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USACE / NAVFAC / AFCESA / NASA **UFGS-41 65 10.00 10 (May 2009)**

Preparing Activity: USACE **Superseding**
UFGS-41 65 10.00 10 (January 2008)

UNIFIED FACILITIES GUIDE SPECIFICATIONS

References are in agreement with UMRL dated July 2012
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DIVISION 41 - MATERIAL PROCESSING AND HANDLING EQUIPMENT

SECTION 41 65 10.00 10

[DIESEL][NATURAL GAS] FUELED ENGINE PUMP DRIVES

05/09

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SECTION 41 65 10.00 10

[DIESEL][NATURAL GAS] FUELED ENGINE PUMP DRIVES
05/09

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NOTE: This guide specification covers the requirement for diesel or natural gas fueled engines used as prime movers for vertical pumps at civil works flood control pumping stations. This section was originally developed for USACE Civil Works projects.

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).
****

PART 1 GENERAL

****
NOTE: This guide is intended to be used in the preparation of project specifications along with Section 22 10 00.00 10 VERTICAL PUMPS, AXIAL-FLOW AND MIXED-FLOW IMPELLER-TYPE, and Section 33 45 00.00 10 SPEED REDUCERS FOR STORM WATER PUMPS. The Designer should edit the title of this section to reflect appropriate project requirements.

The designer is responsible for making a prime mover selection from either an electric motor, a diesel engine, or a natural gas engine. The guidance for making proper selection is contained in EM

1110-2-3105, "Mechanical and Electrical Design of Pumping Stations".

The specification is written for a construction contract. Under a construction contract, these components can be purchased and installed by a Construction Contractor. A single contract allows the Contractor to obtain the most optimum combination and be responsible for the total performance of the unit, including shaft alignment. This also makes it feasible for the Contractor to perform a dynamic analysis of the pump, speed reducer, and prime mover system, as described in Section 22 10 00.00 10, and makes the Contractor solely responsible for acquiring the necessary data to perform such analysis.

****

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.

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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.

AMERICAN NATIONAL STANDARDS INSTITUTE (ANSI)

ANSI C39.1	(1981; R 1992) Requirements for Electrical Analog Indicating Instruments

ASME INTERNATIONAL (ASME)

ASME B16.11	(2011) Forged Fittings, Socket-Welding and Threaded
ASME B16.3	(2011) Malleable Iron Threaded Fittings, Classes 150 and 300
ASME B16.5	(2009) Pipe Flanges and Flanged Fittings:

	NPS 1/2 Through NPS 24 Metric/Inch Standard
ASME B31.1	(2010) Power Piping
ASME BPVC SEC IX	(2010) BPVC Section IX-Welding and Brazing Qualifications
ASME BPVC SEC VIII D1	(2010) BPVC Section VIII-Rules for Construction of Pressure Vessels Division 1

ASTM INTERNATIONAL (ASTM)

ASTM A106/A106M	(2011) Standard Specification for Seamless Carbon Steel Pipe for High-Temperature Service
ASTM A181/A181M	(2006; R 2011) Standard Specification for Carbon Steel Forgings, for General-Purpose Piping
ASTM A234/A234M	(2011a) 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 B395/B395M	(2008) Standard Specification for U-Bend Seamless Copper and Copper Alloy Heat Exchanger and Condenser Tubes
ASTM C533	(2011) Standard Specification for Calcium Silicate Block and Pipe Thermal Insulation
ASTM D975	(2011b) Standard Specification for Diesel Fuel Oils

INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS (IEEE)

IEEE C2	(2012; Errata 2012; INT 1 2012; INT 2 2012) National Electrical Safety Code

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

MSS SP-58	(2009) Pipe Hangers and Supports - Materials, Design and Manufacture, Selection, Application, and Installation
MSS SP-69	(2003) Pipe Hangers and Supports - Selection and Application (ANSI Approved American National Standard)
MSS SP-80	(2008) Bronze Gate, Globe, Angle and Check Valves

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)

NEMA ICS 2	(2000; R 2005; Errata 2008) Standard for Controllers, Contactors, and Overload Relays Rated 600 V
NEMA ICS 6	(1993; R 2011) Enclosures
NEMA MG 1	(2011) Motors and Generators

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 30	(2012; Errata 2011; Errata 2011) Flammable and Combustible Liquids Code
NFPA 37	(2010; TIA 10-1) Standard for the Installation and Use of Stationary Combustion Engines and Gas Turbines
NFPA 70	(2011; Errata 2 2012) National Electrical Code

SOCIETY OF AUTOMOTIVE ENGINEERS INTERNATIONAL (SAE)

SAE ARP892	(1965; R 1994) DC Starter-Generator, Engine
SAE J1995	(19905; R 1995) Engine Power Test Code - Spark Ignition and Compression Ignition - Gross Power Rating
SAE J537	(2011) Storage Batteries

U.S. DEPARTMENT OF DEFENSE (DOD)

UFC 3-310-04	(2007; Change 1) Seismic Design for Buildings

UNDERWRITERS LABORATORIES (UL)

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

1.2 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.

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

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Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for [Contractor Quality Control approval.] [information only. When used, a designation following the "G" designation identifies the office that will review the submittal for the Government.] The following shall be submitted in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-02 Shop Drawings

Layout and Shop Drawings[; G][; G, [_____]]
Installation[; G][; G, [_____]]

SD-03 Product Data

Equipment and Performance[; G][; G, [_____]]
Cooling System[; G][; G, [_____]]

****

NOTE: Delete requirement for dynamic analysis of engine, pump, and speed reducer system, if this analysis will be performed by others.

****

Dynamic Analysis of Engine, Pump, and Governor[; G][; G, [_____]]
Project/Site Conditions
Onsite Training[; G][; G, [_____]]
Manufacturer's Published Instructions[; G][; G, [_____]]
Field Engineer[; G][; G, [_____]]
DieselNatural Gas Fueled Engine Pump Drive[; G][; G, [_____]]
Welder Qualifications
Installation[; G][; G, [_____]]

SD-06 Test Reports

Engine

A fully documented shop test report.

The field test report, documenting all data for lubrication oil temperature and flow, cooling [water] [air] temperature and flow, and compliance with specified performance criteria tested during

the field tests.

SD-07 Certificates

Pressure Vessels
Regulatory Requirements[; G][; G, [_____]]

SD-11 Closeout Submittals

As-Built Drawings[; G][; G, [_____]]
Operation and Maintenance Manual[; G][; G, [_____]]

1.3 WELDER QUALIFICATIONS

Welding shall be in accordance with qualifying procedures using performance qualified welders and welding operators. Qualify procedures and welders in accordance with ASME BPVC SEC IX. Welding procedures qualified by others, and welders and welding operators qualified by a previously qualified employer may be accepted as permitted by ASME B31.1.[Structural members shall be welded in accordance with Section 05 05 23 WELDING, STRUCTURAL.][Welding and nondestructive testing procedures for pressure piping are specified in Section 40 05 13.96 WELDING PROCESS PIPING.]

Notify the Contracting Officer 24 hr in advance of tests, and the tests shall be performed at the work site, if practical. The welder or welding operator shall apply the assigned symbol near each weld made as a permanent personal record. Submit a letter listing the welder-qualifying procedures for each welder, complete with all supporting data such as test procedures used, what was tested to, and a list of the names of all welders and their identification symbols.

1.4 REGULATORY REQUIREMENTS

1.4.1 General

Design, fabrication, and installation of the equipment shall conform to the [specified] [applicable national, state, and local] codes. Submit documentation for conformance according to paragraph SUBMITTALS.

1.4.2 Layout and Shop Drawings

Submit layout and shop drawings including the following:

a. Base-mounted equipment, complete with base and all attachments including anchor bolt template and recommended clearances for maintenance and operation.

b. Complete starting system.

c. Complete fuel system.

d. Complete cooling system.

e. Complete intake and exhaust systems.

f. Layout of relays, breakers, switches, and instrumentation provided and applicable single line and wiring diagrams with a written description of the sequence of operation.

g. Lubrication system complete including piping, pump(s), strainers, filters, [heat exchangers for lube oil and turbocharger cooling], [electric heater], controls, and wiring.

h. Location, type, and description of vibration isolation devices for all applications.

i. The safety system, together with a detailed description of its operation. Wiring schematics, safety devices with a listing of their normal ranges, alarm and shutdown valves (to include operation parameters such as pressures, temperatures, voltages, currents, and speeds) shall be included.

j. Layout of the engine control panel and alarm panel.

k. Mounting and support for each panel and major piece of electrical equipment.

l. Engine lifting points and rigging instructions.

m. Alignment information for the engine, [gear box] and [pump] specifying sequences, tolerances, and temperature change effects.

1.5 DELIVERY, STORAGE, AND HANDLING

Protect material and equipment from weather, humidity, temperature variation, dirt, dust, and other contaminants during delivery and storage. Lifting, moving, and storage of the engine shall be in accordance with manufacturer's requirements.

1.6 PROJECT/SITE CONDITIONS

****

NOTE: The designer should specify the ambient conditions where the engine drive will be installed. Maximum and minimum air temperature is determined by location. For indoor installation, use indoor design maximum and minimum temperatures. For outdoor installations use the 99-percentile selection from ASHRAE Guide application tables for the installation location.

****

Maximum Air Temperature	[_____] degrees C F
Minimum Air Temperature	[_____] degrees C F
Raw Water Temperature	Max. [_____] degrees C F
	Min. [_____] degrees C F
Installation Elevation	[_____] m ft above sea level

Submit the record of the survey of the existing installation site conditions and verification of site work details.

1.7 MAINTENANCE

1.7.1 Extra Materials

****
NOTE: Spare parts to be furnished under this contract should be specified here. The designer is responsible for determining and providing a list of spare parts requirements. The following is a partial list:
****

Furnish the following minimum spare parts when applicable to the type of engine proposed.

UNITS	DESCRIPTION
[_____]	Complete engine cylinder head(s) and valve set, etc. (if applicable)
[_____]	Complete valve set(s) for one cylinder with springs, cages, etc.
[_____]	Cylinder liner(s) with all necessary water seal rings
[_____]	Complete piston(s) with rings and connecting rod assemblies
[_____]	Wrist pins with retaining rings and wrist pine bearing shells
[_____]	Complete set(s) of piston rings for one engine
[_____]	Complete set(s) of main bearing shell of each size and type for the crankshaft of each engine rating supplied
[_____]	Crankpin bearing shell for each crankshaft of each engine rating supplied
[_____]	Complete fuel injector nozzle assembly and fuel injector pump assembly
[_____]	Air start motor (if applicable)
[_____]	Air start check valve (if applicable)
[_____]	Complete gaskets set for one engine
[_____]	Refills, with storage box, for all lubricating oil filters for each engine
[_____]	Refills, with storage box, for all fuel oil filters for each engine
[_____]	Spare lubricating oil circulating pump assembly
[_____]	Jacket water pump
[_____]	Pre-lube oil pump and motor assembly (if applicable)

UNITS	DESCRIPTION
[_____]	Pressure transducer(s)

1.7.2 Special Tools

Provide one complete set of special tools required for maintenance. Special tools are those that only the manufacturer provides for special purposes or to reach otherwise inaccessible parts. The tools shall be supplied complete with a suitable tool box.

PART 2 PRODUCTS

2.1 SYSTEM DESCRIPTION

2.1.1 General Requirements

Provide and install complete and totally functional, [the] [each] engine with all necessary ancillary equipment including, but not limited to, air filtration, starting system, instrumentation, lubrication, fuel system, cooling system, and engine exhaust system. [The] [Each] engine rating shall be in accordance with SAE J1995. The DieselNatural Gas Fueled Engine Pump Drive shall be complete units with all components, accessories, and system interconnections coordinated, so that the complete assembly shall have the capabilities required, for proper operation with the pump specified under Section 22 10 00.00 10 VERTICAL PUMPS, AXIAL-FLOW AND MIXED-FLOW IMPELLER-TYPE and the speed reducer specified in Section 33 45 00.00 10 SPEED REDUCERS FOR STORM WATER PUMPS.

Submit written documentation that the products being supplied are appropriate for this engine pump drive, including past performance of the drive on certain types of service, i.e., marine generators, pump drives, locomotives, metal shredders, etc., with a minimum operation of 2,000 hr per year of service with a minimum of 2 years of qualifying service. The certification of the unit's speed, horsepower, and duty rating that forms the basis of the qualifying experience is required for acceptance and shall be within 30 percent of [this drive's rating] [these drives' ratings].

2.1.2 Performance Requirements

****
NOTE: The designer should specify the service requirements for the pump drive: Continuous, Standby, or Emergency. The designer should furnish pump manufacturer's data including pump curves and plans unless this specification is used in conjunction with pump specification Section 22 10 00.00 10 as a package. The selection of the engine speed should follow the guidance given in EM 1110-2-3105. Rated capacity should be based on the pump manufacturer's recommendation.
****

Service Requirements	**[Continuous] [Standby] [Emergency]**
Rated Capacity	110 percent maximum kW (hp) required from the pump curves at specified speed plus power required by the accessories
Overload Capacity	110 percent rated capacity for 2 hours in 24 consecutive hours
Maximum Speed	[_____] [900] [1,200] [1,800] RPM
[Characteristics of the pump load for the engine drive are described in the pump curves and pump plans included in [____].]	
Site Ambient Conditions: The site characteristics are as described in paragraph PROJECT/SITE CONDITIONS.	

2.1.3 Arrangement

****

NOTES: The engine shaft can be connected to the gear box by either a flexible coupling or universal joint assembly. In cases where the engine is large or the operating floor space is limited, a flexible coupling would be more appropriate. Manufacturer's recommendations should be solicited for arrangement alternatives. The designer should determine the configuration of the day tank, main fuel storage tank, and engine injection ports. If the main storage fuel tank is the lowest point in the engine fuel system, then a pump will be required to deliver fuel oil to the day tank.

****

Each engine, as shown and specified, is to be used as the prime mover for the vertical pump.[Connect the engine shaft to the reducer input shaft with two universal joints and an intermediate shaft.][Connect the engine shaft to the reducer input shaft with a flexible coupling.] Coordinate among the manufacturers of the dieselnatural gas fueled engine, gear reducer, and the pump manufacturer to ensure the compatibility of these components including, but not limited to, the proper fit of engine and reducer shafts, the interaction of major components, and control of safety and alarm signals. Supply fuel for each engine by an individual day tank located near the engine and in accordance with NFPA 37. Fuel oil will be [supplied by gravity] [pumped] to day tank from outside storage tanks. Natural gas shall be supplied to the fuel solenoid shutoff valve to be supplied on the engine. Use a cooling system to maintain engine and lubricating oil temperatures at the temperatures recommended by the manufacturer. Furnish a starting system along with necessary accessories for engine start-up. Provide each engine with a completely independent lubrication [and pre-lubrication] system with an engine-driven primary pump.

2.2 MATERIALS AND EQUIPMENT

2.2.1 Standard Products

Provide materials and equipment, comprising the engine drive system, which

are the standard products of manufacturers regularly engaged in the production of dieselnatural gas fueled engine pump drives and that essentially duplicate products which have been used satisfactorily for at least two years prior to bid opening. An offer proposing an experimental engine, one having a lesser or greater number of cylinders than the offerers' standard production engines, or one without a demonstrated satisfactory service record as a full dieselnatural gas fueled engine operating not less than 1,200 hr a year at not less than 75 percent rated load, will be rejected. All products shall be new.

2.2.2 Equipment and Performance

Submit equipment and performance data certifying that the engine and cooling system function properly in the ambient temperature specified and provides the following design and performance data:

a. The maximum allowable inlet temperature of the [coolant fluid] [coolant air].

b. The minimum allowable inlet temperature of the [coolant fluid] [coolant air].

c. The maximum allowable temperature rise in the [coolant fluid through the engine] [cooling air across the engine].

d. The magnitude of monitored values defining alarm or action set points, and the tolerance (plus and/or minus) at which the protective device activates the alarm or action.

e. The minimum allowable inlet fuel temperaturefuel supply pressure.

f. The maximum impact/dynamic load that will be transferred from the engine to the structure.

Manufacturer's standard catalog data including a description and depiction of each engine and all ancillary equipment in sufficient detail to demonstrate complete specification compliance. If standard catalog data does not contain sufficient detail to verify compliance, then submit supplementary support documentation to verify compliance. All data submitted shall be on the engine manufacturer's letterhead and signed by a representative or official of the manufacturer authorized to make technical representations of his company's products.

2.2.3 Nameplates

Provide each major component with the manufacturer's name, address, type or style, model or serial number, and catalog number on a plate secured to the equipment. As a minimum, nameplates shall be provided for the following items:

a. Engines
b. Pumps and pump motors
c. Radiators
d. Heaters
e. Exhaust mufflers
f. Heat exchangers
g. Day tanks

2.2.4 Personnel Safety Devices

Insulate, fully enclose, guard, or fit with other types of safety devices all exposed moving parts, parts that produce high operating temperatures, parts which may be electrically energized, and parts that may be a hazard to operating personnel. Install the safety devices so that proper operation of the equipment is not impaired.

2.3 MATERIALS

2.3.1 Filter Elements

Provide fuel-oil, lubricating-oil, and combustion-air filter elements which are the manufacturer's standard type and able to filter out particles down to a 25 to 40 micron size, unless otherwise noted.

2.3.2 Pipe (150 psi System and Under)

Pipe for sleeves, fuel/lube-oil, compressed air, coolant, exhaust, and miscellaneous uses shall comply with ASTM A53/A53M, or ASTM A106/A106M steel pipe. Pipe smaller than 50 mm 2 inch shall be Schedule 80. Pipe 50 mm 2 inch and larger shall be Schedule 40.

a. Flanges and flanged fittings: ASTM A181/A181M, Class 150, or ASME B16.5.

b. Pipe welding fittings: ASTM A234/A234M, Grade WPB or WPC, Class 150 or ASME B16.11, 1360.7 kg 3,000 lbs.

c. Threaded fittings: ASME B16.3, Class 150.

d. Valves: MSS SP-80, Class 150.

e. Gaskets: manufacturer's standard.

2.3.3 Temperature Gauges for Oil or Water Service

Manufacturer's standard flush-mounted, 100 mm 4 inch minimum diameter dial size with standard operating point at 50 percent of the full gauge range. Gauge construction and materials shall be appropriate for the intended service.

2.3.4 Pipe Hangers

MSS SP-58 and MSS SP-69

2.3.5 Pressure Gauges

Manufacturer's standard flush mounted, 100 mm 4 inch minimum dial diameter with standard operating point at 50 percent of the full gauge range. Gauge construction and materials shall be appropriate for the intended service.

2.4 DIESELNATURAL GAS FUELED ENGINE

****

NOTES: Specify the fuel type if different than No. 2 diesel. The rating of the equipment should be in accordance with SAE standards. If the facility is located below 457 m (1,500 ft) in elevation above sea level and the intake air temperature is under 38

degrees C (100 degrees F), then de-rating is not required.

Naturally aspirated engines are available to about 1,500 kW continuous. Turbocharged engines are generally available from 50 to 350 kW continuous. Turbocharged-aftercooled engines are generally available from 200 kW to over 4,000 kW continuous. Engine suppliers should be contacted for recommendations regarding the appropriate engine based on the application.

****

a. The engine shall be a full diesel, 2 or 4 cycle, compression-ignition type, for stationary applications and shall operate on No. 2-D diesel fuel conforming to ASTM D975. The engine shall be naturally aspirated, turbocharged, or turbocharged-aftercooled.

a. The engine shall be a natural gas fueled, 2 or 4 cycle, spark ignition type, for stationary applications and shall operate on standard pipeline natural gas. The engine shall be naturally aspirated or turbocharged-aftercooled.

b. The engine rating shall be as specified in paragraph PERFORMANCE REQUIREMENTS. The engine shall be of the vertical in-line, vee, or opposed-piston type, with a solid cast block or individually cast cylinders. Opposed-piston engines shall have no less than four cylinders. Engines shall be current models of a type in regular production and shall be complete with all devices specified or normally furnished with the engine.

2.4.1 Fuel Consumption

Engine fuel consumption shall not exceed the following maximum limits based on the conditions listed below:

SIZE RANGE NET kW	PERCENT OF RATED FULL LOAD	FUEL USAGE kg/kWhLbs/bhp-hr
100 - 299	75 - 100	0.2720.447
300 - 999	75 - 100	0.2610.429
1,000 - 2,500	75 - 100	0.2430.400

Conditions:

a. 45 MJ/kg 19,350 BTU/pound heat value for fuel.

b. Sea level operation.

c. Intake air temperature not over 32 degrees C 90 degrees F.

d. Intake air barometer pressure not less than 95.7 kPa 28.25 inch of mercury.

SIZE RANGE NET kW	PERCENT OF RATED FULL LOAD	FUEL USAGE kJ/kWhbtu/bhp-hr
100 - 299	75 - 100	12,3408,700
300 - 999	75 - 100	11,3258,000
1,000 - 2,500	75 - 100	11,3258,000

Conditions:

a. Based on 118 octane natural gas with a heat value of 33,500 kJ/m3 900 btu/ft3.

b. Sea level operation.

c. 25 degrees C 77 degrees F ambient air temperature at 30 percent relative humidity.

d. 100 kPa 29.53 inch of mercury barometer pressure.

2.4.2 Crankcase Pressure Relief Valve

****
NOTES: Engines larger than 20 kW (27 hp) shall utilize a pressure relief valve on the crankcase to relieve primary crankcase explosions. The crankcase pressure relief valve vents quickly and then reseats to prevent return of air and to protect against secondary explosions. The plans should show the crankcase pressure relief valve vent piping on indoor engine installations.
****

A pressure relief valve shall be provided in the crankcase. The crankcase shall be vented in accordance with the manufacturer's recommendations, except the engine exhaust shall not be used as the venting system. Crankcase breathers, if provided on engines installed in either a building or enclosure, shall be piped to vent to the outside. If the engine is located outside, the crankcase breather shall be fitted with a goose-neck to prevent rain entry.

A pressure relief valve shall be provided in the crankcase. The crankcase shall be vented in accordance with the manufacturer's recommendations. Crankcase breathers using the venturi effect of the exhaust system will be allowed only when designed, installed, and provided directly from the engine manufacturer. Otherwise, the crankcase shall be vented to the outside and fitted with a goose neck to prevent rain entry.

2.5 FUEL SYSTEM

The fuel system for each engine shall conform to requirements of NFPA 30 and NFPA 37. The fuel system shall include the following items.

2.5.1 Fuel Pump

Each engine shall be provided with an engine-driven, positive displacement

engine fuel pump. The pump shall have the capacity to transfer fuel from the day tank at a rate in excess of maximum fuel consumption stated in paragraph FUEL CONSUMPTION, as well as supplying adequate pressure for the fuel injectors.

Each engine shall be provided with a fuel solenoid shutoff wired to a shutdown system and a fuel pressure regulator supplied by the engine manufacturer to control the fuel over air mixture to the engine. The fuel supply pressure available at the site is [_____] kPainch H20. The engine fuel system design shall be adequate to power to 110 percent load at the site fuel supply pressure as stated above.

2.5.2 Filter

A minimum of one duplex filter with a trans-flow change-over valve shall be supplied for each engine. The filter shall have inlet and outlet connections plainly marked. An indicating differential pressure gauge shall be provided across the filter. The filter shall be located on the inlet side of the fuel pump. The filter shall be capable of filtering out particles down to 25 micron size.

Each engine shall be provided with a fuel filter located upstream of the fuel solenoid shutoff to filter 100 percent of the incoming gas. The filter shall have inlet and outlet connections plainly marked. An indicating differential pressure gauge shall be provided across the filter. The filter shall be capable of filtering out particles down to 5 micron size.

2.5.3 Strainer

A full flow strainer of the replaceable cartridge type shall be provided between the engine and the fuel tank, upstream of the duplex filter. An indicating differential pressure gauge shall be provided for upstream and downstream of the strainer. The strainer cartridge shall be capable of filtering out particles down to 125 micron size.

2.5.4 Fuel Gas Compressor

Where the basic engine fuel system design requires fuel pressures above that available at the site, a fuel gas compressor is required. This fuel gas compressor shall be selected and certified by the engine manufacturer to comply with both these specifications and the requirements of the engine throughout its load range and up to 110 percent load. The fuel gas compressor shall be packaged on the same skid as the engine with a fully plumbed fuel system providing one point for fuel connection and junction boxes as required for electrical connections.

2.5.5 Safety Bypass Valve

A safety bypass valve shall be provided next to the pump isolation valve to prevent the buildup of excessive pressures if the discharge line or fuel pump filters become clogged. This bypass shall protect the fuel piping from over-pressurizing and will relieve it at [_____] kPa psi. The bypass valve relief line shall return the fuel to the engine day tank.

2.5.6 Day Tank

****

NOTE: See NFPA 37 and NFPA 30 for day tank

restrictions on allowable day tank sizes. The day tank should be located in close proximity to the engine to avoid exceeding the total suction head capabilities of the engine-driven fuel pump (paragraph FUEL PUMP). Nominal suction head capabilities of typical engine-driven fuel pumps are in the range of 2.75 to 3.65 m (9 to 12 ft).

Delete this paragraph in its entirety if natural gas fueled engines are specified.

****

Each engine shall be provided with a day tank located next to the engine. Each day tank shall be fitted with a fuel supply line, fuel return line, local fuel fill port, direct reading liquid level indicator, vent, fill limit float switch assembly for automatic control of the fuel oil transfer pump (if provided), alarm level sensing device, and a drain line. A fuel return line cooler shall be provided, if recommended by the engine manufacturer. Each day tank shall have [a [_____] L gal capacity] [capacity sufficient to supply the engine without interruption for 2 hr] [capacity sufficient to supply the engine for [_____] hr continuously at 100 percent rated load without being refilled].

2.5.6.1 Drain Line

Each day tank drain line shall be equipped with a shutoff valve and be arranged to allow drainage into 220 L 55 gal drums.

2.5.6.2 Local Fuel Fill

Each local fill port shall have a [screw-on cap][hinged, fill cap]. An air vent with brass screen shall be provided so that the day tank does not develop a vacuum leading to the collapse of the day tank as the system empties.

2.5.6.3 Fuel Level Limit Devices

a. Each day tank shall be provided with a fill level float switch assembly device to:

(1) Initiate refueling of the day tank at the low level mark, (e.g., 30 percent volume remaining).

(2) Stop refueling of the day tank at the high level mark, (e.g., 90 percent volume).

b. Each day tank shall be provided with a separate level-sensing device to activate alarms at day tank overfill and day tank empty. Day tank empty shall indicate at 20 percent volume remaining. Day tank overfill shall indicate at 95 percent volume. See paragraph ALARM PANEL for further function requirements.

2.5.6.4 Redundant Fuel Shutoff

To stop fuel flow to the day tank, an automatic shutoff valve shall be provided on the fill line of the day tank and an automatic safety device shall be provided to stop the pump supplying fuel to the day tank. The valve and the safety device shall be activated at the overfill level as defined in paragraph SAFETY SYSTEM, and shall respond before any fuel is

forced out of the fuel overflow line.

2.5.6.5 Arrangement

The day tank shall be positioned and arranged so that fuel level in the day tank at the day tank empty level is above the suction port of the engine-driven fuel pump. The day tank overflow connection shall be positioned and arranged so that the highest possible fuel level in the day tank is below the fuel injectors. The fuel supply line from the day tank to the engine connections shall be welded steel pipe. A water drain shall be provided at the low point of the day tank.

2.5.7 Fuel Supply System

The diesel fuel supply from the main diesel fuel storage to the day tank shall be as specified in Section 33 56 10 FACTORY-FABRICATED FUEL STORAGE TANKS. The natural gas fuel supply system shall be as specified in Section 33 51 15 NATURAL-GAS/LIQUID PETROLEUM GAS DISTRIBUTION and Section 23 11 25 FACILITY GAS PIPING.

2.5.8 Main Fuel Storage Tank

****
NOTE: The location of this tank is important for day tank draining and day tank fuel supply. The appropriate type and location should be determined by costs and operational requirements and should follow local, state, and Federal Environmental Protection Agency regulations, Section 33 56 10 and NFPA-30.
****

The main fuel storage tank is specified in [Section 33 56 10 FACTORY-FABRICATED FUEL STORAGE TANKS][_____].

2.6 LUBRICATION

****
NOTE: Delete the adjustable requirement for pressure regulation on the pressurized lube oil system for engines smaller than 1,000 kW (1,350 hp).
****

Each engine shall have a separate lube-oil system conforming to NFPA 30 and NFPA 37. Each system shall be pressurized by engine-driven pumps.[The system pressure shall be adjustable and regulated as recommended by the engine manufacturer.] A sump tank shall be furnished as required. The lube-oil pump shall draw oil from the oil pan or sump tank through a mesh intake strainer and force it through a lubricating oil cooler and a single or duplex full-flow strainer into the engine. The pump shall be protected by a relief valve to bypass the oil into sump. A portion of the oil from the sump shall be bypassed through a lubricating oil filter and back into the engine oil pan or sump. The lubricating oil temperature shall be regulated by means of an automatic temperature regulator which will control the amount of bypass oil around the cooler. The system shall be readily accessible for service such as draining or refilling. Each system shall permit the addition of oil and have oil-level indication with the set operating.

2.6.1 Pump Filters

One full-flow, duplex, 80 micron filter shall be provided for each pump. The filter shall be readily accessible and capable of being changed without disconnecting the piping or disturbing other components. The filter shall have inlet and outlet connections plainly marked. An indicating differential pressure gauge shall be provided across the filter.

2.6.2 Lube-Oil Sensors

Each engine shall be equipped with lube-oil temperature and pressure sensors. Temperature sensors shall provide signals for pre-high and high lube-oil indication and alarms. Pressure sensors shall be located downstream of the filters and provide signals for pre-low and low lube-oil indication and alarms.

2.6.3 Lubricating Oil Strainer

A full-flow, oil strainer shall be furnished in-line, ahead of the engine. The strainer shall be as recommended by the engine manufacturer. A bottom drain plug shall allow easy removal of the sludge.

[2.6.4 Pre-Lubrication Oil Pump

****
NOTE: Normally, engine size greater than 350 kW (470 hp) and engines with a period in excess of two weeks between operations require pre-lubrication. If pre-lubrication is required, utilize this paragraph.
****

The pre-lubricating oil pump shall have a capacity and head rating as recommended by the engine manufacturer. The pump shall incorporate a built-in relief valve and be directly connected to an electric motor with the motor-pump assembly mounted on a common case iron or steel base. The pump shall be furnished complete and ready for operation with all controls inclusive. The pre-lubrication pump shall completely fill the engine oil lines and establish lubricating oil pressure prior to starting. The pump motor shall be in accordance with the requirements of paragraph MOTORS.

]2.7 COOLING SYSTEM

****
NOTE: There are three basic types of engine cooling systems available. These are systems using liquid-to-air heat exchangers (radiators) or cooling towers, systems using liquid-to-liquid heat exchangers (systems using shell and tube, plate and frame heat exchangers) and systems using submerged pipe systems. No matter which system is specified, engine outlet water temperature should be kept constant, and the differential between inlet water to outlet water of the cooling system should be kept at about 8 degrees C (15 degrees F). The radiator requires forced air through the heat exchanger causing higher noise levels. For an indoor application, the radiator can be located outside with a higher pressure pumping system to deliver the

required flow to the radiator. The radiator should be mounted less than 15 m (50 ft) above the engine to avoid leakage at the engine water pump seal.

When the approach between coolant and air temperatures is under 15 degrees C (27 degrees F), towers become more economical. A surrounding clean environment is required with towers due to the openness of the design. The shell and tube heat exchanger requires an expansion tank to remove air from the system. The raw water supply system should be closely coordinated when applying a shell and tube heat exchanger.

Cooling towers have limiting working ranges and can be applied successfully only in certain climates.

The submerged pipe cooling system requires a large quantity of raw water and an expansion tank. Factors for consideration when evaluating cooling systems include engine size, space limitations, acceptable noise levels, raw water supply, maintenance, operational requirements, and system operating costs. Engine suppliers should be contacted for assistance in selecting the appropriate cooling system for the application.

****

a. Each engine shall have its own cooling system. The system shall be of the closed type and operate automatically while the engine is running.

b. The cooling system shall have an engine-driven water pump, [fin-tube radiator,] [cooling tower,] [remotely mounted fin-tube radiator,] [shell-tube heat exchanger, expansion tank,] [plate and frame heat exchanger, expansion tank,] [submerged pipe, expansion tank,] and an automatic temperature regulating valve. The maximum temperature rise of the coolant across each engine shall not exceed the engine manufacturer's recommendation as submitted in paragraph SUBMITTALS.

c. The engine cooling system shall be of the closed type arranged to prevent rust and minimize formation of scale deposits within the engine. The system shall circulate jacket-coolant through the engine at the temperature and flow rate recommended by the engine manufacturer. The coolant shall be an ethylene-glycol water mixture with a concentration sufficient for freeze protection at the minimum outdoor temperature specified. The maximum temperature rise of the coolant shall be no more than that recommended and submitted in paragraph SUBMITTALS.

2.7.1 Coolant Pumps

****

NOTE: Delete raw-water pump option for closed-loop systems.

****

Engine-driven jacket water pumps shall be of the centrifugal type.[Raw-water centrifugal circulating pumps shall be [electric motor driven equipped with manual-off-automatic controllers] [engine driven].] Each

engine shall have an engine-driven primary pump. Secondary pumps shall be electric motor driven and have automatic controllers. The pump shall be a bronze fitted, single stage type with removable seal rings and stuffing box and properly sized for the intended purpose.

2.7.2 Radiator

****
NOTE: Radiator location and mounting details should be shown on the plans. An electric motor-driven fan is provided on remotely located radiators to circulate air across the radiator. The fan should operate when the engine operates.
****

Each radiator shall be sized to limit the maximum allowable temperature rise on the coolant across the engine to that recommended and submitted in paragraph SUBMITTALS, for the maximum outdoor design temperature and site elevation. Radiator fabrication materials shall be corrosion resistant and suitable for service in the ambient application conditions. The radiator may be factory coated with corrosive resistant film provided that corrective measures are taken to restore the heat rejection capability of the radiator to the initial design requirement via over-sizing or other compensating methods. Internal surfaces shall be compatible with liquid fluid coolant used. Materials and coolant are subject to approval by the Contracting Officer. Radiators shall be the pressure type incorporating a pressure valve, vacuum valve, and a radiator cap. Radiator caps shall provide for pressure relief prior to removal. Each radiator and the entire cooling system shall be capable of withstanding a minimum pressure of 48.4 kPa 7 psig. Each radiator shall be protected with a strong grille or screen guard. Radiators shall have at least two tapped holes. One tapped hole in the radiator shall be equipped with a drain cock; the rest shall be plugged. [The remote located radiator shall be provided with an electric motor-driven fan. The fan shall be wired to operate when the engine operates.]

[2.7.2.1 Shell and Tube Heat Exchanger

The heat exchanger shall be a multiple pass shell type with removable U-tube bundles to facilitate cleaning and retubing. The heat exchanger shall be of sufficient capacity to cool the engine with [_____] degrees C F input cooling water. The heat exchanger shall operate with low temperature water in the shell and high temperature coolant in the tubes. Exchangers shall be constructed in accordance with requirements of ASME BPVC SEC VIII D1 and certified with an ASME stamp secured to the heat exchanger. Shells shall be constructed with seamless steel, welded steel, or cast iron. Tubes shall be either cupronickel or inhibited admiralty, meeting requirements of ASTM B395/B395M, suitable for the temperature and pressure specified. The shell side and tube side of the heat exchanger shall be designed for 1.03 MPa 150 psig working pressure and factory tested at 2.06 MPa 300 psig. High temperature, low temperature, and pressure relief connections shall be located in accordance with the manufacturer's standard practice. Coolant pressure loss through clean tubes shall be as recommended by the engine manufacturer. Minimum coolant velocity through the tubes shall be at least 300 mm/sec 12 inch/sec and sufficient to assure turbulent flow. One or more pressure relief valves shall be provided for each heat exchanger in accordance with ASME BPVC SEC VIII D1. A drain connection with a 19 mm 3/4 inch hose bib connection shall be installed at the lowest point in the system near the heat exchanger.

][2.7.2.2 Plate and Frame Heat Exchanger

The heat exchanger shall be a multiple pass type with removable plates to facilitate cleaning. The heat exchanger shall be of sufficient capacity to cool the engine with [_____] degrees C F input cooling water. Heat exchangers shall be constructed in accordance with ASME BPVC SEC VIII D1 and certified with an ASME stamp secured to the heat exchanger. Materials selected for the plate and frames shall be appropriate for the service required. High and low temperature and pressure relief connections shall be located in accordance with the manufacturer's standard practice. Water pressure loss through clean plates shall be as recommended by the engine manufacturer. One or more pressure relief valves shall be provided for each heat exchanger in accordance with ASME BPVC SEC VIII D1. A drain connection with a 19 mm 3/4 inch hose bib connection shall be installed at the lowest point in the system near the heat exchanger.

][2.7.2.3 Cooling Tower

****
NOTE: The maximum outdoor design temperature, coolant temperature, and availability of water are critical to the proper selection of the appropriate cooling tower. Applicable ASHRAE guides should be consulted for application guidance.
****

Size the cooling tower to limit the maximum allowable temperature rise in the coolant across the engine to that recommended by the engine manufacturer. The Contractor is responsible for the proper selection of system components based on the site conditions and the dieselnatural gas fueled engine pump drive[s] used. Internal and external materials shall be appropriate for the heat used. Use cooling towers in conjunction with a liquid-to-liquid heat exchanger to keep the engine cooling in a closed loop with conditioned coolant. Furnish the cooling tower as a complete operating system with a liquid-to-liquid heat exchanger, a surge tank, an auxiliary water pump, necessary filters in the water return lines, and interconnecting piping and isolation valves as required for maintenance and operation.

][2.7.2.4 Submerged Pipe

****
NOTE: Protection for the submerged pipe or coil should be considered. The pipe or coil should be kept out of mud or silt and away from the bottom of the cooling pond to ensure maximum efficiency.
****

The pipe or coil shall be of sufficient length to cool the engine at the specified raw water temperature. The piping materials shall be as specified in paragraph PIPE. The pipe installation shall be as specified in paragraph PIPING INSTALLATION. The pipe from the return bend shall always slope up to prevent air locks in the system. A drain plug shall be furnished at the lowest point of the system. The system shall be connected so that the jacket water flows from the engine to the cooling coils and then to the expansion tank before returning to the jacket water pump inlet.

]2.7.3 Thermostatic Control Valve

A modulating type, thermostatic control valve shall be provided in the coolant system to maintain the engine coolant temperature in the range submitted in paragraph SUBMITTALS.

2.7.4 Ductwork

The ductwork shall be as specified in [Section 23 00 00 AIR SUPPLY, DISTRIBUTION, VENTILATION, AND EXHAUST SYSTEM] [_____] except that a flexible connection shall be used to connect the engine radiator. Material for the connection shall be wire-reinforced fiber glass. The connection shall be airtight.

2.7.5 Temperature Sensors

Each engine shall be equipped with coolant temperature sensors. Temperature sensors shall provide signals for pre-high and high coolant temperature indication and alarms.

Each engine shall be equipped with coolant temperature systems for both the jacket water system and the intercooler system when the engine is turbocharged.

2.7.6 Expansion Tank

****
NOTE: Size of the expansion tank at least 15 percent of the coolant volume in the total system to take care of expansion.
****

An expansion tank of not less than [_____] L gal shall be furnished for each engine. The tank shall be properly fitted for vent, overflow, expansion, and make-up lines. The tank shall be suitable for an operating temperature of 121 degrees C 250 degrees F and a working pressure of 860 kPa 125 psig. The tank shall be constructed of welded steel, hot-dipped galvanized inside and outside after fabrication, tested, and stamped in accordance with ASME BPVC SEC VIII D1 and registered with the National Board of Boiler and Pressure Vessel Inspectors. The tank shall be mounted so that the bottom of the tank is above the top of the engine. The tank shall be supported by steel legs or bases for vertical installations or steel saddles for horizontal installation.

2.8 SPECIAL LIMITATIONS

2.8.1 Sound Limitations

****
NOTE: The noise limits shall conform to applicable local and OSHA codes. The designer is responsible for determining code noise limit requirements for specific site applications. Specific information regarding applicable noise limits should be inserted in this section. Site specific requirements and limitations are key components in the criteria selection. Generally, the most cost effective approach is to use hearing protection in conjunction with building and room insulation to control noise.

****

[_____]

2.8.2 Vibration Isolation and Seismic Restraints

****

NOTE: Provide seismic requirements and show details on the drawings if the Government designer (either Corps office or A/E) is the Engineer of Record. Delete the bracketed phrase in the last sentence of this paragraph if seismic details are not provided. Pertinent portions of UFC 3-310-04 and properly edited Sections 13 48 00 and 22 05 48.00 20 must be included in the contract documents.

****

The maximum engine vibration in the horizontal, vertical, and axial directions shall be limited to 0.15 mm 6 mils peak-peak RMS, with an overall velocity limit of 24 mm/sec 0.95 inch/sec RMS.[A vibration-isolation system shall be installed between the floor and the base. The vibration-isolation system shall limit the maximum vibration transmitted to the floor at all frequencies to a maximum of [_____] [_____] peak force.][The engine shall be provided with a vibration-isolation system in accordance with the manufacturer's standard practice.] Vibration-isolation systems shall be designed and qualified (as an integral part of the base and mounting system) to the seismic forces specified. Where the vibration-isolation system does not secure the base to the structure floor or unit foundation, seismic restraints shall be provided in accordance with UFC 3-310-04 and Sections 13 48 00 SEISMIC PROTECTION FOR MISCELLANEOUS EQUIPMENT and 13 48 00.00 10 SEISMIC PROTECTION FOR MECHANICAL EQUIPMENT[and as indicated].

2.9 AIR INTAKE EQUIPMENT

Filters and silencers shall be provided in locations that are convenient for servicing as shown on the project plans. The silencer shall be of the high-frequency filter type, located in the air intake system as recommended by the engine manufacturer. A combined filter silencer unit meeting requirements for the separate filter and silencer items may be provided. Expansion elements in air-intake lines shall be [copper][rubber].

2.10 EXHAUST SYSTEM

The system shall be separate and complete for each engine. Exhaust piping shall be supported to minimize vibration. Provisions shall be made for pipe thermal expansion. Where a V-type engine having more than one exhaust outlet is provided, a V-type connector, with necessary flexible sections and hardware, shall connect the engine exhaust outlets. The exhaust connectors shall incorporate engine-mating and silencer-mating flanges, eliminating the need for adapters. The muffler and exhaust piping together shall be capable of reducing the noise level at the exhaust discharge location to a point below the maximum sound levels specified in paragraph SOUND LIMITATIONS, at a distance of [_____] m ft from the end of the exhaust piping directly along the path of discharge for horizontal discharged exhaust; or at a radius of [_____] m ft from the muffler/discharge piping, at 45 deg apart in all directions, for vertically discharged exhausts, with the engine operating at 100 percent of service load.

2.10.1 Flexible Sections and Expansion Joints

A flexible section shall be provided at each engine and an expansion joint at each muffler. Flexible sections and expansion joints shall have flanged connections. Flexible sections shall be multiple-ply stainless steel expansion bellows type with standard 38 and 76 mm 1.5 and 3 inch allowable axial expansion. Elements in the flexible sections shall be capable of absorbing vibration from the engine and compensating for thermal expansion and contraction.

2.10.2 Exhaust Muffler

****

NOTE: Muffler locations and mountings should be shown on the plans. The designer should consider the use of first cost versus life-cycle cost analysis to determine the appropriate metal to use. Stainless steel Series 321 and aluminized steel should be considered in lieu of painted steel materials.

****

A chamber type exhaust muffler shall be provided. The muffler shall be fabricated of welded steel and designed for [outside] [inside] [vertical] [horizontal] mounting. Eyebolts, lugs, flanges, or other items shall be provided as necessary for support of the muffler in the location and position indicated on the plans. The pressure drop through the muffler shall not exceed the recommendations of the engine manufacturer. Outside mufflers shall be fabricated from [aluminized steel] [stainless steel]. The muffler shall have a drain valve, nipple, and cap at the low-point of the muffler. The muffler shall be supplied complete with any necessary soot boxes or inspection ports required for adequate operation and maintenance. The entire exhaust system shall be sized appropriately so that the operation of the engine is not affected by the exhaust system.

2.10.3 Exhaust Piping

****

NOTE: Exhaust piping should be sized at a gas velocity of less than 25.4 m/p sec (5,000 fpm). The exhaust piping location and routing should be shown on the plans.

****

Horizontal sections of the exhaust piping shall be sloped downward away from the engine to a condensate trap and drain valve. Changes in direction shall be made utilizing long radius fittings. Exhaust piping not covered in this paragraph shall be run in accordance with paragraph PIPING INSTALLATION. Exhaust piping, mufflers, and silencers shall be insulated with ASTM C533 calcium silicate insulation, minimum of 75 mm 3 inch thickness or an appropriate thickness to limit the surface temperature to values below 80 degrees C 175 degrees F. Insulation shall be secured with not less than 9.525 mm 0.375 inch width Type 304 stainless steel bands spaced no farther apart than 200 mm 8 inches on center. An aluminum jacket encasing the insulation shall be provided. The aluminum jacket shall have a minimum thickness of 0.406 mm 0.016 inch with a factory-applied polyethylene and kraft paper moisture barrier. The jacket shall be secured with not less than 13 mm1/2 inch wide stainless steel bands, spaced no

farther apart than 200 mm 8 inch on centers. Longitudinal and circumferential seams of the jacket shall be lapped not less than 75 mm 3 inch. Jackets on horizontal lines shall be installed so that the longitudinal seams are on the bottom side of the pipe. The seams of the jacket for the vertical lines shall be placed on the off-weather side of the pipe. On vertical lines, the circumferential seams of the jacket shall overlap so that the lower edge of each jacket overlaps the upper edge of the jacket below. Vertical exhaust piping shall be provided with a hinged, gravity-operated, self-closing rain cover. When the exhaust pipe exits the building, the pipe should be isolated from the [wall][roof] by means of thimbles in accordance with NFPA 37.

2.11 PYROMETER

****
NOTE: For engines smaller than 1,000 kW (1,340 hp) delete this paragraph. Pyrometers with individual thermocouples are not normally available and should not be specified for engines smaller than 1000 kW (1,340 hp).
****

A pyrometer [multi-point selector with individual thermocouples][and thermocouple] with calibrated leads shall be provided to indicate the temperature [in each engine cylinder and the combined exhaust] [in the combined exhaust]. For a supercharged engine, additional points, thermocouples and leads shall be provided to show the temperature in the turbocharger exhaust gas outlet and combustion air discharge passages. The selector switch shall be double pole, with an off position, one set of points for each thermocouple, and a suitable indicating dial. The pyrometer, thermocouple, leads, and compensating devices shall be calibrated to show true exhaust temperature within ñ1 percent above the highest temperature encountered at 110 percent load conditions.

2.12 EMISSIONS

The finished installation shall comply with Federal and local regulations and restrictions regarding the limits of emissions such as carbon monoxide (CO), hydrocarbon (HC), and nitros (NOx).

2.13 STARTING SYSTEM

****
NOTE: The engine can be started by either pneumatic (compressed air) or an electric starting system. The selection of the starting system should be based on costs and availability of compressed air or electric power. The starting system should be of adequate capacity to start the engine under the coldest conditions encountered. Generally, in pumping plants with an existing station air system or where a station air system will be installed, a pneumatic system will have the lowest initial cost. The designer should ensure that the requirements for the station air system include an air receiver of adequate size to accommodate the cranking cycle of each engine in the station without recharge by the station air compressor. Paragraph 2.11.1 ALTERNATE 1 should be deleted when a pneumatic starting system

is specified. ALTERNATE 2 of this paragraph should be deleted when an electric start system is specified.

Torque available from air motors of pneumatic systems is capable of accelerating the engine to twice the engine cranking speed in about half the time required by electric starters. The starting system should be the manufacturer's standard equipment.

The starting system, regardless of type, should have a start-stop switch providing functions including testing, reset, manual run/start manual stop, an adjustable cranking cycle and cool down mode of operation.

If an electric system is provided, an adjustable cranking limit device should be specified to limit the engine cranking to a specified time limit.

****

Each diesel engine shall be provided with a starting system. The system shall be [pneumatic] [electric] and of sufficient capacity to start the engine at the minimum temperature specified. The system shall have a start-stop switch which provides functions including testing, reset, manual run/start, manual stop, and adjustable cranking and cooling down operation. The starting system shall be the manufacturer's standard equipment.

2.13.1 Electrical Starting System

****

NOTE: Delete this paragraph and subparagraphs in their entirety if a pneumatic starting system is specified.

****

An electrical starting system shall be provided to operate on a [24] [____]-V DC utilizing a negative circuit ground. An adjustable cranking device should be included to limit the engine cranking to a specified time limit. Starting motors shall be in accordance with SAE ARP892.

2.13.1.1 Battery

****

NOTE: Select a nickel-cadmium type battery only when the battery temperature cannot be maintained above -6 degrees C (22 degrees F).

****

A starting battery system shall be provided and include the battery, battery rack, intercell connectors, spacers, automatic battery charger with overcurrent protection, metering, and relaying. The battery shall be in accordance with SAE J537. Critical system components (rack, protection, etc.) shall be designed to withstand the seismic acceleration forces specified in subparagraph VIBRATION ISOLATION AND SEISMIC RESTRAINTS under paragraph SPECIAL LIMITATIONS. The battery shall be a [lead-acid] [nickel-cadmium] type, with sufficient capacity, at the minimum [outdoor]

[indoor] temperature specified, to provide a minimum cranking cycle consisting of three cranking periods of up to 8 sec per period with 8-sec intervals between crank periods.

2.13.1.2 Battery Charger

A current-limiting battery charger, conforming to UL 1236, shall be provided to automatically recharge the batteries. The charger shall be capable of providing both automatic float charging and equalizing charging of the battery installation. The charger shall be capable of recharging fully depleted batteries within [8] [_____] hr and providing a floating charge rate for maintaining the batteries in a fully charged condition. An ammeter and voltmeter shall be provided on the charger to indicate charging rate and voltage. The charger shall have alarm functions providing indications of low battery voltage, high battery voltage, and battery charger malfunction.

2.13.2 Compressed Air Starting System

****

NOTES: Delete this paragraph and subparagraphs in their entirety if an electric starting system is specified.

The complete compressed air system should be shown on the plans. Two receivers, redundant piping, and two compressors may be required so that starting capability is not lost when tank maintenance is required. Valve arrangement should permit any receiver to be removed from service, drained, repaired, or replaced without loss of starting air from the system. The check valves between the plant air system and the air starting receivers should be considered to ensure that failure of the plant air system does not deplete the backup supply. The designer should analyze various starting scenarios and determine the necessity of providing a gasoline or diesel engine-driven compressor for a black-plant (no electrical sources available) start-up.

Each compressor should have sufficient capacity to refill the air starting system air receiver in a maximum of 3 min. The receiver shall be sized to crank the largest engine for 15 sec at an ambient temperature of 21 degrees C (60 degrees F) without recharging.

Either the air-motor starting option or the cylinder injection starting option should be used and the other paragraph deleted.

****

A compressed air starting system shall be provided. The starting system shall use station service air. The system shall be furnished complete with oilers, regulators, and solenoid control valves. The starting system shall be air motor type with a working pressure of 1.03 MPa 150 psig or cylinder injection type with a working pressure of 2.07 MPa 300 psig. The compressed air system piping shall be as specified in Section 22 00 00 PLUMBING, GENERAL PURPOSE.

2.13.2.1 Air Filter

An air filter shall be installed upstream of the air connection to each engine. The filter shall be capable of removing particles 10 mm 3/8 inch and larger.

2.13.2.2 Air Driven Motors or Cylinder Injection

Either type of air starting system, air motors or direct injection, is acceptable. If an air motor starting system is used, the cranking motors shall be complete with a solenoid valve, strainer, and lubricator. If cylinder injection starting is used it shall be accomplished by admitting compressed air into two or more engine cylinders through a timing valve, or through a distributor into a sufficient number of cylinders to ensure successful starting regardless of piston positions.

2.13.3 Starting Aids

****

NOTE: Jacket coolant and/or lube-oil heaters are normally provided for most applications to aid starting. Either injection or glow plugs may also be required for combustion air temperatures significantly below 0 degrees C (32 degrees F). Consult manufacturers for availability and need in the application size range.

****

2.13.3.1 Jacket-Coolant Heaters

A thermostatically controlled electric heater shall be mounted in the engine coolant jacketing to automatically maintain the coolant within ñ10 deg of the control temperature. The heater shall operate independently of engine operation so that starting times are minimized, condensation is controlled, and the system ensures dependable, cold weather starts. Power supply for the heaters will be [_____] volts AC.

2.13.3.2 Glow Plugs

Glow plugs shall be designed to provide sufficient heat for fuel combustion within the cylinders to guarantee starting at an ambient temperature of -23 degrees C -20 degrees F.

[2.13.3.3 Lube Oil Heaters

A thermostatically controlled electric heater shall be mounted in the engine lube oil storage tank to automatically maintain the lube oil within ñ10 deg of the control temperature. The heater shall operate independently of engine operation so that starting times are minimized and the system ensures dependable cold weather starts. Heaters shall be selected so that heater skin temperatures do not exceed 150 degrees C 300 degrees F and have maximum heat densities of 0.02 W/mm square 13 W/inch square. Power supply for the heaters will be [_____] volts AC.

]2.14 SAFETY SYSTEM

Devices, wiring, remote annunciator panels, alarm panels, etc., shall be provided and installed as a complete system to automatically activate the

appropriate signals and initiate appropriate safety actions. The safety system shall be provided with a self-test method to verify its operability. Alarm signals shall have manual acknowledgment and reset devices. The alarm signal systems shall reactivate for new signals after acknowledgment is given to any signal. The systems shall be dealt with as an alarm on that system element. The remote annunciator panels and alarm panel shall be as specified in paragraph PANELS.

2.14.1 Audible Signal

****
NOTE: High dB levels are required for audible alarms located near an engine. Audible signaling devices with sound levels in excess of 100 dB should be specified for engine room application, and the alarm location should be shown on the plans.
****

The audible alarm signal shall sound at a frequency of [70] [_____] Hz at a volume of [75] [_____] dB at 3.1 m 10 ft. The sound shall be continuously activated upon alarm and silenced upon acknowledgment. Signal locations shall be as shown on the plans.

2.14.2 Visual Signal

The visual signal shall be a panel light. The light shall normally be off but activated to blinking upon alarm. The light shall change to continuously lit upon acknowledgment. If automatic shutdown occurs, the display shall remain in an activated status to indicate the cause of failure and shall not be reset until the cause of alarm has been cleared and/or restored to the normal condition. Shutdown alarms shall be amber.

2.14.3 Alarms and Action Logic

2.14.3.1 Shutdown

Shutdown signals shall simultaneously activate the audible signal, activate the visual signal, and stop the engine.

2.14.3.2 Problem

Problem signals shall activate the visual signal.

2.14.4 Alarm Panel

The panel shall be fabricated and located as specified in paragraph PANELS, and shall contain the following functions:

FUNCTION OR INDICATION/CONTROL ACTION (AUXILIARY ACTION)

a. Red emergency stop (push button or switch)/shutdown engine.

b. Day tank overfill indication (95 percent volume)/problem (shutdown pump supplying fuel to day tank).

b. Panel-mounted detonation sensing system with alarm and shutdown lights. The detonation system will sense individual cylinder detonation and individually adjust cylinder timing to avoid detonation. The system must be programmable by standard PC with

software and operating manual supplied at no additional charge. The system installed must have the capability of up to 30 crankshaft degrees of total timing variation for each cylinder. Beyond a programmed limit, the system will act to shut down the engine.

c. Engine overspeed indication (overspeed indication point as recommended by the engine supplier)/shutdown engine.

d. High lube-oil temperature indication (temperature as submitted)/shutdown engine.

e. Low lube-oil pressure indication (pressure as submitted)/shutdown engine.

f. High coolant fluid outlet temperature indication (temperature as submitted)/shutdown engine.

g. Pre-low lube-oil pressure indication (110 percent of low lube-oil pressure)/problem (none).

h. Pre-high coolant fluid temperature indication (5 degrees C 10 degrees F lower than high coolant-fluid outlet temp. alarm)/problem (none).

i. Pre-high lube oil temperature indication (5 degrees C 10 degrees F) lower before problem (none).

j. Day tank empty indication (20 percent volume remaining)/shutdown engine.

j. Crankcase pressure switch (adjustable) to detect crankcase pressure increase associated with scoring of liner and possible short term catastrophic failure. Shutdown with setpoint as submitted. Setpoint of the crankcase pressure switch is to be adjusted during start-up to provide close tolerance protection without nuisance tripping.

k. Failure to start within the specified time indication/problem (none).

[l. Compressed air low-pressure indication (80 percent of working pressure)/problem (none).

][m Engine battery voltage-low/problem (none).

][n. Engine battery voltage-high/problem (none).

][o. Engine battery charger malfunction/problem (none).]

2.14.5 Time-Delay on Alarms

For startup of the engine, time-delay devices shall be installed bypassing the low lubricating oil pressure alarm during cranking[and the low coolant-fluid outlet temperature alarm]. The lube-oil time-delay device shall return its alarm to normal status after the engine starts.[The coolant time-delay device shall return its alarm to normal status 5 minutes after the engine starts.]

[2.14.6 Remote Alarm Panel

****
NOTE: The remote alarm panel location should be shown on the plans. Delete requirements for the remote alarm panel where it is not used. The remote panel may be furnished loosely and unmounted, to be installed on the pump station control console by others.
****

A remote alarm panel with 100 percent functional redundancy to the alarm panel shall be provided.[The remote panel shall be located and mounted as shown on the plans.] [The remote panel shall be suitably packed and shipped as directed by the Contracting Officer for installation by others on the station control console.]

]2.15 GOVERNOR

Each engine shall be provided with a governor to control the rotational speed of the engine in response to changing load requirements. The governor shall be configured for safe manual adjustment of the speed during operation of the engine, without special tools.

2.15.1 Speed Regulating Governor

The engine governor shall maintain close speed regulation under all load conditions. The speed variation shall not exceed 6 percent of normal speed when full load is suddenly applied or removed. The design of the governor shall be such that the engine speed may be changed by governor adjustment during engine operation to any speed between 80 and 100 percent of the normal speed (corresponding to normal operating pump speeds) within 2 percent. The speed fluctuation at any load shall not exceed 2 percent. A raise/lower speed control shall be mounted on the engine instrument board.[The speed adjust control shall have provisions for allowing control of the speed control circuits from a remote location.] The engine fuel rack servomotor shall be suitable for operation from a 120-V AC source.

2.15.2 Emergency Overspeed Governor and Load Limit

****
NOTE: If the pump drive is out of service for extended periods with little or no maintenance, then the shutdown mechanisms for overspeed should prevent both fuel and air supplies from entering the cylinders. If the units are well maintained and used frequently, either type termination should work satisfactorily.
****

An emergency governor with overspeed trip shall be provided on each engine to shutdown the unit should the speed exceed a predetermined RPM. The overspeed trip shall also provide an alarm signal for remote indication. The emergency governor shall be independent of the regulating governor. When the overspeed stop has been tripped, the shutdown mechanisms shall be such that the engine fuel[and][or] air supply is prevented in the shortest time practicable from entering the engine cylinders. The trip mechanism may be part of the governor. The engine shall have an overload fuel limit set at 110 percent of the full load specified in paragraph

DIESEL ENGINE.

2.15.3 Governor Controls Location

The governor control shall be located at a point convenient to the location of the engine instrument board as shown on the plans.

2.16 ENGINE INSTRUMENT BOARD

****
NOTES: All panels (including the engine instrument board), except the remote panel, can be combined. Delete the pyrometer devices for engines smaller than 1,000 kW (1,340 hp). See paragraph PYROMETER.

Use the first subparagraph "f" and first subparagraph "g" if diesel engines are specified; use the second subparagraph "f" and second subparagraph "g" if natural gas fueled engines are specified.
****

The engine instrument board shall be as specified in paragraph PANELS, and shall contain the following items:

a. Coolant-fluid inlet temperature display

b. Lubricating-oil pressure indicator

c. Lubricating-oil inlet temperature display

d. Red emergency stop (push-button or switch)

e. Run-time meter

f. Fuel meter display

g. Fuel-header-pressure display

f. Manifold vacuum display

g. Intake air temperature display

h. Tachometer display

i. Engine start-stop switch

j. Start-attempt indicator light

k. Lubricating-oil prelubricating pump start-stop switch

l. Alarm panel

[m. Pyrometer display with selector switch]

****
NOTE: The following instrumentation may be included on the engine instrument board.
****

[n. Ammeter for starting battery charger

][o. Voltmeter for starting battery

][p. Timer for setting the starting battery charger's equalize charging rate duration

][q. Air starting system pressure]

2.17 PANELS

****
NOTE: All panels (including the engine instrument board), except the remote panel, can be combined into a single panel paragraph. Provide a panel-mounting location and detail for panels not mounted on the engine base. The designer may elect other locations such as adjacent to the engine, etc. Provide panel nameplate and instrument nameplate, unique identifiers, or user-preferred identifiers. Provide sizes, materials, and attachment preferences.

Delete either the analog or electronic instruments paragraph option.
****

Each panel shall be of the type and kind necessary to provide specified functions. Panels shall be mounted [on the engine base by vibration/shock absorbing type mountings][as shown on the plans]. Instruments shall be mounted flush or semiflush. Convenient access to the back of panels shall be provided to facilitate maintenance. Instruments shall be calibrated using recognized industry calibration standards. Each panel shall be provided with a panel identification plate which clearly identifies the panel function as indicated. Each instrument and device on the panel shall be provided with a plate which clearly identifies the device and its function as indicated. All instruments and devices shall be vibration resistant.

2.17.1 Enclosures

Enclosures shall be designed for the application and environment, conforming to NEMA ICS 6. Locking mechanisms [are optional] [shall be keyed alike].

2.17.2 [Analog] [Electronic]

****
NOTE: Select appropriate alternative paragraph.
****

[Analog electrical indicating instruments shall be in accordance with ANSI C39.1 with semiflush mounting. Panel-mounted instruments shall [be the manufacturer's standard][have 100-deg scales] with an accuracy of not less than 2 percent. The instrument's operating temperature range shall be -20 to +65 degrees C -4 to +150 degrees F.]

[Electronic indicating instruments shall be 100 percent solid state,

state-of-the-art, microprocessor controlled to provide all specified functions. Control, logic, and function devices shall be compatible as a system, sealed, dust and water tight, and shall utilize modular components with metal housings and digital instrumentation. An interface module shall be provided to decode serial link data from the electronic panel and translate alarm, fault, and status conditions to a set of relay contacts. Instrument accuracy shall be not less than 2 percent for unit mounted devices, and 1 percent for control room, panel mounted devices, throughout a temperature range of -20 to +65 degrees C -4 to +150 degrees F. Data display shall utilize LED or back-lit LCD. Additionally, the display shall provide indication of cycle programming and diagnostic codes for troubleshooting. Numeral height shall be [13 mm1/2 inch] [[_____] mminch].]

2.17.3 Parameter Display

Continuous indication of the tachometer, lubricating-oil pressure, and safety system parameters shall be provided. A momentary switch shall be specified for other panels.

2.18 BASE

****

NOTES: The diesel-engine pump drive can be equipped so that it has its own base, or it can be on an integral base with the pump and speed reducer. With an integral base, coordination with the other equipment specifications and the use of the statement, "suitable holes for anchor bolts", should be included in the plans and specifications.

Coordinate with the subparagraph VIBRATION ISOLATION AND SEISMIC RESTRAINTS under paragraph SPECIAL LIMITATIONS.

****

The base shall be constructed of structural steel. The base shall be designed to rigidly support the engine, ensure permanent alignment of all rotating parts, be arranged to provide easy access to allow changing of lube-oil, and ensure that alignment is maintained during shipping and normal operation. The base shall not permit skidding in any direction during installation and shall withstand and mitigate the effects of synchronous vibration of the engine and pump. The base shall be provided with [suitable holes for anchor bolts] [[_____] mm inch diameter holes for anchor bolts]. The entire engine assembly shall be capable of withstanding the load imposed by earthquake forces.

2.19 MOTORS

Electric motors shall conform to the requirements of NEMA MG 1. Motors shall have sealed ball bearings and a maximum speed of 1,800 rpm. Motors shall have drip-proof frames; alternating current motors larger than 373 W 1/2 hp shall be of the squirrel-cage induction type for operation on [_____] V, [50] [60] Hz, three-phase AC power. Alternating current motors 373 W (1/2 hp) or smaller, shall be suitable for operation on 120 V, [50] [60] Hz, single-phase, AC power. Direct current motors shall be suitable for operation on [125] [_____] V DC. Motor controllers and starters shall conform to the requirements of NFPA 70 and NEMA ICS 2.

2.20 PAINTING

The engine and the accessory equipment including, but not limited to, panels, valves, piping, intake, and exhaust system components shall be cleaned, primed, and painted [in accordance with the manufacturer's standard color and practice] [as specified in Section [09 90 00 PAINTS AND COATINGS] [09 97 02 PAINTING: HYDRAULIC STRUCTURES].]

2.21 FACTORY INSPECTION AND TESTS

Prior to shipment, each engine shall be inspected and tested at the factory in the presence of the Contracting Officer or the authorized government representatives. The inspection shall cover all components including, but not limited to, governors, instrumentation panels, engine starting system, intake and exhaust, lubrication system, cooling system, and fuel system. Inspection shall be completed and all necessary repairs made prior to testing. Unless otherwise directed by the Contracting Officer or the authorized government representative, the following factory tests shall be performed:

a. Simulated emergency or overspeed trip test.

b. Sustained operation test of 4 hr at rated full load.

c. Sustained operation test of 2 hr at 70 percent of rated full load.

d. Fuel consumption tests of not less than 1 hr each at 70 and 100 percent rated full load, respectively, using [the type of diesel fuel specified][natural gas].

e. The engine shall be operated at no load to demonstrate that the governor and its associated engine manifold shutoff valve function properly.

f. Test data shall be taken at 30-min intervals and recorded on the manufacturer's dieselnatural gas fueled engine test data sheets. The test data sheets shall provide entries for all data required for the evaluation of dieselnatural gas fueled engine performance including noise and vibration. The test data shall be submitted for approval as required in paragraph SUBMITTALS. No engine shall be shipped until the test data has been approved by the Contracting Officer.

PART 3 EXECUTION

3.1 EXAMINATION

Before performing any work, visit the installation site and verify all details of the work. For new construction, review plans and elevations for adequacy and notify the Contracting Officer in writing of any discrepancies.

3.2 INSTALLATION

****

NOTE: Provide an equipment layout on the plans which allow clear space for operation and maintenance in accordance with NFPA 70 and IEEE C2. Include requirements for staging and a laydown area for disassembly or removal and replacement of major parts of the engine. Additionally, it is advisable

to provide access to remove the unit and/or major parts of equipment from the engine room and the building through either doors/passageways or equipment hatches. For large units, specify a bridge crane of an adequate capacity as recommended by the engine manufacturer.

****

The installation of the equipment furnished under this section and related pumps and gear reducers under other sections shall be coordinated and installed in accordance with the approved installation procedures. Submit a copy of the manufacturer's installation and alignment procedures, including a detailed description of the manufacturer's recommended break-in procedure.

3.3 PIPING INSTALLATION

No section of pipe within a building shall exceed 6 m 20 ft in length between flanged fittings. Except where otherwise specified, flanged fittings shall be utilized to allow for complete dismantling and removal of each piping system from the facility without disconnecting or removing any portion of any other system's equipment or piping. Connections to all equipment shall be made with flexible connectors and isolation valves. Bending of pipe shall be done with pipe benders, and no malformation shall be visible on bent pipe. Pipes extending through the roof shall be properly flashed. Piping shall be supported and permitted to expand and contract without damage to joints or hangers. Drain valves of 15 mm 0.6 inch shall be installed at each low point in the piping.

3.3.1 Supports

Hangers, inserts, and supports shall be of sufficient size to accommodate any insulation and shall conform to MSS SP-58 and MSS SP-69. Supports shall be spaced in accordance with ASME B31.1. Piping supports shall not be attached to metal decking. Supports shall not be attached to the underside of concrete filled floors or concrete roof decks unless approved by the Contracting Officer.

3.3.1.1 Ceiling and Roof

Exhaust piping shall be supported with appropriate sized Type-41 single pipe roll and threaded rods; all other piping shall be supported with appropriately sized Type 1 clevis and threaded rods.

3.3.1.2 Wall

Wall supports for pipe shall be made by suspending the pipe from appropriately sized Type 33 brackets with the appropriate ceiling and roof pipe supports.

3.3.2 Flanged Joints

Flanges shall be Class 125 type, drilled, and of the proper size and configuration to match the exhaust outlet of the engine. Flanged joints shall be gasketed and made to be square and tight.

3.3.3 Cleaning

After fabrication and before assembly, all piping interiors shall manually

be wiped clean of all debris.

3.3.4 Pipe Sleeves

Pipes passing through construction such as ceilings, floors, or walls shall be fitted with sleeves. Each sleeve shall extend through and be securely fastened in its respective structure and shall be cut flush with each surface. The structure shall be built tightly to the sleeve. The inside diameter of each sleeve shall be a minimum of 15 mm 0.6 inch larger than the outside diameter of the passing pipe or pipe covering, and where pipes pass through combustible materials, 25 mm 1 inch larger than the outside diameter of the passing pipe or pipe covering.

3.4 ELECTRICAL INSTALLATION

Electrical installation shall comply with NFPA 70, IEEE C2, and Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM. Vibration isolation shall be provided for all conduit, cable trays, and raceways attached to the engine.

3.5 ONSITE INSPECTION AND TESTS

Perform the tests outlined in the subsequent subparagraphs after complete installation of each engine and its associated equipment and in accordance with the approved Dynamic Analysis of Engine, Pump, and Governor. Include supporting calculations with the Dynamic Analysis submittal.

Record data taken during runs at 30-min intervals and include all available pressure and temperature data which is monitored by the instrumentation furnished with the engine.

3.5.1 Instruments

Readings of panel gauges, meters, displays, instruments, etc. provided under the specification shall be verified during all test runs by test instruments of greater precision and accuracy than the operational equipment. Instruments used in the tests shall be calibrated by a recognized standards laboratory within 30 days prior to testing.

3.5.2 Sequence

The tests shall follow the sequence outlined in subsequent paragraphs. Measurements shall be made and recorded of all parameters necessary to verify that each engine meets specified parameters. If the results of any of the test sequences are not satisfactory, adjustments or replacements shall be made and the test sequence repeated until satisfactory results are obtained.

3.5.2.1 Piping Test

a. Lube-oil and fuel-oil piping shall be flushed with the same type of fluid intended to flow through the piping, until the out-flowing fluid is free of obvious sediment and emulsions.

b. The lube oil, fuel-oil and coolant piping [and piping and pressure vessels of the air starting system] shall be hydrostatically pressure tested at 150 percent of the maximum anticipated working pressure, but in no case less than 1.03 MPa 150 psig for a period of 2 hr to demonstrate the piping has no leaks. If piping is to be insulated, the test shall be performed before the insulation is applied.

Submit certificates of compliance for pressure vessels including official, signed statements from the fabricators of heat exchangers and expansion tanks associated with the engine cooling system certifying compliance with ASME BPVC SEC VIII D1.

3.5.2.2 Initial Inspection

a. Engine mounting bolts shall be visually inspected and checked for proper application and torque.

b. Correct functioning of the high and pre-high lubricating oil temperature circuit shall be demonstrated by removing the temperature-sensing elements from the engine and immersing the elements in a vessel containing controlled-temperature hot oil and recording the temperature at which the elements activate.

c. Correct functioning of the high and pre-high coolant-fluid outlet temperature circuit shall be demonstrated by removing the temperature-sensing elements of the circuit from the engine and immersing the elements in a vessel containing controlled-temperature hot coolant-fluid and recording the temperature at which the elements activate.

3.5.2.3 Electric Protective Device Tests

Protective devices shall be visually and mechanically inspected, adjusted, tested, and calibrated in accordance with the manufacturer's published instructions. Device ratings, settings, and other operational data shall be documented.

3.5.2.4 Safety Run Test

Should there be insufficient water available to operate the plant and to perform the engine tests, the Contracting Officer may delay the test for up to 9 months. The safety run test consists of the following sequence of tests:

a. The engine shall be started, the starting time recorded, and all of the engine manufacturer's recommended after-starting checks and inspections performed following a reasonable warm-up period.

b. The engine shall be operated for at least 2 hr at 75 percent rated speed.

c. Proper operation of all controls shall be verified.

d. Proper operation and set points of all gauges and instruments shall be verified. Setpoints shall be recorded.

e. Proper operation of all ancillary equipment shall be verified.

f. The manual emergency stop switch shall be activated and the time to stop the engine recorded.

g. The engine shall be started, the starting time recorded, the engine manufacturer's after-starting checks and inspections performed and recorded, and the engine operated for at least 15 min at 75 percent of rated speed.

h. The governor shall be manually adjusted to increase engine speed past the overspeed limit. The engine RPM at shutdown shall be recorded.

[i. The day tank shall be manually filled to a level above the overfill limit. The level at which the overfill alarm activates shall be recorded. Shutdown of the fuel transfer pump shall be verified. The day tank shall be drained below the overfill limit following the test.]

j. The time-delay low-lube oil pressure alarm bypass shall be temporarily removed from the engine safety circuits and an attempt made to start the engine. The results shall be recorded.

k. A manifold shall be attached to the engine oil system containing a shutoff valve in series with a connection for the engine's oil pressure sensor, followed by an oil pressure gauge, ending in a bleed valve. The oil pressure sensor shall be moved from the engine to the manifold and its normal location on the engine temporarily sealed. The manifold shutoff valve shall be placed in the open position and the bleed valve closed.

l. The engine shall be started, the starting time recorded, the engine manufacturer's after-starting checks and inspections performed and recorded and the engine operated for at least 15 min at 75 percent of rated speed.

m. The manifold shutoff valve shall be closed. The pressure in the manifold shall be slowly bled off through the bleed valve while observing the pressure gauge. The pressure at which the engine shuts down shall be recorded. The oil spillage from the bleed valve shall be captured in a container. The oil system shall be refilled, the manifold removed, and the engine's oil pressure sensor reinstalled on the engine following the test.

n. The engine shall be started, the starting time recorded, the engine manufacturer's after-starting checks and inspections performed and recorded and the engine operated for at least 15 min at 100 percent of rated speed. The maximum sound level in each frequency band at a distance of 22.9 m 75 ft from the end of the exhaust piping directly along the path of discharge for horizontally discharged exhausts shall be recorded. The maximum sound level in each frequency band at a distance of [22.9 m 75 ft] [10.7 m 35 ft] from the silencer at 45 deg apart in all directions around the unit shall be recorded.

[o. The fuel from the day tank shall be slowly drained to lower the fuel level below the no fuel level limit and the level at which the audible alarm sounds recorded. The fuel shall be added back to the day tank, filling it above the low level alarm limit following the test.]

3.5.2.5 Final Inspection

a. The lube-oil filter shall be removed and the oil and filter examined by the engine manufacturer for excessive metal, abrasive foreign particles, and other indications of engine distress. Any corrective actions shall be verified for effectiveness by running the engine for 8 hr at full rated speed, then re-examining the oil and filter.

b. The engine shall be inspected and all engine mounting bolts checked for tightness and visible damage.

3.6 MANUFACTURER'S FIELD SERVICE

3.6.1 Onsite Training

****
NOTE: Delete video taping if not required.
****

Conduct training courses for the plant operating staff as designated by the Contracting Officer. The training period shall consist of a total of [_____] hr of normal working time and shall commence after the system is functionally completed, but prior to final acceptance. The course instructions shall cover pertinent points involved in operating, starting, stopping, and servicing the equipment, as well as all major elements addressed in the operations and maintenance manuals. Additionally, the course shall include demonstrations and instruction in all routine maintenance operations including oil change, oil filter change, air filter change, etc. [Submit Two [CD] [DVD] copies of the entire training session.]

Submit a letter giving the proposed date for conducting the onsite training course[and][,] the agenda of instruction [, a description of the video taping service to be provided, and the kind and quality of the tape].

3.6.2 Field Engineer

The manufacturer or Contractor shall furnish a qualified engineer to supervise the complete installation of the engine, assist in performance of the onsite tests, and instruct personnel regarding operational and maintenance features of the equipment. Submit certification that the field engineer is qualified to perform the functions.

3.7 FIELD PAINTING

Field painting shall be as specified in Section [09 90 00 PAINTS AND COATINGS] [09 97 02 PAINTING: HYDRAULIC STRUCTURES].

3.8 MANUFACTURER'S PUBLISHED INSTRUCTIONS

Post instructions, including wiring and control diagrams showing the key mechanical and electrical control elements and a complete layout of the entire system. The instruction set shall be weatherproof, laminated in plastic, framed, and posted at a location as directed.

3.9 ACCEPTANCE

Final acceptance of the engine will not be made until the Contractor has successfully completed all tests, corrected all defects in installation material, and/or installation procedures, and all deficiencies identified in on-site testing or routine operation have been corrected.

3.10 CLOSEOUT ACTIVITIES

3.10.1 As-Built Drawings

Submit As-Built Drawings accurately depicting the as-built configuration of the supplied, installed, and accepted dieselnatural gas fueled engine pump drive.

3.10.2 Operation and Maintenance Manual

Also submit an Operation and Maintenance Manual for the dieselnatural gas fueled engine detailing start-up and operating procedures, lubrication instructions, installation and alignment procedures, routine maintenance requirements and procedures, complete detailed procedures for disassembly and reassembly of the engine, parts list for all parts detailed, assembly plans of the engine showing all parts, suppliers for all parts, settings and adjustment for protective devices, and a list of all tools, handling devices, and spare parts furnished.

-- End of Section --