (EMI)
suppression for engine-generator set installations
in the proximity of sensitive electronic equipment.**

Provide as an integral part of the generator and excitation system, EMI suppression complying with MIL-STD-461.

]2.2 ENGINE-GENERATOR SET AUXILIARY SYSTEMS AND EQUIPMENT

Provide auxiliary systems and equipment designed for continuous duty at 100 percent of the power rating of the engine-generator set as specified in the paragraph entitled "Engine-Generator Set Ratings and Performance."

2.2.1 Vibration Isolation System

Install the subbase on vibration isolators that are secured to a suitable concrete foundation. Provide isolators as recommended by the engine-generator set and isolator manufacturers and provide integral or external lateral support to limit lateral movement and overturning moments. The isolation system shall reduce the vibration transmitted to the adjacent floor slab to a maximum of 0.038 mm 0.0015 inch total amplitude throughout the frequency range down to 65 Hz.

2.2.2 Exhaust System

Provide exhaust systems for each engine.

2.2.2.1 Exhaust Silencers

NOTE: The normal values given in the table for exhaust sound reduction are for installations in residential applications. If the installation is in a critical environment (such as a hospital), more stringent criteria must be applied, including engine noise dampening, and the attenuation values in the table for critical class should be selected.

A[residential class][critical class] silencer shall be provided for each engine which will reduce the exhaust sound spectrum by the following listed values at a 23 m 75 foot radius from the outlet, with generator set loaded to rated capacity and clear weather. Inlet and outlet connections shall be flanged.

Octave Band Center Frequency (Hertz)								
Minimum Silencer Attenuation Decibels	63	125	250	500	1000	2000	4000	8000
[Residential Class]	[10]	[25]	[32]	[30]	[25]	[25]	[24]	[23]
[Critical Class]	[15]	[32]	[37]	[36]	[30]	[36]	[37]	[37]

2.2.2.2 Field Installed Exhaust Piping System

NOTE: Include the following paragraph when the engine-generator set is installed internal to a building in lieu of in a self contained outdoor enclosure. The designer is responsible for ensuring that:

1. External loads from the exhaust system, such as weight and thermal expansion do not exceed the engine manufacturer's maximum allowed forces and moments on the turbocharger, and;

2. The exhaust piping system pressure loss is coordinated with the visible emission limits of the engine-generator set when air pollution permitting is required.

Field installed exhaust piping shall conform to the following:

- a. Exhaust Piping: Provide flanges for connections to diesel engines, exhaust mufflers, and flexible connections. Provide steel pipe conforming to ASTM A53/A53M for each engine complete with necessary

fittings, flanges, gaskets, bolts, and nuts. Exhaust piping shall be Schedule 40 pipe for 300 mm 12 inches and smaller, standard weight for sizes 350 mm 14 inches through 600 mm 24 inches, and 6 mm 0.25 inch wall thickness for sizes larger than 600 mm 24 inches. Flanges shall be Class 150 slip-on forged steel welding flanges in accordance with ASME B16.5, with material in accordance with ASTM A181/A181M, Grade I. Fittings shall be butt welding conforming to ASTM A234/A234M, with wall thickness same as adjoining piping. Fittings shall be of same material and wall thickness as pipe. Built-up miter welded fittings may be used. 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 exhaust piping shall be of high temperature asbestos-free material suitable for the service and shall be ASME B16.21, composition ring, 1.6 mm 0.0625 inch thick. Bolting material for exhaust flanges shall be alloy-steel bolt-studs conforming to ASTM A193/A193M, Grade B7 bolts and alloy-steel nuts conforming to ASTM A194/A194M, Grade 7. 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. Provide stainless steel counterbalance type rain caps at termination of each exhaust pipe.

**NOTE: Select option for liners in expansion joints
when required to reduce exhaust pressure drop.**

b. Expansion (Flexible) Joints: Provide sections of multiple corrugated stainless steel expansion joints[with liners] in the engine exhaust piping for each engine to absorb expansion strains and vibration transmitted to the piping. Flexible joints shall be suitable for operation at 93 degrees C 200 degrees F above normal exhaust gas temperature at 100 percent load, 10,000 cycles, minimum. Joints shall be flanged and located between engine exhaust manifold and exhaust piping, shall be the same size as exhaust piping size, and shall be designed and constructed for diesel engine exhaust service.

c. Hangers and Supports: MSS SP-58 and MSS SP-69.

**NOTE: Include on the drawings a detail of the
exhaust piping penetrations through walls and roofs
showing the piping sleeve and exterior flashing.**

d. Piping Sleeves: Provide where piping passes through masonry or concrete walls, floors, roofs, and partitions. Sleeves shall be placed during construction. Unless indicated otherwise, pipe sleeves shall comply with following requirements: sleeves in outside walls below and above grade, in floor, or in roof slabs, shall be standard weight zinc coated steel pipe. Sleeves in partitions shall be zinc coated sheet steel having a nominal weight of not less than 4.4 kg per square meter 0.90 pound per square foot. Space between piping insulation and the sleeve shall not be less than 6 mm 0.25 inch. Sleeves shall be held securely in proper position and location during construction. Sleeves shall be sufficient length to pass through entire thickness of walls, partitions, or slabs. Sleeves in floor slabs shall extend 50 mm 2 inches above the finished floor. Space between the pipe and the sleeve shall be firmly packed with insulation and caulked at both ends of the sleeve with plastic waterproof cement.

- e. Piping Insulation: Provide exhaust piping insulation in accordance with Section 23 07 00 THERMAL INSULATION FOR MECHANICAL SYSTEMS.

12.2.3 Cooling System

Provide the specified cooling water system. Properly size equipment to handle the flow rate and pressure losses of the coolant mixture specified in the paragraph entitled "Diesel Engine Capacity," and at the site elevation specified in the paragraph entitled "Site Conditions."

2.2.3.1 Radiators

NOTE: Generally utilize the engine subbase radiator as the less expensive option. In cases where insufficient cooling air or space or additional reliability is necessary (requiring cross-connecting of radiators), provide remote radiators.

NOTE: At the text below, use the maximum dry-bulb temperature of the site plus 8 degrees C 15 degrees F for the first temperature, but not less than 43 degrees C 110 degrees F. Use minus 18 degrees C 0 degrees F, except where minimum dry-bulb temperature permits use of a higher temperature.

Provide for each engine-generator set, as standard with the manufacturer.

- a. Design Conditions: Each radiator unit shall have ample capacity to remove not less than the total kW Btu per hour of heat rejected by its respective engine at 100 percent full-rated load to the jacket water, fuel oil, and lubricating oil system, and intercooler. Radiator capacity shall be rated at optimum temperature of coolant leaving the engine and intercooler as recommended by the engine manufacturer with an ambient dry bulb air temperature outside the enclosure of [_____] degrees C [_____] degrees F maximum, and [_____] degrees C [_____] degrees F minimum at the site elevation specified in the paragraph entitled "Site Conditions," and with the coolant mixture specified in the paragraph entitled "Diesel Engine Capacity." Pressure drop through the radiator shall not exceed 41.34 kPa 6 psi when circulating the maximum required coolant flow. Radiator air velocity shall be a maximum of 7.6 meters per second 1500 feet per minute.
- [b. Engine Mounted Radiator Construction: Radiator fan shall direct airflow from the engine outward through the radiator. Fan shall be V-belt driven directly from the engine crankshaft. Radiator fan shall have sufficient capacity to meet design conditions against a static restriction of [_____] Pa [_____] inch of water. Fan static capacity shall be adjusted to suit the ductwork furnished. Cooling section shall have a tube and fin-type core consisting of copper or copper base alloy tubes with nonferrous fins. Select engine-driven fans for quiet vibration-free operation. Make provision 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.

]

NOTE: Radiator fan cycling controls should be considered for engines to be operated above 500 hours per year.

- [c. Remote Radiator Construction: Provide radiators as described above, except radiators shall be remotely piped and provided with electric motor driven fan. Drive shall be multiple V-belt or reduction gears. Expansion tanks shall be separately mounted. Air flow shall be vertical or horizontal as indicated. Interlock fan with engine operation such that fan shall operate when engine operates when recommended by engine manufacturer.[Provide controls and control devices complete which shall cycle fan on and off based upon coolant temperature.] Provide motors, controllers, contactors, and disconnects in accordance with paragraph entitled "Electrical Support Equipment."
-] d. Coolant solution shall be a mixture of clean water and ethylene glycol, 50 percent by volume each. Provide an anti-freeze solution tester suitable for the mixture.

[2.2.3.2 Jacket Coolant Water Piping Systems

NOTE: Include the following paragraph when providing cooling system with a remote radiator.

Field installed jacket coolant water piping shall conform to the following:

- a. Piping: Provide seamless steel pipe, Schedule 40, conforming to ASTM A53/A53M, Grade A.
- b. Fittings and Flanges: Fittings, 40 mm 1 1/2 inches or smaller, shall be malleable iron conforming to ASME B16.3 for Class 300 threaded type. Fittings, 50 mm 2 inches and larger, shall be steel butt welding conforming to ASME B16.9. Utilize either ASME B16.1 or Class A of ASTM A126 for Class 125 cast-iron flanged fittings. Flanges shall be Class 150 slip-on forged steel welding flanges in accordance with ASME B16.5, with material in accordance with ASTM A181/A181M, Grade I. Provide flat face flanges for connecting to Class 125 standard cast-iron valves, fittings, and equipment connections.
- c. Valves
1. Gate Valves: For valves, 40 mm 1 1/2 inches and smaller, provide double disk, rising stem, inside screw, union bonnet type, Class 125 bronze material conforming to MSS SP-80. For valves, 50 mm 2 inches and larger, provide double-disk, parallel seat type, hydraulic-rated, Class 125, outside screw and yoke type with flanged ends and bronze trim conforming to MSS SP-70. Provide stem packing of material compatible with the system coolant.
 2. Globe Valves: For valves, 40 mm 1 1/2 inches and smaller, provide rising stem, inside screw, union bonnet type, Class 125 bronze valves conforming to MSS SP-80. For valves, 50 mm 2 inches and larger, provide Class 125 cast iron, flanged ends, bronze trim globe valves conforming to MSS SP-85. Valves shall have renewable

composition or cast iron discs compatible with the system coolant.

3. Check Valves: MSS SP-71 or MSS SP-80, swing check type.

d. Hangers and Supports: MSS SP-58 and MSS SP-69.

**NOTE: Include on the drawings a detail of the
cooling piping penetrations through walls and roofs
showing the piping sleeve and exterior flashing.**

e. Piping Sleeves: Provide where piping passes through masonry or concrete walls, floors, roofs, and partitions. Place sleeves during construction. Unless indicated otherwise, pipe sleeves shall comply with following requirements: Sleeves in outside walls below and above grade, in floor, or in roof slabs, shall be standard weight zinc coated steel pipe. Sleeves in partitions shall be zinc coated sheet steel having a nominal weight of not less than 4.4 kg per square meter 0.90 pound per square foot. Space between piping insulation and the sleeve shall be not less than 6 mm 0.25 inch. Sleeves shall be held securely in proper position and location during construction. Sleeves shall be of sufficient length to pass through entire thickness of walls, partitions, or slabs. Sleeves in floor slabs shall extend 50 mm 2 inches above the finished floor. Space between the pipe and the sleeve shall be firmly packed with insulation and caulked at both ends of the sleeve with plastic waterproof cement.

2.2.4 Diesel Fuel System

NFPA 30 and NFPA 37 and the requirements herein.

2.2.4.1 Diesel Fuel Piping System

Factory installed piping shall conform to the engine manufacturer's standard. Provide flange connections in accordance with ASME B16.1 Class 125 flanges.[Piping between the engine and the diesel fuel day tank shall comply with Section 33 52 10 SERVICE PIPING, FUEL SYSTEMS.]

2.2.4.2 Diesel Fuel Day Tank System

Provide[120][_____] volt ac diesel fuel day tank system. Include necessary equipment, piping, controls, wiring, and accessories.

**NOTE: Use the following guidelines for specifying
diesel fuel day tanks:**

**1. Select integral day tank in skid where
applicable and available. Day tank capacity
available varies from 100 gallons to 5,000 gallons.**

**2. See NFPA 37 for allowable day tank sizes and
restrictions.**

**3. Provide an overflow or return line between the
diesel fuel day tank and storage tank in accordance
with NFPA 37 where applicable.**

4. Day tank capacity shall be in accordance with the following table for facilities complying with MIL-HDBK-1191, "DOD Medical and Dental Treatment Facilities Design and Construction Guide."

50 KW - 100 KW GEN SET	:	25 MIN - 50 MAX GAL
101 KW - 200 KW GEN SET	:	50 MIN - 75 MAX GAL
201 KW - 300 KW GEN SET	:	75 MIN - 100 MAX GAL
OVER 300 KW GEN SET	:	100 MIN - 250 MAX GAL

- a. Day Tanks: UL 142. Provide[integral in skid][free standing] double wall (110 percent containment) diesel fuel day tanks with a[minimum capacity of [_____] hours of engine-generator set operation at full-rated load][capacity as indicated]. Epoxy coat day tanks inside and prime and paint outside. Construct tanks of not less than 4.76 mm 3/16 inch steel plate with welded joints and necessary stiffeners on exterior of tank. Provide a braced structural steel framework support. Weld tank top tight and provide an access opening with dustproof, removable 600 mm 24 inch cover. Provide 114 mm 4 1/2 inch square inspection port. Provide proper venting of both inner and outer containment.
- b. Float Switches: Provide tank-top mounted or external float cage, single-pole, single-throw type designed for use on fuel oil tanks. Arrange high level float switches to close on rise of liquid level, and low level float switches to close on fall of liquid level. Mount float cage units with isolating and drain valves. Contacts shall be suitable for the station battery voltage.
 1. Critical low level float switch which shall activate at 5 percent of normal liquid level shall shut engine off.
 2. Low-low level float switch which shall activate alarm at 30 percent of normal liquid level.
 3. Low level float switch which shall open the fuel oil solenoid valve and start the[remote] fuel transfer pump at 75 percent of normal liquid level.
 4. High level float switch which shall close the fuel oil solenoid valve and stop the[remote] fuel transfer pump at 90 percent of normal liquid level.
 5. Critical high level float switch which shall activate alarm at 95 percent of normal liquid level.
- c. Leak Detector Switch: Actuates when fuel is detected in containment basin, stops fuel transfer pump, and closes the fuel oil solenoid valve.
- d. Control Panel: Provide NEMA ICS 6, Type[1][_____] , enclosed control panel for each day tank. Control panel shall include the following accessories.
 1. Power available LED (green).
 2. Critical low fuel alarm contacts for shut down of engine.
 3. Low-low level fuel alarm LED.

4. Low-low level fuel alarm contacts for remote annunciator.

5. Critical high level fuel alarm LED.

6. Leak detecting alarm LED.

7. Alarm horn.

- e. Tank Gages: Provide buoyant force type gages for diesel fuel day tanks with dial indicator not less than 100 mm 4 inches in size and arranged for top mounting. Calibrate each reading dial or scale for its specific tank to read from empty to full, with intermediate points of 1/4, 1/2, and 3/4.

[2.2.4.3 Fuel Transfer Pump[s]

NOTE: Delete this paragraph when remote fuel transfer pump(s) are provided. Select duplex pumps for facilities complying with UFC 4-510-01, "Design: Medical Military Facilities".

Fuel transfer pumps may be day tank or base mounted. Pump[s] shall be [duplex,] horizontal, positive displacement. Direct-connect pump to motor through a flexible coupling. Equip each pump with a bypass relief valve, if not provided with an internal relief valve. Provide motor and controller in accordance with paragraph entitled "Electrical Support Equipment."

]2.2.4.4 Fuel Oil Solenoid Valve

UL 429. Provide electric solenoid type control valve for each day tank. Solenoid shall be rated for starting battery voltage. Valve body shall have a minimum working pressure rating of 1033 kPa 150psig at 93 degrees C 200 degrees F. Valve shall be capable of passing 0 to 0.63 L/s 0 to 10 gpm of fuel oil. Valves shall be two-way, direct acting, normally closed (open when energized, closed when de-energized), with brass body and resilient seat material. Solenoid enclosures shall be NEMA ICS 6, Type 1. Body connections shall be same size as connecting piping. Valve shall be in line before the fuel pump.

2.2.4.5 Strainer

NOTE: Select the options for duplex filters when changing of the filter will be required while the engine-generator set is operating. Do not provide duplex filters when the engine-generator set is to be installed in an enclosure or provided with an engine-driven radiator.

[Simplex][Duplex] strainers shall comply with Section 33 52 10 SERVICE PIPING, FUEL SYSTEMS.

[2.2.4.6 Fuel Oil Meters

**NOTE: Provide fuel oil meters when required by the
using activity.**

Fuel oil meter shall comply with Section 33 52 10 SERVICE PIPING, FUEL SYSTEMS.

]2.2.4.7 Fuel Oil Cooler

Provide an air cooled fuel oil cooler if the temperature of the fuel returned to the tank from the engine will cause overheating of the tank fuel above the maximum fuel temperature allowed by the engine manufacturer when operating at maximum rated generator power output and low fuel level in the tank. The fuel oil cooler shall be furnished by the engine manufacturer for the application and the installation shall be complete including piping and power requirements.

2.2.5 Starting Battery System

**NOTE: Starting battery system shall be 24-volt dc
for engine-generator sets greater than 100 kW and
12-volt dc for engine-generator sets rated 100 kW
and less.**

Provide a[24][12]-volt dc starting battery installation for starting of each engine-generator set utilizing an electric cranking system.

2.2.5.1 Engine Starting Battery

**NOTE: The ambient temperature selected shall be the
lowest temperature at which the engine might be
cranked. Battery configuration shall be two
parallel sets of two 12-volt batteries for
engine-generator sets rated 750 kW and above.**

Provide maintenance free, sealed, lead-acid, SAE Type D diesel engine starting batteries.[Battery configuration shall be two parallel sets of two 12-volt batteries.] Batteries shall have sufficient capacity to provide 60 seconds of continuous cranking of the engine in an ambient temperature of [_____] degrees C [_____] degrees F.

2.2.5.2 Starting Battery Charger

UL 1236. Provide[120][____] volt ac, enclosed, automatic equalizing, dual-rate, solid-state, constant voltage type battery charger with automatic ac line compensation. Dc output shall be voltage regulated and current limited. Charger shall have two ranges, float and equalize, and shall provide continuous taper charging. The charger shall have a continuous output rating of not less than 10 amperes and shall be sized to recharge the engine starting batteries in a minimum of 8 hours while providing the control power needs of the engine-generator set. Enclosure shall be NEMA ICS 6, Type[1][_____]. The following accessories shall be

included:

- a. Dc ammeter
- b. Dc voltmeter
- c. Equalize light
- d. Ac on light
- e. Low voltage light
- f. High voltage light
- g. Equalize test button/switch
- h. Ac circuit breaker
- i. Low dc voltage alarm relay
- j. High dc voltage alarm relay
- k. Current failure relay
- l. Ac power failure relay

2.2.6 Engine-Generator Control Panel

Provide NEMA ICS 6, Type[1][____], enclosed control panel mounted on the engine-generator set with vibration isolators. Provide the following control panel mounted devices and control features.

2.2.6.1 Control Panel Mounted Devices

- a. Engine Control Switch (ECS): Provide a three position control switch with "MANUAL START" - "OFF/RESET" - "AUTO START" positions.
- b. Emergency Stop Push Button (ESPB): Provide a red, mushroom head, twist-to-reset, maintained contact type push button.
- c. Generator Metering: Provide ac metering package that displays ac voltage, current, and frequency of one phase of the generator output simultaneously. Metering package shall include a voltmeter/ammeter phase selector switch to allow viewing of each phase.
- d. Generator Voltage Adjust Potentiometer (VAP): Provide a potentiometer, locking screwdriver type, to adjust generator voltage.
- e. Engine Instrumentation: Provide instrumentation package that displays the following engine information:
 1. Engine oil pressure
 2. Engine coolant temperature
 3. Engine speed (rpm)
 4. Engine running hours

f. Indicating Lamps: Provide LED type indicating lamps and a lamp test switch. Lamps shall indicate the following alarm and shutdown conditions:

1. Low engine lubricating oil pressure alarm
2. Low engine lubricating oil pressure shutdown
3. High engine coolant temperature alarm
4. High engine coolant temperature shutdown
5. Engine overcrank shutdown
6. Engine overspeed shutdown
7. Emergency stop shutdown
8. Starting battery system trouble alarm
9. Day tank low fuel shutdown
10. Low engine coolant temperature alarm
11. Low coolant level shutdown

g. Alarm Horn: Provide an alarm horn and a horn silence switch.

h. Panel Lamp: Provide a panel lamp and lamp "ON-OFF" switch.

2.2.6.2 Crank Cycle/Terminate Relay

Provide crank cycle/terminate relay with adjustable crank/rest periods of 1 to 60 seconds (initially set for 15 seconds) and adjustable total crank time of 30 seconds to 10 minutes (initially set for 75 seconds).

2.2.6.3 Engine Cooldown Relay

Provide cooldown relay with adjustable cool down time of 0 to 30 minutes (initially set at engine manufacturer's recommended time).

[2.2.7 Remote Alarm Annunciator

NOTE: Include option for remote alarm panel located in a location readily observed by operating personnel when the engine-generator set is not in a readily observed location. For most applications the remote alarm annunciator should be powered from the engine starting battery system. When a separate battery power source is necessary, select the option for "Storage Battery."

Provide NEMA ICS 6, Type[1][____], enclosed remote alarm annunciator[powered by the engine starting battery system]. The annunciator shall have a lamp test switch and LED type indicating lamps. The annunciator shall give visual and audible warnings for the following operating and alarm conditions:

- a. Provide lamps for the following operating conditions:
 - 1. Operating power source, normal or emergency
 - 2. Starting battery system trouble
- b. Provide lamps and an audible signal for the following alarm conditions:
 - 1. Low engine lubricating oil pressure
 - 2. Low engine coolant temperature
 - 3. High engine coolant temperature
 - 4. Low fuel
 - 5. Engine overcrank shutdown
 - 6. Engine overspeed shutdown

[2.2.7.1 Storage Battery

Provide storage batteries of suitable rating and capacity to supply and maintain power for the remote alarm annunciator for a period of 90 minutes minimum without the voltage applied falling below 87.5 percent of normal. Provide a[120][_____] volt ac automatic battery charger.

]2.2.8 Generator Circuit Breaker

UL 489, molded case, adjustable thermal magnetic trip type circuit breaker. The circuit breaker continuous current rating shall be adequate for the power rating of the engine-generator set and the circuit breaker shall be rated to withstand the short circuit current provided by the generator set. Provide circuit breaker in a NEMA ICS 6, Type[1][_____] enclosure mounted on the engine-generator set.

2.2.9 Electrical Support Equipment

Furnish with respective pieces of equipment. Motors, controllers, contactors, and disconnects shall conform to Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM. Provide electrical connections under Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM. Provide controllers and contactors with maximum of 120-volt control circuits, and auxiliary contacts for use with controls furnished. When motors and equipment furnished are larger than size indicated, the cost of providing additional electrical service and related work shall be included under this section.

[2.2.10 Weatherproof Enclosure

Provide for each engine-generator set and fabricate from zinc coated or phosphatized and shop primed 16 gage minimum sheet steel in accordance with the manufacturer's standard design. Provide a complete, weatherproof enclosure for the engine, generator, and auxiliary systems and equipment. Support exhaust piping and silencer so that the turbocharger is not subjected to exhaust system weight or lateral forces generated in connecting piping that exceed the engine manufacturer's maximum allowed forces and moments. The housing shall have sufficient louvered openings to allow entrance of outside air for engine and generator cooling at full

load. Design louvered openings to exclude driving rain and snow. Provide properly arranged and sized, hinged panels in the enclosure to allow convenient access to the engine, generator, and control equipment for maintenance and operational procedures. Provide hinged panels with spring type latches which shall hold the panels closed securely and will not allow them to vibrate. Brace the housing internally to prevent excessive vibration when the set is in operation.

12.3 SPECIAL WRENCHES AND TOOLS

Wrenches and tools specifically designed and required to work on the new equipment, which are not commercially available as standard mechanic's tools, shall be furnished to the Contracting Officer.

2.4 IDENTIFICATION OF EQUIPMENT

Provide plates and tags sized so that inscription is readily legible to operating or maintenance personnel and securely mounted to or attached in proximity of their identified controls or equipment. Lettering shall be normal block lettering, a minimum of 6.4 mm 0.25 inch high.

2.4.1 Materials

Construct ID plates and tags of 16 gage minimum thickness bronze or stainless steel sheet metal engraved or stamped with inscription. Construct plates and tags not exposed to the weather or high operational temperature of the diesel engine of laminated plastic, 3.2 mm 0.125 inch thick, matte white finish with black center core, with lettering accurately aligned and engraved into the core.

2.4.2 Control Devices and Operation Indicators

Provide ID plates or tags for control devices and operation indicators, including valves, off-on switches, visual alarm annunciators, gages and thermometers, that are required for operation and maintenance of provided mechanical systems. Plates or tags shall be minimum of 13 mm 0.5 inch high and 50 mm 2 inches long and shall indicate component system and component function.

2.4.3 Equipment

Provide ID plates of a minimum size of 75 mm 3 inches high and 130 mm 5 inches long on provided equipment indicating the following information:

- a. Manufacturer's name, address, type and model number, and serial number;
- b. Contract number and accepted date;
- c. Capacity or size;
- d. System in which installed; and
- e. System which it controls.

2.5 ASSEMBLED OPERATION AND MAINTENANCE MANUALS

The contents of the assembled operation and maintenance manuals shall include the manufacturer's O&M information required by the paragraph entitled "SD-10, Operation and Maintenance Data" and the manufacturer's O&M

information specified in Section 26 36 23.00 20 AUTOMATIC TRANSFER SWITCHES.

- a. Manuals shall be in separate books or volumes, assembled and bound securely in durable, hard covered, water resistant binder, and indexed by major assembly and components in sequential order.
- b. A table of contents (index) shall be made part of the assembled O&M. The manual shall be assembled in the order noted in table of contents.
- c. The cover sheet or binder on each volume of the manuals shall be identified and marked with the words, "Operation and Maintenance Manual."

2.6 SOURCE QUALITY CONTROL

**NOTE: Include the bracketed option below for
projects located outside the continental United
States (OCONUS)**

Perform and report on factory tests and inspections prior to shipment. Provide certified copies of manufacturer's test data and results. Test procedures shall conform to ASME, IEEE,[IEC,] and ANSI standards, and to ISO requirements on testing, as appropriate and applicable. The manufacturer performing the tests shall provide equipment, labor, and consumables necessary for tests and measuring and indicating devices shall be certified to be within calibration. Tests shall indicate satisfactory operation and attainment of specified performance. If satisfactory, equipment tested will be given a tentative approval. Equipment shall not be shipped before approval of the factory test reports for the following tests.

2.6.1 Engine Tests

Perform customary commercial factory tests in accordance with ISO 3046 on each engine and associated engine protective device, including, but not limited to the following:

- a. Perform dynamometer test at rated power. Record horsepower at rated speed and nominal characteristics such as lubricating oil pressure, jacket water temperature, and ambient temperature.
- b. Test and record the values that the low oil pressure alarm and protective shutdown devices actuate prior to assembly on the engine.
- c. Test and record values that the high jacket water temperature alarm and protective shutdown devices actuate prior to assembly on the engine.

2.6.2 Generator Tests

**NOTE: Include the bracketed option below for
projects located outside the continental United
States (OCONUS)**

Tests shall be performed on the complete factory assembled generator prior to shipment. Conduct tests in accordance with IEEE 115, NEMA C50.10[,

IEC 60034-2A], and NEMA MG 1.

2.6.2.1 Routine Tests

Perform the following routine tests on the generators and their exciters:

- a. Resistance of armature and field windings
- b. Mechanical balance
- c. Phases sequence
- d. Open circuit saturation curve and phase (voltage) balance test
- e. Insulation resistance of armature and field windings
- f. High potential test

2.6.2.2 Design Tests

Submit the following design tests made on prototype machines that are physically and electrically identical to the generators specified.

- a. Temperature rise test
- b. Short circuit saturation curve and current balance test

2.6.3 Assembled Engine-Generator Set Tests

**NOTE: Select the first option for engine-generator
sets rated up to 250 kW. Select the second option
for engine-generator sets rated greater than 250 kW.**

[Submit the following tests made on prototype machines that are physically and electrically identical to the engine-generator set specified.][Perform the following tests on the assembled engine-generator set.

]2.6.3.1 Initial Stabilization Readings

Operate the engine-generator set and allow the set to stabilize at rated kW at rated power factor, rated voltage, and rated frequency. During this period record instrument readings for output power (kW), terminal voltage, line current, power factor, frequency (rpm) generator (exciter) field voltage and current, lubricating oil pressure, jacket water temperature, and ambient temperature at minimum intervals of 15 minutes. Adjust the load, voltage, and frequency to maintain rated load at rated voltage and frequency. Adjustments to load, voltage, or frequency controls shall be recorded on the data sheet at the time of adjustment. Stabilization shall be considered to have occurred when four consecutive voltage and current recorded readings of the generator (or exciter) field either remain unchanged or have only minor variations about an equilibrium condition with no evident continued increase or decrease in value after the last adjustment to the load, voltage, or frequency has been made.

2.6.3.2 Regulator Range Test

Remove load and record instrument readings (after transients have

subsided). Adjust voltage to the maximum attainable value or to a value just prior to actuation of the overvoltage protection device. Apply rated load and adjust voltage to the minimum attainable value or a value just prior to activation of the undervoltage protection device. The data sheets shall indicate the voltage regulation as a percent of rated voltage and the maximum and minimum voltages attainable. Voltage regulation shall be defined as follows:

$$\text{Percent Regulation} = \frac{((\text{No-Load Voltage}) - (\text{Rated-Load Voltage})) \times 100}{(\text{Rated-Load Voltage})}$$

2.6.3.3 Frequency Range Test

Adjust the engine-generator set frequency for the maximum attainable frequency at rated load. Record instrument readings. Adjust the engine-generator set frequency for the specified minimum attainable frequency at rated load. Record instrument readings. Reduce the load to zero and adjust the engine-generator set frequency for the maximum attainable frequency. Record instrument readings. Adjust the engine-generator set frequency for the minimum attainable frequency. Record instrument readings. The data sheet shall show the maximum and minimum frequencies attained at rated load, and at no load.

2.6.3.4 Transient Response Test

Drop the load to no load and re-apply rated load three times to ensure that the no load and rated load voltage and frequency values are repeatable and that the frequency and voltage regulation is within the limits specified. Record generator terminal voltage and frequency using a high speed strip chart recorder. The data sheet shall show the following results:

a. Frequency

1. Stability bandwidth or deviation in percent of rated frequency.
2. Recovery time.
3. Overshoot and undershoot.

b. Voltage

1. Stability bandwidth or deviation in percent of rated voltage.
2. Recovery time.
3. Overshoot and undershoot.

PART 3 EXECUTION

3.1 INSTALLATION

Installation shall conform to the applicable requirements of IEEE C2 NFPA 30, NFPA 37, and NFPA 70.

3.2 GROUNDING

NOTE: Where rock or other soil conditions prevent obtaining a specified ground value, other methods of

grounding should be specified. Where it is impractical to obtain the indicated ground resistance values, make every effort within reason to obtain ground resistance values as near as possible to the indicated values.

NFPA 70 and IEEE C2, except that grounding systems shall have a resistance to solid earth ground not exceeding 5 ohms.

3.2.1 Grounding Electrodes

Provide driven ground rods as specified in [Section 33 71 02 UNDERGROUND ELECTRICAL DISTRIBUTION] [and] [Section 33 71 01 OVERHEAD TRANSMISSION AND DISTRIBUTION]. Connect ground conductors to the upper end of ground rods by exothermic weld or compression connector. Provide compression connectors at equipment end of ground conductors.

3.2.2 Engine-Generator Set Grounding

Provide separate copper grounding conductors and connect them to the ground system as indicated. When work in addition to that indicated or specified is required to obtain the specified ground resistance, the provision of the contract covering "Changes" shall apply.

3.2.3 Connections

Make joints in grounding conductors by exothermic weld or compression connector. Exothermic welds and compression connectors shall be installed as specified in Section 33 71 02 UNDERGROUND ELECTRICAL DISTRIBUTION paragraph regarding "Grounding."

3.2.4 Grounding and Bonding Equipment

UL 467, except as indicated or specified otherwise.

3.3 START-UP ENGINEER

Provide the services of a qualified factory trained start-up engineer, regularly employed by the engine-generator set manufacturer. The start-up services shall include conducting preliminary operations and functional acceptance tests. The start-up engineer shall be present at the engine generator set installation site, full-time, while preliminary operations and functional acceptance tests are being conducted.

3.4 PREREQUISITES FOR FUNCTIONAL ACCEPTANCE TESTING

Completion of the following requirements is mandatory prior to scheduling functional acceptance tests for the engine-generator set and auxiliary equipment.

3.4.1 Piping Tests

Complete as specified in Section 33 52 10 SERVICE PIPING, FUEL SYSTEMS.

3.4.2 Performance of Acceptance Checks and Tests

The acceptance checks and tests shall be accomplished by the testing organization as described in Section 26 08 00 APPARATUS INSPECTION AND

TESTING.

3.4.2.1 Generator Sets

Complete as specified in the paragraph entitled "Acceptance Checks and Tests."

3.4.2.2 Automatic Transfer Switches

Complete acceptance checks and tests as specified in Section 26 36 23.00 20 AUTOMATIC TRANSFER SWITCHES.

3.4.3 Preliminary Operations

The start-up engineer shall conduct manufacturer recommended start-up procedures and tests to verify that the engine-generator set and auxiliary equipment are ready for functional acceptance tests. Give the Contracting Officer 15 days' advance notice that preliminary operations will be conducted. After preliminary operation has been successfully conducted, the start-up engineer will notify the Contracting Officer in writing stating the engine-generator set and auxiliary equipment are ready for functional acceptance tests.

3.4.4 Preliminary Assembled Operation and Maintenance Manuals

Preliminary assembled operation and maintenance manuals shall have been submitted to and approved by the Contracting Officer. Manuals shall be prepared as specified in the paragraph entitled "Assembled Operation and Maintenance Manuals."

3.4.5 Functional Acceptance Test Procedure

Test procedure shall be prepared by the start-up engineer specifically for the engine-generator set and auxiliary equipment. The test agenda shall cover the requirements specified in the paragraph entitled "Functional Acceptance Tests." The test procedure shall indicate in detail how tests are to be conducted. A statement of the tests that are to be performed without indicating how the tests are to be performed is not acceptable. Indicate what work is planned on each workday and identify the calendar dates of the planned workdays. Specify what additional technical support personnel is needed such as factory representatives for major equipment. Specify on which testing workday each technical support personnel is needed. Data recording forms to be used to document test results are to be submitted with the proposed test procedure. A list of test equipment and instruments shall also be included in the test procedure.

3.4.6 Test Equipment

Test equipment and instruments shall be on hand prior to scheduling field tests or, subject to Contracting Officer approval, evidence shall be provided to show that arrangements have been made to have the necessary equipment and instruments on site prior to field testing.

3.5 FIELD QUALITY CONTROL

NOTE: Include the bracketed option below for NAVFAC projects. coordinate Echelon III REach-back Support with NAVFAC LANT CIEE Office or NAVFAC PAC CI44

**Office during the design stage of the specific
project.**

Give Contracting Officer[NAVFAC [____], Code [____]] 30 days notice of dates and times scheduled for tests which require the presence of the Contracting Officer. The Contracting Officer will coordinate with the using activity and schedule a time that will eliminate or minimize interruptions and interference with the activity operations. The Contractor shall be responsible for costs associated with conducting tests outside of normal working hours and with incorporating special arrangements and procedures, including temporary power conditions. The Contractor shall provide labor, equipment, diesel fuel, test load, and consumables required for the specified tests. The test load shall be a cataloged product. Calibration of measuring devices and indicating devices shall be certified. Refer to Section 26 00 00.00 20 BASIC ELECTRICAL MATERIALS AND METHODS, for requirements for a cataloged product. Perform the following field tests.

3.5.1 Acceptance Checks and Tests

Perform in accordance with the manufacturer's recommendations, and include the following visual and mechanical inspections and electrical tests, performed in accordance with NETA ATS.

3.5.1.1 Circuit Breakers - Low Voltage Insulated Case/Molded Case

a. Visual and mechanical inspection

1. Compare nameplate data with specifications and approved shop drawings.
2. Inspect circuit breaker for correct mounting.
3. Operate circuit breaker to ensure smooth operation.
4. Inspect case for cracks or other defects.
5. Verify tightness of accessible bolted connections and cable connections by calibrated torque-wrench method. Thermographic survey is not required.
6. Inspect mechanism contacts and arc chutes in unsealed units.

b. Electrical Tests

1. Perform contact-resistance tests.
2. Perform insulation-resistance tests.
3. Adjust Breaker(s) for final settings in accordance with engine-generator set manufacturer's requirements.

3.5.1.2 Current Transformers

a. Visual and Mechanical Inspection

1. Compare equipment nameplate data with specifications and approved shop drawings.

2. Inspect physical and mechanical condition.
3. Verify correct connection.
4. Verify that adequate clearances exist between primary and secondary circuit.
5. Verify tightness of accessible bolted electrical connections by calibrated torque-wrench method. Thermographic survey is not required.
6. Verify that all required grounding and shorting connections provide good contact.

b. Electrical Tests

1. Perform insulation-resistance tests.
2. Perform polarity tests.
3. Perform ratio-verification tests.

3.5.1.3 Metering and Instrumentation

a. Visual and Mechanical Inspection

1. Compare equipment nameplate data with specifications and approved shop drawings.
2. Inspect physical and mechanical condition.
3. Verify tightness of electrical connections.

b. Electrical Tests

1. Determine accuracy of meters at 25, 50, 75, and 100 percent of full scale.
2. Calibrate watthour meters according to manufacturer's published data.
3. Verify all instrument multipliers.
4. Electrically confirm that current transformer secondary circuits are intact.

3.5.1.4 Battery Systems

a. Visual and mechanical inspection

1. Compare equipment nameplate data with specifications and approved shop drawings.
2. Inspect physical and mechanical condition.
3. Verify tightness of accessible bolted electrical connections by calibrated torque-wrench method. Thermographic survey is not required.

4. Measure electrolyte specific gravity and temperature and visually check fill level.
5. Verify adequacy of battery support racks, mounting, anchorage, and clearances.

b. Electrical tests

1. Set charger float and equalizing voltage levels.
2. Verify all charger functions and alarms.
3. Measure each cell voltage and total battery voltage with charger energized and in float mode of operation.
4. Perform a capacity load test.

3.5.1.5 Engine-Generator Set

a. Visual and mechanical inspection

1. Compare equipment nameplate data with specifications and approved shop drawings.
2. Inspect physical and mechanical condition.
3. Inspect for correct anchorage and grounding.

b. Electrical and mechanical tests

1. Perform an insulation-resistance test on generator winding with respect to ground. Calculate polarization index.
2. Perform phase rotation test to determine compatibility with load requirements.

3.5.1.6 Grounding System

a. Visual and mechanical inspection

1. Inspect ground system for compliance with contract plans and specifications.

b. Electrical tests

1. Perform ground-impedance measurements utilizing the fall-of-potential method. On systems consisting of interconnected ground rods, perform tests after interconnections are complete. On systems consisting of a single ground rod perform tests before any wire is connected. Take measurements in normally dry weather, not less than 48 hours after rainfall. Use a portable ground testing megger in accordance with manufacturer's instructions to test each ground or group of grounds. The instrument shall be equipped with a meter reading directly in ohms or fractions thereof to indicate the ground value of the ground rod or grounding systems under test.

3.5.2 Functional Acceptance Tests

NOTE: Include the bracketed option below for NAVFAC projects.

The tests shall be performed by the start-up engineer. Upon successful test completion, the start-up engineer shall provide the Contracting Officer with a written test report within 15 calendar days showing the tests performed and the results of each test. The report shall include the completed approved test data forms and certification from the start-up engineer that the test results fall within the manufacturer's recommended limits and meet the specified requirements performance. The report shall be dated and signed by the start-up engineer, and submitted for approval by the Contracting Officer. The Contracting Officer[and NAVFAC [____], Code [____]] will witness final acceptance tests. Testing shall include but not be limited to:

- a. Verify proper functioning of each engine protective shutdown device and pre-shutdown alarm device. Testing of the devices shall be accomplished by simulating device actuation and observing proper alarm and engine shutdown operation.
- b. Verify proper functioning of the engine overspeed trip device. Testing of the overspeed trip device shall be accomplished by raising the speed of the engine-generator set until an overspeed trip is experienced.
- c. Verify proper functioning of the crank cycle/terminate relay. Testing of the relay shall be accomplished by engaging the starter motor with the engine being prevented from running. Observe the complete crank/rest cycle as described in the paragraph entitled "Crank Cycle/Terminate Relay."
- d. Verify proper functioning of the following automatic and manual operations. Testing shall include but not be limited to:
 1. Loss of Utility: Initiate a normal power failure with connected test load of rated kW at 1.0 power factor. Record time delay on start, cranking time until engine starts and runs, time to come up to operating speed, voltage and frequency overshoot, and time to achieve steady state conditions with all switches transferred to emergency position.
 2. Return of Utility: Return normal power and record time delay on retransfer for each automatic transfer switch, and time delay on engine cooldown and shutdown.
 3. Manual starting
 4. Emergency stop
- e. Operate the engine-generator set at rated current (amperes) until the jacket water temperature stabilizes. Stabilization will be considered to have occurred when three consecutive temperature readings remain unchanged. Continue to operate the generator set for an additional 2 hours. Record instrument readings for terminal voltage, line current, frequency (Hz), engine speed rpm, lubricating oil pressure, jacket

water temperature, and ambient temperature at 5 minute intervals for first 15 minutes and at 15 minute intervals thereafter.

[3.5.3 Emissions Tests

**NOTE: Include the following paragraph when
verification of diesel engine emission limits are
required by air pollution permit.**

Provide on site testing by a certified testing organization of each engine-generator set. Testing shall be in accordance with an EPA approved method, 40 CFR 60, (Appendix, Method 7, 7A, 7B, 7C, 7D or 7E). Emissions at rated full load shall be within the limits specified in the paragraph entitled "Diesel Engine Emissions Limits."

]3.6 DEMONSTRATION

Upon completion of the work and at a time approved by the Contracting Officer, the Contractor shall provide instructions by a qualified instructor to the Government personnel in the proper operation and maintenance of the equipment. [_____] Government personnel shall receive training comparable to the equipment manufacturer's factory training. The duration of instruction shall be for not less than one 8 hour working day for instruction of operating personnel and not less than one 8 hour working day for instruction of maintenance personnel.

3.6.1 Instructor's Qualification Resume

Instructors shall be regular employees of the engine-generator set manufacturer. The instruction personnel provided to satisfy the requirements above shall be factory certified by the related equipment manufacturer to provide instruction services. Submit the name and qualification resume of instructor to the Contracting Officer for approval.

3.6.2 Training Plan

Submit training plan 30 calendar days prior to training sessions. Training plan shall include scheduling, content, outline, and training material (handouts). Content shall include but not limited to the following:

3.6.2.1 Operating Personnel Training

This instruction includes operating the engine-generator set, auxiliary equipment including automatic transfer switches in all modes, and the use of all functions and features specified.

3.6.2.2 Maintenance Personnel Training

Shall include mechanical, hydraulic, electrical, and electronic instructions for the engine-generator set and auxiliary equipment including automatic transfer switches.

a. Mechanical Training: Shall include at least the following:

1. A review of mechanical diagrams and drawings.
2. Component location and functions.

3. Troubleshooting procedures and techniques.
 4. Repair procedures.
 5. Assembly/disassembly procedures.
 6. Adjustments (how, when, and where).
 7. Preventive maintenance procedures.
 8. Review of flow diagram.
 9. Valve locations and function.
 10. Valve and hydraulic equipment adjustment and maintenance procedures.
 11. Hydraulic system maintenance and servicing.
 12. Lubrication points, type, and recommended procedures and frequency.
- b. Electrical and Electronic Maintenance Training: Shall include at least the following:
1. A review of electrical and electronic systems including wiring diagrams and drawings.
 2. Troubleshooting procedures for the machine and control systems.
 3. Electrical and electronic equipment servicing and care.
 4. Use of diagnostics to locate the causes of malfunction.
 5. Procedures for adjustments (locating components, adjustments to be made, values to be measured, and equipment required for making adjustments).
 6. Maintenance and troubleshooting procedures for microprocessor or minicomputer where applicable.
 7. Circuit board repair procedures where applicable (with schematics provided).
 8. Use of diagnostic tapes.
 9. Recommended maintenance servicing and repair for motors, switches, relays, solenoids, and other auxiliary equipment and devices.

-- End of Section --