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USACE / NAVFAC / AFCEC / NASA **UFGS-43 21 13 (January 2008)**

Preparing Activity: USACE **Superseding UFGS-43 21 13 (April 2006)**

UNIFIED FACILITIES GUIDE SPECIFICATIONS

References are in agreement with UMRL dated July 2014
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SECTION TABLE OF CONTENTS

DIVISION 43 - PROCESS GAS AND LIQUID HANDLING, PURIFICATION, AND STORAGE EQUIPMENT

SECTION 43 21 13

PUMPS: WATER, CENTRIFUGAL

01/08

-- End of Section Table of Contents --

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SECTION 43 21 13

PUMPS: WATER, CENTRIFUGAL
01/08

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NOTE: This guide specification covers the requirements for centrifugal pumps - electric motor and internal combustion engine operated.

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

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

Comments, suggestions and recommended changes for this guide specification are welcome and should be submitted as a Criteria Change Request (CCR).
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PART 1 GENERAL

1.1 REFERENCES

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

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

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

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

ASME INTERNATIONAL (ASME)

ASME B1.1	(2003; R 2008) Unified Inch Screw Threads (UN and UNR Thread Form)
ASME B16.1	(2010) Gray Iron Pipe Flanges and Flanged Fittings Classes 25, 125, and 250
ASME B16.5	(2013) Pipe Flanges and Flanged Fittings: NPS 1/2 Through NPS 24 Metric/Inch Standard
ASME B40.100	(2013) Pressure Gauges and Gauge Attachments

ASSOCIATION FOR IRON AND STEEL TECHNOLOGY (AIST)

AIST PB-229	(2008) Stainless Steels: A Steel Products Manual

ASTM INTERNATIONAL (ASTM)

ASTM A123/A123M	(2013) Standard Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products
ASTM A153/A153M	(2009) Standard Specification for Zinc Coating (Hot-Dip) on Iron and Steel Hardware
ASTM A307	(2012) Standard Specification for Carbon Steel Bolts and Studs, 60 000 PSI Tensile Strength
ASTM D975	(2014) Standard Specification for Diesel Fuel Oils
ASTM F593	(2013a) Stainless Steel Bolts, Hex Cap Screws, and Studs

HYDRAULIC INSTITUTE (HI)

HI 1.1-1.2	(2008) Rotodynamic (Centrifugal) Pump for Nomenclature and Definitions

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)

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

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 20	(2013) Standard for the Installation of Stationary Pumps for Fire Protection
NFPA 30	(2012; Errata 2011; Errata 2011) Flammable and Combustible Liquids Code
NFPA 37	(2010; TIA 10-1; TIA 13-2; TIA 13-3) Standard for the Installation and Use of Stationary Combustion Engines and Gas Turbines
NFPA 70	(2014; AMD 1 2013; Errata 1 2013; AMD 2 2013; Errata 2 2013; AMD 3 2014; Errata 3 2014) National Electrical Code

THE SOCIETY FOR PROTECTIVE COATINGS (SSPC)

SSPC Paint 21	(1982; E 2004) White or Colored Silicone Alkyd Paint (Type I, High Gloss and Type II, Medium Gloss)
SSPC Paint 25	(1997; E 2004) Zinc Oxide, Alkyd, Linseed Oil Primer for Use Over Hand Cleaned Steel, Type I and Type II

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

47 CFR 15	Radio Frequency Devices

UNDERWRITERS LABORATORIES (UL)

UL 448	(2007; Reprint Jul 2013) Centrifugal Stationary Pumps for Fire-Protection Service

1.2 SYSTEM DESCRIPTION

1.2.1 Selection Criteria

Design pumps using hydraulic criteria based upon actual model developmental test data. Select pumps at a point within the maximum efficiency for a given impeller casing combination. Deviations within 3 percent of maximum efficiency are permissible, provided the lesser efficiency is not less than the scheduled efficiency. Pumps having impeller diameters larger than 90 percent of the published maximum diameter of the casing or less than 15 percent larger than the published minimum diameter of the casing will be rejected. Acceptable maximum impeller diameter calculations shall not be based on percentage of impeller diameter range for a given casing.

1.2.2 Conformance With Agency Requirements

Where materials or equipment are specified to be an approved type, the seal or label of approval from a nationally recognized testing agency, adequately equipped and competent to perform such services, shall be attached thereto. A written certificate from the testing agency shall accompany the materials or equipment and shall be submitted to the Contracting Officer stating that the items have been tested and that they

conform to the applicable requirements of the specifications and to the standards listed herein. The certificate shall indicate the methods of testing used by the testing agency. In lieu of a certificate from a testing agency, published catalog specification data, accompanied by the manufacturer's certified statement to the effect that the items are in accordance with the applicable requirements of the specifications and the referenced standards, will be considered by the Contracting Officer and may be acceptable as evidence that the items conform with agency requirements.

1.2.3 Governing Requirements

Fire pumps and appurtenances shall conform in all respects to NFPA 20.

1.2.4 Safety Requirements

Fully enclose or properly guard gears, couplings, projecting set-screws, keys, and other rotating parts, so located that any person can come in close proximity thereto.

1.3 SUBMITTALS

****

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

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

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

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

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

01 33 00 SUBMITTAL PROCEDURES:

SD-02 Shop Drawings

Installation[; G][; G, [_____]]

SD-03 Product Data

Materials and Equipment
Operating Instructions[; G][; G, [_____]]
Training Period[; G][; G, [_____]]

SD-06 Test Reports

Field Tests

SD-07 Certificates

Manufacturer's Representative

SD-10 Operation and Maintenance Data

Operation and Maintenance Manuals

1.4 QUALITY ASSURANCE

Provide the services of a manufacturer's representative experienced in the installation, adjustment, and operation of the equipment specified. The representative shall supervise the installation, adjustment, and testing of the equipment. Provide up to [_____] days service at no expense to the Government. Submit the names and qualifications of the manufacturer's representative and written certification from the manufacturer that the representative are technically qualified.

1.5 DELIVERY, STORAGE, AND HANDLING

Protect all equipment, delivered and designated for storage, from the weather, humidity and temperature variations, dirt and dust, or other contaminants.

PART 2 PRODUCTS

2.1 MATERIALS AND EQUIPMENT

Provide materials and equipment which are as specified below, as shown, and are suitable for the service intended. Provide materials and equipment which are new and unused, except for tests. Where two or more pieces of equipment performing the same function are required, they shall be duplicate products of the same manufacturer.

Submit manufacturer's descriptive data and technical literature, performance charts and curves for all impeller sizes for a given casing, catalog cuts, and installation instructions. Spare parts data for each different item of material and equipment specified, after approval of the detail drawings and not later than [_____] months prior to the date of beneficial occupancy. Data shall include a complete list of parts and supplies, with current unit prices and source of supply.

2.1.1 Standard Products

Provide material and equipment which are the standard products of a manufacturer regularly engaged in the manufacture of such products and that essentially duplicate equipment that has been in satisfactory waterworks operation at least 2 years prior to bid opening. Equipment shall be supported by a service organization that is, in the opinion of the Contracting Officer, reasonably convenient to the jobsite. Pumps [and] [,] [motors] [and] [engines] of the same types shall each be the product of one manufacturer.

2.1.2 Description

The pumps shall be [horizontal] [and] [vertical] centrifugal water pumps of the types indicated and specified. The [single] [dual] driving units for the pumps shall be [electric motors] [and] [gasoline engines] [diesel engines] as indicated and specified. On dual drive units, each type of drive shall be equipped with an approved free-wheeling clutch.

2.1.3 Nameplates

Pumps and motors shall have a standard nameplate securely affixed in a conspicuous place showing the manufacturer's name, address, type or style, model, serial number, and catalog number. In addition, the nameplate for each pump shall show the capacity in L/second gpm at rated speed in rpm and head in mm feet of water. Nameplate for each electric motor shall show at least the minimum information required by 10.38 NEMA MG 1. [Nameplate for each [gasoline] [diesel] engine shall show the horsepower and the speed in rpm to produce rated output from the pump.] Such other information as the manufacturer may consider necessary to complete identification shall be shown on the nameplate.

2.2 CENTRIFUGAL WATER PUMPS

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NOTE: The pump numbers shown on the drawings will be entered in the appropriate blanks. A pump may have more than one type of service. Inapplicable configurations, types of service, and types of pump drivers will be deleted. NFPA 20 includes only horizontal centrifugal fire pumps and vertical turbine fire pumps.

****

The pumps shall be the centrifugal, [single-stage or multi-stage type,] designed for waterworks service in the following configurations:

	Pump No.
Horizontal	[_____]
Vertical	[_____]

2.2.1 Pump Service

The pumps shall be utilized for the following service:

	Pump No.
Fire Pump	[_____]
Water treatment plant pump	[_____]
Elevated storage pump	[_____]
Line pressure booster pump	[_____]

2.2.2 Pump Drives

The pumps shall have the following driving units and shall be directly connected to the driving units through solid shafts, flexible couplings, or free wheeling clutches (as appropriate):

	Pump No.
Electric motor drive	[_____]
Gasoline engine drive	[_____]
Diesel engine drive	[_____]
Combination electric motor and [gasoline] [diesel] engine drive	[_____]
Variable speed drive	[_____]

2.2.3 Pump Construction

Except as below specified, centrifugal water pumps[including required priming equipment] shall be constructed in accordance with the Hydraulic Institute HI 1.1-1.2.[Additionally, fire pumps shall be constructed in accordance with NFPA 20 and UL 448.]

2.2.4 Pump Characteristics

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NOTE: Characteristics of each pump will normally be specified by a minimum of two points on the head-capacity curve. The blanks for liters per second (gpm) and total head in mm (feet) will be filled in appropriately. If two or more pumps are to operate in parallel or in series, and a system head curve is shown, the appropriate brackets will be removed indicating pumps will match the system curve. Approved fire pump ratings will be indicated by filling in the applicable blanks.

****

The pumps shall be capable of discharging quantities at total discharge heads measured at the discharge flange, between the following limits:

Pump No.	liters per second at total discharge head, mm H(2)O		liters per second at total discharge head, mm H(2)O
[_____]		and [_____]	[_____]
[_____]		and [_____]	[_____]
[_____]		and [_____]	[_____]

Pump No.	gpm at total discharge head, ft. H(2)O		gpm at total discharge head, ft. H(2)O
[_____]		and [_____]	[_____]
[_____]		and [_____]	[_____]
[_____]		and [_____]	[_____]

Pumps shall operate at optimum efficiencies to produce the most economical pumping system under the conditions encountered [and shall be sized to make optimum match with the system head curve as shown]. [Suction lift on pump No. [_____] will be not more than [_____] mm ft.] [Fire pumps shall be rated at [_____] L/second gpm at [_____] kPa psi, total discharge head.] Pumps shall furnish not less than 150 percent of rated capacity at a total discharge head of not less than 65 percent of total rated head. [The shutoff total head shall be not greater than 120 percent of total rated head.]

2.2.5 Pump Casings

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NOTE: For water conditions where cast iron is not applicable, indicate other casing material.
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Pump casings shall be [cast iron] [_____] of the following design:

	Pump No.
Horizontal shaft, horizontal split casing	[_____]
Horizontal shaft, vertical split casing	[_____]
Vertical shaft, dry pit	[_____]
Vertical shaft, wet pit	[_____]

The casings shall be designed to permit replacement of wearing parts. [Horizontal-split casings shall have the suction and discharge nozzles cast integrally with the lower half, so that the upper part of the casings may be removed for inspection of the rotating parts without disturbing pipe connections or pump alignment.] Pump casings shall be of uniform quality and free from blowholes, porosity, hard spots, shrinkage defects, cracks and other injurious defects. Defects in casings shall not be repaired except when such work is approved and is done by or under the supervision

of the pump manufacturer, and then only when the defects are small and do not adversely affect the strength or use of the casing. Casings shall be single or double volute with flanged piping connections conforming to ASME B16.1, Class 125. The direction of shaft rotation shall be conspicuously indicated. The casing shall have tapped openings for air venting, priming, draining, and suction and discharge gauges. A brass or bronze umbrella or vent cock shall be furnished for venting except where automatic air vents are indicated. Drain openings in the volute, intake, or other passages capable of retaining trapped water shall be located in the low point of such passages.

2.2.6 Impellers

Impellers shall be of enclosed design and shall be constructed of [bronze] [_____], carefully finished with smooth water passageways, and shall be statically and dynamically balanced. Impellers shall be securely keyed to the pump shaft. [Provisions shall be made for vertical impeller adjustment at the top of the motor.] [Impellers on vertical-split pumps shall be additionally secured with a self-locking nut.]

2.2.7 Wearing Rings

Wearing rings of [bronze] [_____] shall be provided for impellers. Wearing rings of a different composition or of a suitable ferrous material shall be provided for pump casings. Casing rings shall be securely fixed in position to prevent rotation. Rings shall be renewable and designed to ensure ease of maintenance.

2.2.8 Shaft

Shaft shall be of high grade steel, accurately machined, and shall be of sufficient size and strength to perform the work required. Vertical shafts shall be the [open] [closed] type and shall be adequately provided with alignment bearings. Bronze renewable shaft sleeves shall be provided for protection of the shaft in contact with water, and in the stuffing boxes. Shaft sleeves shall be keyed to the pump shaft.

2.2.9 Packing Seals

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NOTE: Where pump duty conditions include severe ON/OFF or extreme of either end-of-curve operation, pump should be packed only, or one packed and one mechanically sealed pump should be specified with the latter pump convertible to packing. Select either paragraph "Packing Seals" or "Mechanical Seals" and edit accordingly.

****

Packing shall be non-asbestos. Pump shall be shipped to the site without the packing inserted and shall be packed onsite in the presence of the pump or packing manufacturer's representative. At no time during startup or run-in shall the gland drip less water than 80 drops per minute. After not less than 40 operating hours and upon permission of the Contracting Officer, leakage rate may be reduced to 50 drops per minute or to the rate recommended by packing manufacturer.

2.2.9.1 Gland

Gland shall be split-bronze type with ASTM F593 stainless steel eyebolts and pins or studs. Hex-nuts shall be bronze or nongalling stainless steel.

2.2.9.2 Stuffing boxes

Stuffing boxes exposed to below atmospheric pressure at any operating condition, including starting, shall be provided with a water seal. Water seal shall consist of nonferrous lantern ring or a seal cage and required connections to the pump case.

2.2.10 Mechanical Seals

Mechanical seals shall be balanced or unbalanced, as necessary to conform to specified service requirements. Mechanical seals shall be constructed in a manner and of materials particularly suitable for the temperature service range and quality of water being pumped. Seal construction shall not require external source cooling for pumped-fluid service temperatures up to 120 degrees C 250 degrees F. Seal pressure rating shall be suitable for maximum system hydraulic conditions. Materials of construction shall include AIST PB-229 series stainless steel, solid tungsten-carbide rotating-seal face, and Buna-N vinylidene-fluoride-hexafluoropropylene, EPT, or tetrafluoroethylene seals. Bypass flushing water supply shall be free of iron rust products and other abrasive materials and shall be directed onto face of seal without dead ending. All piping and accessories shall be provided. Throttling bushing shall have clearances to minimize leakage in case of complete seal failure without restriction of flushing water. Mechanical seals shall not be subjected to hydrostatic test pressures in excess of the manufacturer's recommendations.

2.2.11 Couplings

Couplings shall be of the heavy-duty flexible type, keyed and locked to the shaft. The outside surface of the couplings for horizontal pumps and close-coupled vertical pumps shall be machined parallel to the axis of the shaft. The faces of the couplings shall be machined perpendicular to the axis of the shaft. Disconnecting the couplings shall be accomplished without removing the driver half or the pump half of the couplings from the shaft. Couplings for vertical pumps other than close-coupled vertical pumps may be of the universal type. Flexible couplings shall not be used to compensate for misalignment of pump.

2.2.12 Balance

All rotating parts of the equipment shall operate throughout the required range without excessive end thrust, vibration, or noise. Defects of this type that cannot be eliminated by installation adjustments will be sufficient cause for rejection of the equipment. Pump impeller assemblies shall be statically and dynamically balanced to within 1/2 percent of W times R squared, where W equals weight and R equals impeller radius. Shaft construction shall be substantial to prevent seal or bearing failure due to vibration. Total shaft peak-to-peak dynamic deflection measured by vibrometer at pump-seal face shall not exceed 0.051 mm 2.0 mils under shutoff-head operating conditions. Flow from 6 mm 1/4 inch iron pipe size (ips) pipe shall be provided during testing.

2.2.13 Bearings

Bearings shall be ball or roller type, and the main bearings shall take all radial and end thrust. Pumps that depend only on hydraulic balance to overcome end thrust will not be acceptable.

2.2.14 Lubrication

[Bearings on horizontal-shaft pumps shall be either oil-bath type or grease type. Each oil reservoir shall be liberal in size and provided with an opening for filling, an overflow opening at the proper location to prevent overfilling, an oil-level sight glass, and a drain at the lowest point.] [Bearings on vertical shaft wet-pit pumps shall be either oil or water type. Pumps with oil-lubrication systems shall be designed so that all shaft bearings will be isolated from the pumped liquid. An automatic sight feed oiler shall be provided on a suitable mounting bracket with connection to the shaft tube. Bearings on vertical-shaft dry-pit pumps shall be grease type.] Grease type bearings shall be provided with fittings for a grease gun and, if the bearings are not easily accessible, with grease tubing extending to convenient locations. The grease fittings shall be of a type that prevent over lubrication and the buildup of pressure injurious to the bearings.

2.2.15 Base Plates

[Horizontal-shaft centrifugal pumps shall be provided with a common base for mounting each pump and driving unit of the pump on the same base. Each base shall be constructed of cast iron with a raised lip tapped for drainage, or of welded steel shapes with suitable drainage pan.] [Horizontal-shaft end suction pumps shall be mounted on a factory furnished channel steel frame. With the exception of close-coupled pumps, horizontal-shaft end suction pumps shall be frame mounted.] [Vertical-shaft pumps shall be provided with complete mounting suitable for the type of pump furnished, with the base for the pump separate from the base of the driving unit.] The drainage structure shall collect the packing box leakage and shall have a 13 mm 1/2 inch NPT connection to connect it to a drain.

2.2.16 Cocks, Plugs, and Accessories

The pumps shall be equipped with air cocks, drain plugs, and [single] [duplex] gauges indicating discharge pressures for all pumps [and suction pressures for pumps without suction lift]. Gauges, equipped with a shutoff cock and snubber, shall conform to ASME B40.100, and shall be calibrated in kPa and psi psi [and feet of water] in not more than 10 kPa and 2 psi 2 psi [5 foot] increment[s]. Gauge ranges shall be appropriate for the particular installation. Normal operating suction and discharge pressures of the pump shall be indicated on the mid-point range of the gauges. [Pressure relief valve shall be furnished and installed where indicated.] [Suction lift pipe shall be provided with a foot valve as shown, capable of preventing loss of prime when the pump rotation is stopped.]

2.2.17 Piping Connections

The pump suction and discharge shall be provided with flanged connections of suitable size and suitably arranged for piping shown. Pipe flanges shall conform to ASME B16.1 and ASME B16.5. Piping shall be installed to preclude the formation of air pockets.

2.2.18 Finish

****
NOTE: Where the using service has specific requirements for color coding differing from the color specified, this paragraph will be modified accordingly.
****

Pump shall have painted or enameled finish as is standard with the manufacturer except that fire pumps shall be red in color.

2.3 ELECTRICAL WORK

Electrical motor driven equipment specified herein shall be provided complete with motors, motor starters, and controls. Electric equipment and wiring shall be in accordance with Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM. Electrical characteristics shall be as indicated. Equipment for control of automatic fire pumps shall be in accordance with NFPA 20. Motor starters shall be provided complete with properly sized thermal overload protection in each phase and other appurtenances necessary for the motor control specified. Each motor shall be of sufficient capacity to drive the equipment at the specified capacity without exceeding the nameplate rating of the motor when operating at proper electrical system voltage and frequency. Manual or automatic control and protective or signal devices required for the operation herein specified and any control wiring required for controls and devices but not shown on electrical plans shall be provided under this section of the specifications.

2.4 ELECTRICAL EQUIPMENT

****
NOTE: If any of the pumps have an electric drive, then include the following.
****

Electrical equipment shall conform to Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM. Electrical motor driven equipment herein specified shall be provided complete with motors, motor starters, and controls. Motor controls, equipment, and wiring shall be in accordance with NFPA 70.

2.4.1 Electric Motors

Each electric motor-driven pump shall be driven by a [weather-protected, Type [I][II]][totally-enclosed fan cooled] continuous-duty electric motor. Motor shall have a [_____] service factor. Motors shall be [squirrel-cage induction][synchronous] motors having normal-starting-torque and low-starting-current characteristics, and shall be of sufficient size so that the nameplate horsepower rating will not be exceeded throughout the entire published pump characteristic curve. Integral size motors shall be the premium efficiency type in accordance with NEMA MG 1. Motor bearings shall provide smooth operations under the conditions encountered for the life of the motor. Adequate thrust bearing shall be provided in the motor to carry the weight of all rotating parts plus the hydraulic thrust and shall be capable of withstanding upthrust imposed during pump starting[and under variable pumping head conditions specified]. Motors shall be rated [_____] volts, [_____] phase, 60 Hz and such rating shall be stamped on the nameplate. [Motors for fire pumps shall conform to NFPA 20.] [Motors, not driving fire pumps, shall conform to NEMA MG 1.]

2.4.2 Control Equipment

[Manually controlled pumps shall have START-STOP pushbutton in cover.][Automatically controlled pumps shall have three-position "MANUAL-OFF-AUTOMATIC" selector switch in cover.] Additional controls or protective devices shall be as indicated.[Control equipment for fire pumps shall conform to NFPA 20.][A pump low-water cutoff shall be installed [in the well][on the suction pipe] and shall shut the pump off when the water level in the well reaches the level shown.]

2.4.3 Variable Speed Controls

****
NOTE: If any of the motors have a variable speed control, then include this paragraph.
****

The variable speed motor controller shall convert 460 volt plus 15 percent, minus 5 percent, three phase, 60 Hz (plus or minus 2 Hz) utility power to adjustable voltage/frequency, three phase, ac power for stepless motor control from 5 percent to 105 percent of base speed.

2.4.3.1 Description

The variable speed drive shall produce an adjustable ac voltage/frequency output for complete motor speed control. The variable speed drive shall be automatically controlled by [a pneumatic (20.7 - 103.4 kPa) (3-15 psig) control signal] [a grounded electronic control signal]. The variable speed drive shall be self contained, totally enclosed in a NEMA MG 1 ventilated cabinet and capable of operation between 0 and 40 degrees C 32 and 104 degrees F. The variable speed drive maximum output current rating shall be equal to or exceed the motor nameplate full load. The manufacturer shall advise the maximum recommended motor sine wave current for each controller rating. Variable speed drive multiple motor operation at same frequency/speed shall be possible as long as the sum of connected motor full load sine wave currents are less than or equal to the variable speed drive maximum continuous current rating. Variable speed drive shall be 95 percent efficient at 100 percent rated output power, 60 Hz.

2.4.3.2 Governing Requirements

Variable speed drives shall conform to the following requirements:

a. Variable speed drive shall comply with 47 CFR 15 regulation of RF1/EM1 emission limits for Class A computing devices. The FCC label of compliance shall be displayed on the variable speed drive.

b. The variable speed drive and options shall comply with the applicable requirements and the standards of the American National Standards Institute (ANSI).

c. Variable speed drive and option design and construction thereof shall comply with all applicable provisions of NFPA 70, Article 43D, Sections A-L.

2.4.3.3 Quality Assurance

To ensure quality the variable speed drive shall be subject to the

following tests:

a. The integrated circuits shall undergo a 160-hour "burn-in" to test reliability. During the "burn-in" the temperature shall be cycled between 0 and 70.0 degrees C 32 and 158 degrees F.

b. The completed unit shall undergo a fully loaded 24-hour "burn-in."

c. The unit shall be subject to a series of in-plant quality controlled inspections before approval for shipment from manufacturer's facilities.

2.4.3.4 Service

The variable speed drive shall be supplied with the following:

a. One-year parts and labor warranty.

b. A troubleshooting guide to help the building operator determine what steps must be taken to correct any problem that may exist in the system.

2.4.3.5 Basic Features

The variable speed drive shall have the following basic features:

a. Hand/Off/Auto Operation.

b. Manual/Auto speed reference switch.

c. Minimum/maximum adjustable speeds.

d. Speed potentiometer.

e. Auto restart.

f. Linear timed acceleration and deceleration for soft starting/stopping.

g. 3-63 Hz controlled speed range. (Factory set at 15 Hz minimum).

h. Terminal connections for time clock control, fire, smoke, freeze detectors, and EP relay pre-set speed override.

i. Output frequency terminals for remote metering.

2.4.3.6 Protective Circuits and Features

The variable speed drive controller shall include the following protective circuits/features:

a. Current limits to 100 percent design by slowing down motor.

b. Instantaneous Electronic Trip - automatically shutdown motor if current exceed 120 percent of design or phase-to-phase output short circuit occurs.

c. The variable speed drive will restart automatically when input line returns to normal in the event of intermittent power outage or phase loss or overvoltage shutdown.

d. Input power protection shuts down the unit if the following faults

occur; low input line voltage or loss of an input phase.

e. Insensitive to incoming power phase.

f. Fast acting current limiting input fuses, (Class J) rated with 200,000 interrupting amperes capability.

g. Isolated 115 volt control circuit and dedicated control transformer.

h. Line-to-line fault protection.

i. Line-to-ground short circuiting and accidental motor grounding protection.

j. Output thermal overload relay trip.

2.4.3.7 Adjustments

The variable speed drive has the following adjustments available via potentiometers located on the faceplate of a single, regulator printed circuit board.

a. Minimum speed: 0-75 percent.

b. Maximum speed: 100 percent.

2.5 DIESEL ENGINES

****
NOTE: Diesel engines and diesel fuel systems have been found to be more reliable and are generally the preferred selection. If the only engine drive is for fire pump service, delete all engine references that differ from NFPA 20 requirements. For large engine drives or units intended for continuous prime power duty, consider reducing engine speed limitation or better engine selection. Lube oil heaters are not normally used on smaller engines.
****

Diesel engines shall be water-cooled, heavy duty, compression-ignition, cold-starting engines with removable cylinder sleeves. Engines may be 2-cycle or 4-cycle and may be either naturally aspirated, scavenged or turbocharged and shall operate satisfactorily on No. 2D diesel fuel conforming to ASTM D975. Engines shall be provided with a manual clutch and arranged for connection to the pump through a flexible shaft with a splined joint. Engines shall be current models of a type in regular production and shall be complete with all devices specified and normally furnished with the engine. Engines shall have a published continuous horsepower rating at least [_____] percent greater than that required at any point on the pump performance curve at the specified pump speed plus power required for any engine driven accessories. Naturally aspirated ratings shall be decreased by 3 percent for every 300 m 1,000 feet of altitude, and 1 percent for every 5 degrees C 10 degrees F that the engine performance conditions exceed the published rating conditions. Scavenged or turbocharged engine ratings shall be decreased as indicated by the engine manufacturer's engine performance data. Engine shall be suitable for performance at [_____] degrees C degrees F ambient and [_____] mm foot elevation. Engine speed shall not exceed 1,800 rpm when driving the pump

at rated conditions. [Engines driving fire pumps shall conform to NFPA 20.] Engines shall be capable of starting and assuming full load within 10 to 15 seconds, with a minimum ambient temperature of [_____] degrees C degrees F. Approved engine jacket water [and lube oil] heaters shall be provided as recommended by the manufacturer. [Lube oil heaters shall be of the circulation type.]

2.6 GASOLINE ENGINES

****
NOTE: Use of gasoline engines may be applicable where fuel logistics or other factors rule against diesels. Note that gasoline engines are not recommended by NFPA 20 for fire service. Lube oil heaters are not normally used on smaller engines.
****

Gasoline engines shall be heavy-duty, 4-cycle, water cooled, spark ignition engines designed to operate efficiently on gasoline having an octane rating of 85 or higher. Engines shall be provided with a manual clutch and arranged for connection to the pump through a flexible shaft with a splined joint. Engines shall be current models of type in regular production and shall be complete with all devices specified and normally furnished with the engine. Engine shall have a published continuous rating at least [_____] percent greater than that required at any point on the pump performance curve at the specified pump speed plus power required for any engine driven accessories. Engine rating shall be decreased by 3-1/2 percent for every 300 m 1,000 feet of altitude, and 1 percent for every 5 degrees C 10 degrees F that the engine performance conditions exceed the published rating conditions. Engine shall be suitable for performance at [_____] degrees C degrees F ambient and [_____] mm feet elevation. Engine speed shall not exceed 1,800 rpm when driving the pump at rated conditions. Engine shall be capable of starting and assuming full load within 10 to 15 seconds, with a minimum ambient temperature of [_____] degrees C degrees F. Approved engine jacket water [and lube oil] heaters shall be provided as recommended by the manufacturer. [Lube oil heaters shall be of the circulation type.] Automatically controlled engines shall be provided with an approved antidieseling feature that will shut off the fuel supply and air to ensure positive shut down.

2.7 ENGINE EQUIPMENT AND ACCESSORIES

2.7.1 Governor

****
NOTE: Check pump performance and system factors for possible changes to maximum speed limitations.
****

Engine shall be equipped with an adjustable constant speed governor set to maintain pump speed within 3 percent of rated speed at rated load. A separate, manual reset, overspeed device shall be provided which shall shut down the engine in the event the speed reaches approximately 15 percent above rated speed.

2.7.2 Cooling System

****
NOTE: Check raw water quality and probable

frequency of engine operation for adequacy of fouling factor. If remote mounted radiators are utilized, drawings should indicate locations, mounting arrangement, and piping details.

****

Cooling system shall be the forced-circulation, closed type and shall include a fan and [an engine mounted radiator][a remote mounted radiator with expansion tank, if required].[Heat exchanger tube bundle shall be readily removable for cleaning without disturbing the engine piping. Heat exchanger shall be of sufficient capacity to operate the engine at full rated load with a raw water temperature of [_____] degrees C degrees F and a fouling factor of 0.001 on the raw water side. Raw cooling water circuit shall be thermostatically controlled by a self-contained, single-seated, reverse-acting, adjustable valve with a remote bulb supplied with the engine by the engine manufacturer. Valve shall be arranged to provide full flow of cooling water through the exchanger in event of failure of the valve. A solenoid shut-off valve and bronze body strainer with stainless steel screen shall be installed ahead of the thermostatic valve. Isolation valves with manual bypass shall be factory piped on the engine requiring only the raw water connection to be made in the field.] [Flexible connections shall be used to connect the inlet and outlet radiator connections to the engine.][Radiator shall be of sufficient capacity to operate the engine at full rated load at [_____] degrees C degrees F ambient temperature.][Radiator shall be provided with a flange for connection to the exhaust air duct.] Closed jacket water circuit shall be thermostatically controlled, and shall include an integral circulating pump. Drain cocks shall be provided at low points of the closed jacket water system. Exhaust manifolds shall be water jacketed or provided with an insulating jacket furnished by the engine manufacturer. Engine cooling system shall be charged with an inhibited ethylene-glycol solution to provide antifreeze protection to [_____] degrees C degrees F.

2.7.3 Lubrication

Engine lubrication shall be a pressure circulation system with an engine driven pump and engine mounted oil cooler. Full flow type filters with automatic bypass or bypass type filters shall be provided. Filter elements shall be of replaceable type and shall be readily accessible.

2.7.4 Exhaust System

****

NOTE: Drawings should indicate silencer location, mounting, and exhaust arrangement.

****

Engine exhaust system shall be equipped with [an industrial][a residential] type silencer with drains and flexible, stainless steel connection. Flexible connector shall be provided with factory fabricated expanded metal personnel protection guards. Silencers shall be mounted [inside][outside] as indicated and shall be of the straight through, or side inlet type as required to suit the space available and the engine exhaust arrangement. An engine with dual exhaust outlets and provided with one exhaust silencer shall have dual inlets on the silencer or a factory fabricated Y-branch or equivalent fitting to join the two exhausts together.

2.7.5 Air Intake Equipment

****
NOTE: Air quality in the location of the engine or air intake should be checked for adequacy of cleaning devices. Drawings should indicate location and mounting arrangement of remote units.
****

Each engine shall be provided with a dry [replaceable] [cleanable] [combination silencer-filter] type intake air cleaner. Filter shall be [engine mounted] [remote mounted as indicated and furnished with flexible connection for attachment of intake piping to the engine].

2.7.6 Starting Equipment

Engine shall be provided with an electric starting motor suitable for the starting service specified.

2.7.7 Batteries

Each engine shall be provided with heavy-duty [nickel-cadmium alkaline][or][lead acid] type starting batteries. Batteries shall have sufficient capacity at [_____] degrees C degrees F to provide the necessary cranking speed through [_____] minutes of cranking cycles specified. Batteries shall be provided with a battery rack, and if material is not inherently resistant to acid, coating shall be applied to the stand. Connecting cables shall be provided as required. [A dual battery set sized to NFPA 20 requirements with rack and cables shall be provided for fire service systems.]

2.7.8 Battery Charging

Engine shall be equipped with an engine driven battery charging alternator with a regulator for use when the engine is running. A separately mounted battery charger shall also be furnished. Battery charger shall be an automatic, float type providing continuous taper charging. Output characteristics shall match the requirements of the battery furnished. Charger shall be suitable for operation on [_____] volt, single-phase, [_____] Hz current and shall be rated not less than 6 amperes dc.[A dual battery charger of proper type for batteries used shall be provided for fire service systems.] Where wall mounting is indicated, enclosure shall be suitable for conduit connection, and ventilating openings shall be guarded. An interlock is required between the engine driven charging system and the charger. Battery charger shall have the following features:

a. Direct current voltage regulation shall be within plus or minus 2 percent for variations in line voltage of plus or minus 10 percent.

b. Direct current voltmeter and direct current ammeter, each with numerical scales.

c. Automatic surge suppressor.

d. Automatic current limiting to prevent overloading due to engine cracking, shorted output or reversed battery connections.

e. Alternating current line fusing.

f. Equalize charge rate with manually set timer.

g. Integral protection to prevent battery discharge through the charger on loss of alternating current line voltage.

h. Terminal block with terminals for all external connections.

2.7.9 Safety Controls

Each engine shall be equipped with automatic shut down features to stop the engine for high jacket water temperature, low oil pressure, and engine overspeed. Shutdown features shall be connected to the annunciator on the instrument panel and each shutdown feature will be identified.

2.7.10 Instrument Panel

****

NOTE: Delete inapplicable items. Fuel pressure gauges may not be applicable on smaller engines. Consider site location and operational factors for alarm requirements. Auxiliary contacts may be desired for control of combustion air dampers or other appurtenances. Indicate equipment on drawings and/or reference other specifications as appropriate.

****

Each engine shall be furnished with an instrument panel mounted with vibration isolators on the unit. Instruments shall be of the direct reading type and shall be factory mounted and connected. Panel shall include the following features and instruments:

a. Three-position MANUAL-OFF-AUTO switch.

b. Manual starting switch.

c. Water temperature gauge.

d. Ammeter-charging circuit.

e. Tachometer.

f. Lubricating oil pressure gauge.

g. Running time meter.

h. Alarm annunciator [with single audible alarm] [and] [with contacts to operate a remote alarm] and individual indicating lights for low-oil pressure, high-water temperature, engine overspeed, and failure of engine to start.

i. Manual engine speed regulating device.

j. Additional instruments or devices that are required for use in conjunction with the engine controls specified.

k. Auxiliary contacts.

2.7.11 Engine Control

2.7.11.1 Single Units

****
NOTE: Consider application of engine for appropriate cranking periods and coordinate with battery requirements.
****

[Each engine shall be manually started by a pushbutton switch on the engine instrument panel through a suitably enclosed relay. Cyclic operation of the motor shall not be provided.][Each engine shall be automatically started by a pilot-control circuit. A control panel enclosing all relays, contactors, and timers shall be mounted [on][in] the [floor][wall][engine panel]. Panel shall be provided with hinged cover and latch. Engine starting circuit shall provide for 3 or 4 interrupted cranking periods of approximately 15 seconds with equal rest periods between, unless the engine starts before the end of that time. At the end of the period, the starter circuit shall be de-energized. Starter motor shall be automatically de-energized when the engine starts.] Engines shall be stopped manually with the switch on the instrument panel.

2.7.11.2 Multiple Units

****
NOTE: Check drawings to insure that control circuits are indicated and that the starting sequence described is appropriate. Do not use reference to NFPA 20 for gasoline engine units.
****

[Engines shall be manually started by pushbutton switches on the instrument panel through suitable enclosed relays.][Engines shall be automatically started by a pilot-control circuit as indicated. A control panel enclosing all relays, contactors, timers, and selector switches shall be [wall][floor] mounted and provided with hinged cover and latch. The controller for each unit of multiple pump units shall incorporate a sequential timing device to prevent any one engine from starting simultaneously with any other engine. If water requirements call for more than one pumping unit to operate, the units shall start at intervals of 5 to 10 seconds. Failure of a leading engine to start shall not prevent subsequent engines from starting. Engines shall be stopped manually with the switch on instrument panel.] [Automatic pump controller shall conform to NFPA 20.]

2.7.12 Fuel System

Fuel system consisting of storage tank, day tank, connecting piping, and accessories shall conform to the applicable items of NFPA 30 and NFPA 37. A horizontal underground storage tank with a capacity of [_____] liters gallons shall be provided for the storage of [No. 2 diesel] [gasoline] fuel. The storage tank shall be constructed, installed, and tested as specified in Section 33 56 10 FACTORY-FABRICATED FUEL STORAGE TANKS.

2.8 EQUIPMENT APPURTENANCES

2.8.1 Attachments

All necessary bolts, nuts, washers, bolt sleeves, and other types of attachments for the installation of the equipment shall be furnished with the equipment. Bolts shall conform to the requirements of ASTM A307 and nuts shall be hexagonal of the same quality as the bolts used. Threads shall be clean-cut and shall conform to ASME B1.1. Bolts, nuts, and washers specified to be galvanized or not otherwise indicated or specified, shall be zinc coated after being threaded, by the hot-dip process conforming to [ASTM A123/A123M][ASTM A153/A153M] as appropriate. Bolts, nuts, and washers specified or indicated to be stainless steel shall be Type 316.

2.8.2 Equipment Guards

Equipment driven by open shafts, belts, chains, or gears shall be provided with all-metal guards enclosing the drive mechanism. Guard shall be constructed of galvanized sheet steel or galvanized woven wire or expanded metal set in a frame of galvanized steel members. Guards shall be secured in position by steel braces or straps which will permit easy removal for servicing the equipment. The guards shall conform in all respects to all applicable safety codes and regulations.

2.8.3 Tools

A complete set of all special tools which may be necessary for the adjustment, operation, maintenance, and disassembly of all equipment shall be furnished. Special tools are considered to be those tools which because of their limited use are not normally available, but which are necessary for the particular equipment. Special tools shall be high-grade, smooth, forged, alloy, tool steel. One pressure grease gun for each type of grease required for [motors][and][gasoline][and][diesel] engines shall also be furnished. All tools shall be delivered at the same time as the equipment to which they pertain. Properly store and safeguard such tools until completion of the work, at which time they shall be delivered to the Contracting Officer.

2.8.4 Shop Painting

All motors, pump casings, and similar parts of equipment customarily finished in the shop shall be thoroughly cleaned, primed, and given two finish coats of paint at the factory in accordance with the recommendations of the manufacturer. Ferrous surfaces not to be painted shall be given a shop coat of grease or other suitable rust-resistant coating.

2.9 FACTORY TESTS

Pumps shall be tested by the manufacturer or a nationally recognized testing agency in compliance with Hydraulic Institute Standards. Where two or more identical pumps are specified, only one representative pump shall be tested. Certified test results shall be submitted to the Contracting Officer.

PART 3 EXECUTION

3.1 EXAMINATION

After becoming familiar with all details of the work, verify all dimensions in the field and advise the Contracting Officer of any discrepancy before performing the work.

3.2 INSTALLATION

Install each pump and engine in accordance with the written instructions of the manufacturer[and under the direct supervision of the manufacturer's representative].[Install engine fuel supply system as indicated and in conformance with NFPA 30 and NFPA 37.] Concrete for equipment foundations[and for any required ballast for fuel storage tanks] shall be as specified in Section 03 30 00.00 10 CAST-IN-PLACE CONCRETE. Concrete foundations shall be integral with and of the same class as that of the building floor unless otherwise indicated. Use concrete having a compressive strength of at least 17 MPa 2,500 psi in foundations that are entirely separated from the surrounding floor. Install a premolded filler strip between the foundation and floor slab as shown. Furnish foundation bolts, as required, for proper positioning during the placement of the concrete.

3.2.1 System Coordination

Prior to installation, submit drawings containing complete wiring and schematic diagrams and any other details required to demonstrate that the system has been coordinated and will properly function as a unit. Show proposed layout and anchorage of equipment and appurtenances, and equipment relationship to other parts of the work including clearances for maintenance and operation. Provide a complete listing of equipment and materials.

3.2.2 Operating Instructions

Proposed diagrams, instructions, and other sheets, prior to posting. Approved wiring and control diagrams showing the complete layout of the entire system, including equipment, piping valves, and control sequence, framed under glass or in approved laminated plastic, shall be posted where directed. Condensed operating instructions explaining preventive maintenance procedures, methods of checking the system for normal safe operation, and procedures for safely starting and stopping the system shall be prepared in typed form, framed as specified above for the wiring and control diagrams, and posted beside the diagrams. The framed instructions shall be posted before acceptance testing of the systems.

3.3 FIELD TESTS

After installation of the pumping units and appurtenances is complete, carry out operating tests to assure that the pumping installation operates properly. Tests shall assure that the units and appurtenances have been installed correctly, that there is no objectionable heating, vibration, or noise from any parts, and that all manual and automatic controls function properly. If any deficiencies are revealed during any tests, such deficiencies shall be corrected and the tests shall be reconducted.[Make arrangements to have the manufacturer's representatives present when field equipment tests are made.]

3.3.1 Procedures

[Field tests for fire service pumps and engines shall conform to NFPA 20.] Subject each pumping unit to a running field test in the presence of the Contracting Officer for a minimum of 2 hours[with each combination of electric motor and engine drive]. Operate each pumping unit at its rated capacity or such other point on its head-capacity curve selected by the Contracting Officer. Provide an accurate and acceptable method of measuring the discharge flow.[Operate each engine for a minimum of 4 hours at a point of maximum horsepower indicated on the pump head-capacity curve or such other point on the curve selected by the Contracting Officer.]

3.3.2 Insulation Resistance Testing

For submersible pumping units, an insulation resistance test of the cable and the motor shall be conducted prior to installation of the pump, during installation of the pump, and after installation is complete. The resistance readings shall not be less than 10 megohms.

3.3.3 Reporting

Submit test reports in booklet form showing all field tests performed to adjust each component and all field tests performed to prove compliance with the specified performance criteria, upon completion and testing of the installed system. Each test report shall indicate the final position of controls.

3.4 FIELD PAINTING

Do not paint stainless steel, galvanized steel, and nonferrous surfaces.

3.4.1 Touch-Up Painting

Factory painted items requiring touching up in the field shall be thoroughly cleaned of all foreign material and shall be primed and topcoated with the manufacturer's standard factory finish.

3.4.2 Exposed Ferrous Surfaces

Exposed ferrous surfaces shall be painted with two coats of enamel paint conforming to SSPC Paint 21. Factory primed surfaces shall be solvent-cleaned before painting. Surfaces that have not been factory primed shall be prepared and primed with one coat of SSPC Paint 25or in accordance with the enamel paint manufacturer's recommendations.

3.5 CLOSEOUT ACTIVITIES

3.5.1 Training

Upon completion of the work, and at a time designated by the Contracting Officer, the services of one or more competent engineers shall be provided for a training period of not less than [_____] hours to instruct a representative of the Government in the contents of the operation and maintenance manuals for the equipment furnished under these specifications. These field instructions shall cover all the items contained in the bound operating instructions. Submit the names and qualifications of the training engineers and written certification from the manufacturer that the trainers are technically qualified. Also, submit the training course curriculum and training instructions to the Contracting

Officer 14 days prior to the start of training.

3.5.2 Operation and Maintenance Manuals

Submit complete sets of instructions containing the manufacturer's operating and maintenance instructions for each piece of equipment. One complete set at the time the tests procedure is submitted; remaining sets before the contract is completed. Permanently bind each set, including a hard cover. Inscribe the following identification on the covers: the words "OPERATING AND MAINTENANCE INSTRUCTIONS," name and location of the building, name of the Contractor, and contract number. Place flysheets before instructions covering each subject. Instruction sheets shall be approximately 216 by 279 mm 8-1/2 by 11 inches, with large sheets of drawings folded in. Instructions shall include, but not be limited to, the following:

a. System layout showing piping, valves, and controls.

b. Approved wiring and control diagrams.

c. A control sequence describing startup, operation, and shutdown.

d. Operating and maintenance instructions for each piece of equipment, including lubrication instructions and troubleshooting guide.

e. Manufacturer's bulletins, cuts, and descriptive data; and parts list and recommended spare parts.

-- End of Section --