****
USACE / NAVFAC / AFCEC / 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 October 2022
****

SECTION TABLE OF CONTENTS

DIVISION 41 - MATERIAL PROCESSING AND HANDLING EQUIPMENT

SECTION 41 65 10.00 10

[DIESEL][NATURAL GAS] FUELED ENGINE PUMP DRIVES

05/09

-- End of Section Table of Contents --

****
USACE / NAVFAC / AFCEC / 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 October 2022
****

SECTION 41 65 10.00 10

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

****
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 item(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 35 45 01 VERTICAL PUMPS, AXIAL-FLOW AND MIXED-FLOW IMPELLER-TYPE, and Section 35 45 03.00 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 35 45 01, 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 Reference Identifier (RID) outside of the Section's Reference Article to automatically place the reference in the Reference Article. Also use the Reference Wizard's Check Reference feature to update the issue dates.

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

****

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

AMERICAN NATIONAL STANDARDS INSTITUTE (ANSI)

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

AMERICAN SOCIETY OF MECHANICAL ENGINEERS (ASME)

ASME B16.3	(2021) Malleable Iron Threaded Fittings, Classes 150 and 300
ASME B16.5	(2020) Pipe Flanges and Flanged Fittings NPS 1/2 Through NPS 24 Metric/Inch Standard

ASME B16.11	(2016) Forged Fittings, Socket-Welding and Threaded
ASME B31.1	(2020) Power Piping
ASME BPVC SEC IX	(2017; Errata 2018) BPVC Section IX-Welding, Brazing and Fusing Qualifications
ASME BPVC SEC VIII D1	(2019) BPVC Section VIII-Rules for Construction of Pressure Vessels Division 1

ASTM INTERNATIONAL (ASTM)

ASTM A53/A53M	(2022) Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless
ASTM A106/A106M	(2019a) Standard Specification for Seamless Carbon Steel Pipe for High-Temperature Service
ASTM A181/A181M	(2014; R 2020) Standard Specification for Carbon Steel Forgings, for General-Purpose Piping
ASTM A234/A234M	(2019) Standard Specification for Piping Fittings of Wrought Carbon Steel and Alloy Steel for Moderate and High Temperature Service
ASTM B395/B395M	(2018) Standard Specification for U-Bend Seamless Copper and Copper Alloy Heat Exchanger and Condenser Tubes
ASTM C533	(2017) Standard Specification for Calcium Silicate Block and Pipe Thermal Insulation
ASTM D975	(2020) Standard Specification for Diesel Fuel Oils

INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS (IEEE)

IEEE C2	(2023) National Electrical Safety Code

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

MSS SP-58	(2018) Pipe Hangers and Supports - Materials, Design and Manufacture, Selection, Application, and Installation
MSS SP-80	(2019) Bronze Gate, Globe, Angle and Check Valves

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)

NEMA ICS 2	(2000; R 2020) Industrial Control and Systems Controllers, Contactors, and

Overload Relays Rated 600 V

NEMA ICS 6	(1993; R 2016) Industrial Control and Systems: Enclosures
NEMA MG 1	(2021) Motors and Generators

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 30	(2021; TIA 20-1; TIA 20-2; TIA 21-3) Flammable and Combustible Liquids Code
NFPA 37	(2021) Standard for the Installation and Use of Stationary Combustion Engines and Gas Turbines
NFPA 70	(2020; TIA 22-1; ERTA 1 2022) National Electrical Code

SOCIETY OF AUTOMOTIVE ENGINEERS INTERNATIONAL (SAE)

SAE ARP892	(1965; R 1994) DC Starter-Generator, Engine
SAE J537	(2016) Storage Batteries
SAE J1995	(2014) Engine Power Test Code - Spark Ignition and Compression Ignition - Gross Power Rating

U.S. DEPARTMENT OF DEFENSE (DOD)

UFC 3-301-01	(2019, with Change 1, 2022) Structural Engineering

UNDERWRITERS LABORATORIES (UL)

UL 1236	(2015; Reprint Feb 2021) UL Standard for Safety 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, and corresponding submittal items in the text, to reflect only the submittals required for the project. The Guide Specification technical editors have classified 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 Army projects, fill in the empty brackets following the "G" classification, with a code of up to three characters 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.

The "S" classification indicates submittals required as proof of compliance for sustainability Guiding Principles Validation or Third Party Certification and as described in Section 01 33 00 SUBMITTAL PROCEDURES.

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

Government approval is required for submittals with a "G" or "S" classification. Submittals not having a "G" or "S" classification are [for Contractor Quality Control approval.][for information only. When used, a code following the "G" classification identifies the office that will review the submittal for the Government.] Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-02 Shop Drawings

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

Installation; G[, [_____]]

SD-03 Product Data

Equipment and Performance; G[, [_____]]

Cooling System; 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[, [_____]]

Project/Site Conditions

Onsite Training; G[, [_____]]

Manufacturer's Published Instructions

Field Engineer; G[, [_____]]

DieselNatural Gas Fueled Engine Pump Drive; G[, [_____]]

Welder Qualifications

Installation; 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

SD-11 Closeout Submittals

As-Built Drawings; G[, [_____]]

Operation and Maintenance Manual; G[, [_____]]

1.3 WELDER QUALIFICATIONS

Perform welding 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.[Weld structural members in accordance with Section 05 05 23.16 STRUCTURAL WELDING.][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 perform the tests at the work site, if practical. The welder or welding operator must 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

Conform design, fabrication, and installation of the equipment 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. Include 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).

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. Lift, move, and store the engine 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

UNITS	DESCRIPTION
[_____]	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)
[_____]	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. Supply tools 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 must be in accordance with SAE J1995. Provide DieselNatural Gas Fueled Engine Pump Drive composed of complete units with all components, accessories, and system interconnections coordinated, so that the complete assembly has the capabilities required, for proper operation with the pump specified under Section 35 45 01 VERTICAL PUMPS, AXIAL-FLOW AND MIXED-FLOW IMPELLER-TYPE and the speed reducer specified in Section 35 45 03.00 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 must 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 35 45 01 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. Supply natural gas 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 must 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. Submit all data 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, provide nameplates 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)

Provide pipe for sleeves, fuel/lube-oil, compressed air, coolant, exhaust, and miscellaneous uses in compliance with ASTM A53/A53M, or ASTM A106/A106M steel pipe. Pipe smaller than 50 mm 2 inch must be Schedule 80. Pipe 50 mm 2 inch and larger must 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. Provide gauge construction and materials that are appropriate for the intended service.

2.3.4 Pipe Hangers

MSS SP-58

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

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

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

2.4.1 Fuel Consumption

Do 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 must 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.

****

Provide a pressure relief valve in the crankcase. Vent the crankcase in accordance with the manufacturer's recommendations, except do not use the engine exhaust as the venting system. Pipe crankcase breathers, if provided on engines installed in either a building or enclosure, to vent to the outside. If the engine is located outside, fit the crankcase breather with a goose-neck to prevent rain entry.

Provide a pressure relief valve in the crankcase. Vent the crankcase 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, vent the crankcase to the outside and fit with a goose neck to prevent rain entry.

2.5 FUEL SYSTEM

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

2.5.1 Fuel Pump

Provide each engine with an engine-driven, positive displacement engine fuel pump. Provide pump with 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.

Provide each engine 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 must be adequate to power to 110 percent load at the site fuel supply pressure as stated above.

2.5.2 Filter

Supply a minimum of one duplex filter with a trans-flow change-over valve for each engine. Provide filter with inlet and outlet connections plainly marked. Provide an indicating differential pressure gauge across the filter. Locate the filter on the inlet side of the fuel pump. Ensure the filter is capable of filtering out particles down to 25 micron size.

Provide each engine with a fuel filter located upstream of the fuel solenoid shutoff to filter 100 percent of the incoming gas. Provide filter with inlet and outlet connections plainly marked. Provide an indicating differential pressure gauge across the filter. Ensure the filter is capable of filtering out particles down to 5 micron size.

2.5.3 Strainer

Provide a full flow strainer of the replaceable cartridge type between the engine and the fuel tank, upstream of the duplex filter. Provide an indicating differential pressure gauge for upstream and downstream of the strainer. Ensure the strainer cartridge is 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. Select and certify this fuel gas compressor 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. Package the fuel gas compressor 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

Provide a safety bypass valve 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 must protect the fuel piping from over-pressurizing and will relieve it at [_____] kPa psi. The bypass valve relief line must 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.

****

Provide each engine with a day tank located next to the engine. Fit each day tank 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. Provide a fuel return line cooler, if recommended by the engine manufacturer. Provide each day tank with [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

Equip each day tank drain line with a shutoff valve and arrange to allow drainage into 220 L 55 gal drums.

2.5.6.2 Local Fuel Fill

Provide each local fill port with a [screw-on cap][hinged, fill cap]. Provide an air vent with brass screen 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. Provide each day tank 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. Provide each day tank with a separate level-sensing device to activate alarms at day tank overfill and day tank empty. Day tank empty must indicate at 20 percent volume remaining. Day tank overfill must 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, provide an automatic shutoff valve on the fill line of the day tank and provide an automatic safety device to stop the pump supplying fuel to the day tank. Activate the valve and the safety device at the overfill level as defined in paragraph SAFETY SYSTEM, and respond before any fuel is forced out of the fuel overflow line.

2.5.6.5 Arrangement

Position and arrange the day tank 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. Position and arrange the day tank overflow connection 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 must be welded steel pipe. Provide a water drain at the low point of the day tank.

2.5.7 Fuel Supply System

Provide diesel fuel supply from the main diesel fuel storage to the day tank as specified in Section 33 56 10 FACTORY-FABRICATED FUEL STORAGE TANKS. Provide natural gas fuel supply system as specified in Section 33 51 15 NATURAL-GAS / LIQUEFIED PETROLEUM GAS DISTRIBUTION PIPELINES and Section 23 11 20 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.
****

Provide each engine with a separate lube-oil system conforming to NFPA 30 and NFPA 37. Pressurize each system by engine-driven pumps.[Adjust and regulate the system pressure as recommended by the engine manufacturer.] Furnish a sump tank as required. The lube-oil pump must 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. Protect the pump by a relief valve to bypass the oil into sump. Bypass a portion of the oil from the sump through a lubricating oil filter and back into the engine oil pan or sump. Regulate the lubricating oil temperature by means of an automatic temperature regulator which will control the amount of bypass oil around the cooler. Make the system readily accessible for service such as draining or refilling. Permit the addition of oil and have oil-level indication with the set operating.

2.6.1 Pump Filters

Provide one full-flow, duplex, 80 micron filter for each pump. Ensure the filter is readily accessible and capable of being changed without disconnecting the piping or disturbing other components. Provide filter with inlet and outlet connections plainly marked. Provide an indicating differential pressure gauge across the filter.

2.6.2 Lube-Oil Sensors

Equip each engine with lube-oil temperature and pressure sensors. Use temperature sensors to provide signals for pre-high and high lube-oil indication and alarms. Locate pressure sensors downstream of the filters and provide signals for pre-low and low lube-oil indication and alarms.

2.6.3 Lubricating Oil Strainer

Furnish a full-flow, oil strainer in-line, ahead of the engine. The strainer must be as recommended by the engine manufacturer. Provide a bottom drain plug to 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.
****

Provide pre-lubricating oil pump with a capacity and head rating as recommended by the engine manufacturer. Incorporate a built-in relief valve and directly connect to an electric motor with the motor-pump assembly mounted on a common case iron or steel base. Furnish the pump complete and ready for operation with all controls inclusive. Allow the pre-lubrication pump to completely fill the engine oil lines and establish lubricating oil pressure prior to starting. Provide pump motor 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 must have its own cooling system. Provide closed type system that operates automatically while the engine is running.

b. Provide cooling system with 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 is not allowed to exceed the engine manufacturer's recommendation as submitted in paragraph SUBMITTALS.

c. Provide closed type engine cooling system arranged to prevent rust and minimize formation of scale deposits within the engine. Circulate jacket-coolant through the engine at the temperature and flow rate recommended by the engine manufacturer. The coolant must 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 is 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.

****

Provide centrifugal type engine-driven jacket water pumps.[Raw-water centrifugal circulating pumps must be [electric motor driven equipped with manual-off-automatic controllers] [engine driven].] Provide each engine with an engine-driven primary pump. Provide electric motor driven secondary pumps with automatic controllers. Provide a bronze fitted, single stage type pump 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.

****

Size each radiator 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. Use radiator fabrication materials that are 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 must be compatible with liquid fluid coolant used. Materials and coolant are subject to approval by the Contracting Officer. Ensure radiators are the pressure type incorporating a pressure valve, vacuum valve, and a radiator cap. Provide radiator cpas for pressure relief prior to removal. Ensure each radiator and the entire cooling system is capable of withstanding a minimum pressure of 48.4 kPa 7 psig. Protect each radiator with a strong grille or screen guard. Radiators must have at least two tapped holes. Equip one tapped hole in the radiator with a drain cock; plug the rest. [Provide the remote located radiator with an electric motor-driven fan. Wire the fan to operate when the engine operates.]

[2.7.2.1 Shell and Tube Heat Exchanger

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

][2.7.2.2 Plate and Frame Heat Exchanger

The heat exchanger must be a multiple pass type with removable plates to facilitate cleaning. The heat exchanger must be of sufficient capacity to cool the engine with [_____] degrees C F input cooling water. Construct heat exchanges in accordance with ASME BPVC SEC VIII D1 and certify with an ASME stamp secured to the heat exchanger. Select materials for the plate and frames that are appropriate for the service required. Locate high and low temperature and pressure relief connections in accordance with the manufacturer's standard practice. Water pressure loss through clean plates must be as recommended by the engine manufacturer. Provide one or more pressure relief valves for each heat exchanger in accordance with ASME BPVC SEC VIII D1. Install a drain connection with a 19 mm 3/4 inch hose bib connection 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 must 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.

****

Provide pipe or coil of sufficient length to cool the engine at the specified raw water temperature. Use piping materials as specified in paragraph PIPE. Install pipe as specified in paragraph PIPING INSTALLATION. Always slope the pipe from the return bend up to prevent air locks in the system. Furnish a drain plug at the lowest point of the system. Connect the system 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

Provide a modulating type, thermostatic control valve in the coolant system to maintain the engine coolant temperature in the range submitted in paragraph SUBMITTALS.

2.7.4 Ductwork

Provide ductwork as specified in [Section 23 30 00 HVAC AIR DISTRIBUTION] [_____] except use a flexible connection to connect the engine radiator. Material for the connection must be wire-reinforced fiber glass. The connection must be airtight.

2.7.5 Temperature Sensors

Equip each engine with coolant temperature sensors. Use temperature sensors to provide signals for pre-high and high coolant temperature indication and alarms.

Equip each engine 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.

****

Furnish an expansion tank of no less than [_____] L gal for each engine. Properly fit the tank for vent, overflow, expansion, and make-up lines. The tank must be suitable for an operating temperature of 121 degrees C 250 degrees F and a working pressure of 860 kPa 125 psig. Construct tank of welded steel, hot-dipped galvanized inside and outside after fabrication, test, and stamp in accordance with ASME BPVC SEC VIII D1 and register with the National Board of Boiler and Pressure Vessel Inspectors. Mount tank so that the bottom of the tank is above the top of the engine. Support tank 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 must 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 3-301-01 and properly edited Sections 13 48 73 and 22 05 48.00 20 must be included in the contract documents.
****

Limit the maximum engine vibration in the horizontal, vertical, and axial directions to 0.15 mm 6 mils peak-peak RMS, with an overall velocity limit of 24 mm/sec 0.95 inch/sec RMS.[Install a vibration-isolation system between the floor and the base. The vibration-isolation system must limit the maximum vibration transmitted to the floor at all frequencies to a maximum of [_____] [_____] peak force.][Provide engine with a vibration-isolation system in accordance with the manufacturer's standard practice.] Design and qualify vibration-isolation systems (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, provide seismic restraints in accordance with UFC 3-301-01 and Sections 13 48 73 SEISMIC CONTROL FOR MISCELLANEOUS EQUIPMENT and 23 05 48.19 [SEISMIC] BRACING FOR HVAC[and as indicated].

2.9 AIR INTAKE EQUIPMENT

Provide filters and silencers in locations that are convenient for servicing as shown on the project plans. The silencer must 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 must be [copper][rubber].

2.10 EXHAUST SYSTEM

Provide a separate and complete system for each engine. Support exhaust piping to minimize vibration. Make provisions for pipe thermal expansion. Where a V-type engine having more than one exhaust outlet is provided, use a V-type connector, with necessary flexible sections and hardware, to connect the engine exhaust outlets. Incorporate engine-mating and silencer-mating flanges, eliminating the need for adapters. Ensure the muffler and exhaust piping together is 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

Provide a flexible section at each engine and an expansion joint at each muffler. Provide flexible sections and expansion joints with flanged connections. Ensure flexible sections are multiple-ply stainless steel expansion bellows type with standard 38 and 76 mm 1.5 and 3 inch allowable axial expansion. Use elements in the flexible sections that are 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.

****

Provide a chamber type exhaust muffler. Fabricate the muffler of welded steel and design for [outside] [inside] [vertical] [horizontal] mounting. Provide eyebolts, lugs, flanges, or other items as necessary for support of the muffler in the location and position indicated on the plans. Do not allow the pressure drop through the muffler to exceed the recommendations of the engine manufacturer. Fabricate outside mufflers from [aluminized steel] [stainless steel]. Provide muffler with a drain valve, nipple, and cap at the low-point of the muffler. Supply a complete muffler with any necessary soot boxes or inspection ports required for adequate operation and maintenance. Size the entire exhaust system 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/sec 5,000 fpm. The exhaust piping location and routing should be shown on the plans.

****

Slope horizontal sections of the exhaust piping downward away from the engine to a condensate trap and drain valve. Make changes in direction utilizing long radius fittings. Run exhaust piping not covered in this paragraph in accordance with paragraph PIPING INSTALLATION. Insulate exhaust piping, mufflers, and silencers 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. Secure insulation with no less than 9.525 mm 0.375 inch wide Type 304 stainless steel bands spaced no farther apart than 200 mm 8 inches on center. Provide an aluminum jacket encasing the insulation. Provide aluminum jacket with a minimum thickness of 0.406 mm 0.016 inch with a factory-applied polyethylene and kraft paper moisture barrier. Secure the jacket with no less than 13 mm1/2 inch wide stainless steel bands, spaced no farther apart than 200 mm 8 inch on centers. Lap longitudinal and circumferential seams of the jacket no less than 75 mm 3 inch. Install jackets on horizontal lines so that the longitudinal seams are on the bottom side of the pipe. Place the seams of the jacket for the vertical lines on the off-weather side of the pipe. On vertical lines, overlap the circumferential seams of the jacket so that the lower edge of each jacket overlaps the upper edge of the jacket below. Provide vertical exhaust piping with a hinged, gravity-operated, self-closing rain cover. When the exhaust pipe exits the building, isolate the pipe 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 1,000 kW 1,340 hp.

****

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

2.12 EMISSIONS

The finished installation must 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.
****

Provide each diesel engine with a starting system. Provide a [pneumatic] [electric] system of sufficient capacity to start the engine at the minimum temperature specified. Provide system with a start-stop switch which provides functions including testing, reset, manual run/start, manual stop, and adjustable cranking and cooling down operation. Ensure the starting system is 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.
****

Provide an electrical starting system to operate on a [24] [_____]-V DC utilizing a negative circuit ground. Include an adjustable cranking device to limit the engine cranking to a specified time limit. Provide starting motors 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.
****

Provide a starting battery system and include the battery, battery rack, intercell connectors, spacers, automatic battery charger with overcurrent protection, metering, and relaying. Provide battery in accordance with SAE J537. Design critical system components (rack, protection, etc.) to withstand the seismic acceleration forces specified in subparagraph

VIBRATION ISOLATION AND SEISMIC RESTRAINTS under paragraph SPECIAL LIMITATIONS. The battery must 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

Provide a current-limiting battery charger, conforming to UL 1236, to automatically recharge the batteries. Ensure charger is capable of providing both automatic float charging and equalizing charging of the battery installation. The charger must 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. Provide an ammeter and voltmeter on the charger to indicate charging rate and voltage. Ensure charger has 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. Size the receiver 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.

****

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

2.13.2.1   Air Filter

Install an air filter upstream of the air connection to each engine. The filter must 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 must be complete with a solenoid valve, strainer, and lubricator. If cylinder injection starting is used it must 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

Mount a thermostatically controlled electric heater in the engine coolant jacketing to automatically maintain the coolant within ñ10 deg of the control temperature. Operate the heater 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

Design glow plugs 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

Mount a thermostatically controlled electric heater in the engine lube oil storage tank to automatically maintain the lube oil within ñ10 deg of the control temperature. Operate the heater independently of engine operation so that starting times are minimized and the system ensures dependable cold weather starts. Select heaters 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

Provide and install all system items, such as devices, wiring, remote annunciator panels, and alarm panels, as a complete system to automatically activate the appropriate signals and initiate appropriate safety actions. Provide safety system with a self-test method to verify its operability. Provide alarm signals with manual acknowledgment and reset devices. The alarm signal systems must reactivate for new signals after acknowledgment is given to any signal. The systems must be dealt with as an alarm on that system element. Provide remote annunciator panels and alarm panel 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 must sound at a frequency of [70] [_____] Hz at a volume of [75] [_____] dB at 3.1 m 10 ft. The sound must be continuously activated upon alarm and silenced upon acknowledgment. Provide signal locations as shown on the plans.

2.14.2 Visual Signal

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

2.14.3 Alarms and Action Logic

2.14.3.1 Shutdown

Use shutdown signals to simultaneously activate the audible signal, activate the visual signal, and stop the engine.

2.14.3.2 Problem

Use problem signals to activate the visual signal.

2.14.4 Alarm Panel

Fabricate and locate the panel as specified in paragraph PANELS, and 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, install time-delay devices bypassing the low lubricating oil pressure alarm during cranking[and the low coolant-fluid outlet temperature alarm]. The lube-oil time-delay device must return its alarm to normal status after the engine starts.[The coolant time-delay device must 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.
****

Provide a remote alarm panel with 100 percent functional redundancy to the alarm panel.[Locate amd mount the remote panel as shown on the plans.] [Pack and ship the remote panel as directed by the Contracting Officer for installation by others on the station control console.]

]2.15   GOVERNOR

Provide each engine with a governor to control the rotational speed of the engine in response to changing load requirements. Configure the governor for safe manual adjustment of the speed during operation of the engine, without special tools.

2.15.1   Speed Regulating Governor

Maintain close speed regulation under all load conditions. Do not allow the speed variation to exceed 6 percent of normal speed when full load is suddenly applied or removed. Design the governor 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 is not allowed to exceed 2 percent. Mount a raise/lower speed control on the engine instrument board.[Provide speed adjust control with provisions for allowing control of the speed control circuits from a remote location.] Provide engine fuel rack servomotor 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.
****

Provide an emergency governor with overspeed trip on each engine to shutdown the unit should the speed exceed a predetermined RPM. Also provide an alarm signal for remote indication. The emergency governor must be independent of the regulating governor. When the overspeed stop has been tripped, the shutdown mechanisms must 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. Set the overload fuel limit at 110 percent of the full load as specified in paragraph DIESEL ENGINE.

2.15.3 Governor Controls Location

Locate governor control 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.
****

Provide engine instrument board as specified in paragraph PANELS, and 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 must be of the type and kind necessary to provide specified functions. Mount panels [on the engine base by vibration/shock absorbing type mountings][as shown on the plans]. Mount instruments flush or semiflush. Provide convenient access to the back of panels to facilitate maintenance. Calibrate instruments using recognized industry calibration standards. Provide a panel identification plate which clearly identifies the panel function as indicated on each panel. For each instrument and device on the panel, provide a plate which clearly identifies the device and its function as indicated. Ensure all instruments and devices are vibration resistant.

2.17.1   Enclosures

Design enclosures for the application and environment, conforming to NEMA ICS 6. Locking mechanisms [are optional] [must be keyed alike].

2.17.2   [Analog] [Electronic]

****

NOTE: Select appropriate alternative paragraph.

****

[Provide analog electrical indicating instruments in accordance with ANSI C39.1 with semiflush mounting. Panel-mounted instruments must [be the manufacturer's standard][have 100-deg scales] with an accuracy of no less than 2 percent. The instrument's operating temperature range must be -20 to +65 degrees C -4 to +150 degrees F.]

[Provide electronic indicating instruments that are 100 percent solid state, state-of-the-art, microprocessor controlled to provide all specified functions. Ensure control, logic, and function devices are compatible as a system, sealed, dust and water tight, and utilize modular components with metal housings and digital instrumentation. Provide an

interface module to decode serial link data from the electronic panel and translate alarm, fault, and status conditions to a set of relay contacts. Ensure instrument accuracy is no 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 must utilize LED or back-lit LCD. Additionally, the display must provide indication of cycle programming and diagnostic codes for troubleshooting. Use a numeral height of [13 mm1/2 inch] [[_____] mminch].
]

2.17.3 Parameter Display

Provide continuous indication of the tachometer, lubricating-oil pressure, and safety system parameters. Specify a momentary switch 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.

****

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

2.19 MOTORS

Provide electric motors conforming to the requirements of NEMA MG 1. Provide motors with sealed ball bearings and a maximum speed of 1,800 rpm. Provide motors with drip-proof frames; ensure alternating current motors larger than 373 W 1/2 hp are of the squirrel-cage induction type for operation on [_____] V, [50] [60] Hz, three-phase AC power. Provide alternating current motors 373 W (1/2 hp) or smaller, that are suitable for operation on 120 V, [50] [60] Hz, single-phase, AC power. Use direct current motors that are suitable for operation on [125] [_____] V DC. Provide motor controllers and starters conforming to the requirements of NFPA 70 and NEMA ICS 2.

2.20 PAINTING

Clean, prime, and paint the engine and the accessory equipment including, but not limited to, panels, valves, piping, intake, and exhaust system components [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, inspect and test each engine at the factory in the presence of the Contracting Officer or the authorized government representatives. Inspect and test all components including, but not limited to, governors, instrumentation panels, engine starting system, intake and exhaust, lubrication system, cooling system, and fuel system. Complete inspection and make all necessary repairs prior to testing. Unless otherwise directed by the Contracting Officer or the authorized government representative, perform the following factory tests:

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. Operate engine at no load to demonstrate that the governor and its associated engine manifold shutoff valve function properly.

f. Take test data at 30-min intervals and record on the manufacturer's dieselnatural gas fueled engine test data sheets. The test data sheets must provide entries for all data required for the evaluation of dieselnatural gas fueled engine performance including noise and vibration. Subbmit test data for approval as required in paragraph SUBMITTALS. Do not ship engine 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.

****

Coordinate the installation of the equipment furnished under this section and related pumps and gear reducers under other sections and install 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

Do not allow any section of pipe within a building to exceed 6 m 20 ft in length between flanged fittings. Except where otherwise specified, utilize flanged fittings 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. Make connections to all equipment with flexible connectors and isolation valves. Bend pipe with pipe benders, and ensure no malformation is visible on bent pipe. Properly flash pipes extending through the roof. Support piping and permit to expand and contract without damage to joints or hangers. Install drain valves of 15 mm 0.6 inch at each low point in the piping.

3.3.1 Supports

Provide hangers, inserts, and supports of sufficient size to accommodate any insulation and conform to MSS SP-58. Space supports in accordance with ASME B31.1. Do not attach piping supports to metal decking. Do not attach supports to the underside of concrete filled floors or concrete roof decks unless approved by the Contracting Officer.

3.3.1.1 Ceiling and Roof

Support exhaust piping with appropriate sized Type-41 single pipe roll and threaded rods; support all other piping with appropriately sized Type 1 clevis and threaded rods.

3.3.1.2 Wall

Make wall supports for pipe by suspending the pipe from appropriately sized Type 33 brackets with the appropriate ceiling and roof pipe supports.

3.3.2 Flanged Joints

Provide Class 125 type flanges, drilled, and of the proper size and configuration to match the exhaust outlet of the engine. Ensure flanged joints are gasketed and made to be square and tight.

3.3.3 Cleaning

After fabrication and before assembly, manually wipe clean all piping interiors of all debris.

3.3.4 Pipe Sleeves

Fit pipes passing through construction such as ceilings, floors, or walls with sleeves. Extend each sleeve through and securely fasten in its respective structure and cut flush with each surface. Build the structure tightly to the sleeve. The inside diameter of each sleeve must 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 must comply with NFPA 70, IEEE C2, and Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM. Provide vibration isolation 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

Verify readings of items such aspanel gauges, meters, displays, and instruments provided under the specification during all test runs by test instruments of greater precision and accuracy than the operational equipment. Calibrate instruments used in the tests by a recognized standards laboratory within 30 days prior to testing.

3.5.2 Sequence

Follow the sequence outlined in subsequent paragraphs. Make measurements and record all parameters necessary to verify that each engine meets specified parameters. If the results of any of the test sequences are not satisfactory, make adjustments or replacements and repeat the test sequence until satisfactory results are obtained.

3.5.2.1 Piping Test

a. Flush lube-oil and fuel-oil piping 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. Hydrostatically pressure test the lube oil, fuel-oil and coolant piping [and piping and pressure vessels of the air starting system] 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, perform the test 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. Visually inspect and check engine mounting bolts for proper application and torque.

b. Demonstrate correct functioning of the high and pre-high lubricating oil temperature circuit 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. Demonstrate correct functioning of the high and pre-high coolant-fluid outlet temperature circuit 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

Visually and mechanically inspect, adjust, test, and calibrate protective devices in accordance with the manufacturer's published instructions. Document device ratings, settings, and other operational data.

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. Start the engine, record the starting time, and perform all of the engine manufacturer's recommended after-starting checks and inspections following a reasonable warm-up period.

b. Operate engine for at least 2 hr at 75 percent rated speed.

c. Verify proper operation of all controls.

d. Verify proper operation and set points of all gauges and instruments. Record setpoints.

e. Verify proper operation of all ancillary equipment.

f. Activate manual emergency stop switch and record the time to stop the engine.

g. Start the engine, record the starting time, perform and record the engine manufacturer's after-starting checks and inspections, and operate the engine for at least 15 min at 75 percent of rated speed.

h. Manually adjust the governor to increase engine speed past the overspeed limit. Record the engine RPM at shutdown.

[i. Mnaually fill the day tank to a level above the overfill limit. Record the level at which the overfill alarm activates. Verify shutdown of the fuel transfer pump. Drain the day tank below the overfill limit following the test.]

j. Remove the time-delay low-lube oil pressure alarm bypass temporarily from the engine safety circuits and make an attempt to start the engine. Record the results.

k. Attach a manifold 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. Move oil pressure sensor from the engine to the manifold and temporarily seal its normal location on the engine. Place the manifold shutoff valve in the open position and close the bleed valve.

l. Start the engine, record the starting time, perform and record the engine manufacturer's after-starting checks and inspections, and operate the engine for at least 15 min at 75 percent of rated speed.

m. Close the manifold shutoff valve. Slowly bleed off the pressure in the manifold through the bleed valve while observing the pressure gauge. Record the pressure at which the engine shuts down. Capture oil spillage from the bleed valve in a container. Refill oil system, remove the manifold, and reinstall the engine's oil pressure sensor on the engine following the test.

n. Start the engine, record the starting time, perform and record the engine manufacturer's after-starting checks and inspections, and operate the engine for at least 15 min at 100 percent of rated speed. Record 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. Record 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.

[o. Slowly drain the fuel from the day tank to lower the fuel level below the no fuel level limit and record the level at which the audible alarm sounds. Add the fuel back to the day tank, filling it above the low level alarm limit following the test.]

3.5.2.5 Final Inspection

a. Remove the lube-oil filter and examine the oil and filter by the engine manufacturer for excessive metal, abrasive foreign particles, and other indications of engine distress. Verify any corrective actions for effectiveness by running the engine for 8 hr at full rated speed, then re-examine the oil and filter.

b. Inspect the engine and check all engine mounting bolts 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 consists of a total of [_____] hr of normal working time and commence after the system is functionally completed, but prior to final acceptance. 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, 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

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

Perform field painting 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 must 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 --