

\*\*\*\*\*  
USACE / NAVFAC / AFCEA / NASA UFGS-43 21 39 (April 2008)  
-----  
Preparing Activity: USACE Superseding  
UFGS-43 21 39 (January 2008)

## UNIFIED FACILITIES GUIDE SPECIFICATIONS

References are in agreement with UMRL dated January 2009

\*\*\*\*\*

### SECTION TABLE OF CONTENTS

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

SECTION 43 21 39

PUMPS: WATER, VERTICAL TURBINE

04/08

#### PART 1 GENERAL

- 1.1 REFERENCES
- 1.2 SUBMITTALS
- 1.3 DELIVERY, STORAGE, AND HANDLING
- 1.4 EXTRA MATERIALS
  - 1.4.1 spare parts
  - 1.4.2 Special tools

#### PART 2 PRODUCTS

- 2.1 MATERIALS AND EQUIPMENT
  - 2.1.1 Standard Products
  - 2.1.2 Nameplates
  - 2.1.3 Equipment Guards
- 2.2 PUMP AND DRIVER REQUIREMENTS
  - 2.2.1 Type of Installation
  - 2.2.2 Pump Drivers
  - 2.2.3 Well Data
- 2.3 PUMP PERFORMANCE
- 2.4 LINE SHAFT VERTICAL TURBINE PUMPS
  - 2.4.1 Pump Head Assembly
    - 2.4.1.1 Pump Baseplate
    - 2.4.1.2 Discharge Head
    - 2.4.1.3 Pump Driver
  - 2.4.2 Oil-Lubricated Column and Shaft Assembly
    - 2.4.2.1 Lubrication
    - 2.4.2.2 Lubricating Device
  - 2.4.3 Water-Lubricated Column and Shaft Assembly
    - 2.4.3.1 Lubrication
    - 2.4.3.2 Lubricating Device
  - 2.4.4 Pump Bowl Assembly
    - 2.4.4.1 Pump Bowls
    - 2.4.4.2 Impellers
    - 2.4.4.3 Pump Shafts

- 2.4.4.4 Bearings
- 2.4.5 Suction Pipe and Strainer
- 2.5 SUBMERSIBLE VERTICAL TURBINE PUMPS
  - 2.5.1 Pump Head Assembly
  - 2.5.2 Pump Bowl Assembly
    - 2.5.2.1 Pump Bowls
    - 2.5.2.2 Impellers
    - 2.5.2.3 Pump Shafts
    - 2.5.2.4 Bearings
    - 2.5.2.5 Strainer
  - 2.5.3 Discharge Pipe
  - 2.5.4 Check Valves
- 2.6 PUMP ACCESSORIES
  - 2.6.1 Water-Level Indicator Assembly
    - 2.6.1.1 Air-line Indicator
    - 2.6.1.2 Compressed Air Systems
    - 2.6.1.3 Electrode Indicator
  - 2.6.2 Pressure Gauge
  - 2.6.3 Air-Vent Valve
- 2.7 ELECTRICAL EQUIPMENT
  - 2.7.1 General
  - 2.7.2 Line shaft Vertical Turbine Pumps
    - 2.7.2.1 Electric Motors
    - 2.7.2.2 Control Equipment
  - 2.7.3 Submersible Vertical Turbine Pumps
    - 2.7.3.1 Electric Motors
    - 2.7.3.2 Control Equipment
    - 2.7.3.3 Power Cables
- 2.8 DIESEL ENGINES
- 2.9 GASOLINE ENGINES
- 2.10 ENGINE EQUIPMENT AND ACCESSORIES
  - 2.10.1 Governor
  - 2.10.2 Cooling System
  - 2.10.3 Lubrication
  - 2.10.4 Exhaust System
  - 2.10.5 Air Intake Equipment
  - 2.10.6 Starting Equipment
  - 2.10.7 Batteries
  - 2.10.8 Battery Charging
  - 2.10.9 Safety Controls
  - 2.10.10 Instrument Panel
  - 2.10.11 Engine Control
    - 2.10.11.1 Single Units
    - 2.10.11.2 Multiple Units
  - 2.10.12 Fuel System
- 2.11 EQUIPMENT APPURTENANCES
  - 2.11.1 Attachments
  - 2.11.2 Shop Painting

## PART 3 EXECUTION

- 3.1 EXAMINATION
- 3.2 INSTALLATION
  - 3.2.1 General
  - 3.2.2 Foundations
- 3.3 PAINTING AND FINISHING
- 3.4 MANUFACTURER'S FIELD SERVICES
- 3.5 FIELD TRAINING
- 3.6 POSTED INSTRUCTIONS

3.7 TESTING

3.7.1 Factory Pump Test

3.7.2 Factory Fuel Storage Tank Test

3.7.3 Field Equipment Test

3.7.3.1 Correct Installation of Appurtenances

3.7.3.2 Deficiencies

-- End of Section Table of Contents --

\*\*\*\*\*  
USACE / NAVFAC / AFCEA / NASA UFGS-43 21 39 (April 2008)  
-----  
Preparing Activity: USACE Superseding  
UFGS-43 21 39 (January 2008)

## UNIFIED FACILITIES GUIDE SPECIFICATIONS

References are in agreement with UMRL dated January 2009

\*\*\*\*\*

### SECTION 43 21 39

PUMPS: WATER, VERTICAL TURBINE  
04/08

\*\*\*\*\*

NOTE: This guide specification covers the requirements for line shaft and submersible vertical turbine pumping units and their appurtenances.

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 and suggestions on this guide specification are welcome and should be directed to the technical proponent of the specification. A listing of technical proponents, including their organization designation and telephone number, is on the Internet.

Recommended changes to a UFGS should be submitted as a Criteria Change Request (CCR).

\*\*\*\*\*

## PART 1 GENERAL

### 1.1 REFERENCES

\*\*\*\*\*

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

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

the issue dates.

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

\*\*\*\*\*

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

AMERICAN BEARING MANUFACTURERS ASSOCIATION (ABMA)

ABMA 9 (1990; R 2000) Load Ratings and Fatigue Life for Ball Bearings

AMERICAN GEAR MANUFACTURERS ASSOCIATION (AGMA)

AGMA 2001 (2004d) Fundamental Rating Factors and Calculation Methods for Involute Spur and Helical Gear Teeth

AGMA 2003 (1997b; R 2003) Rating the Pitting Resistance and Bending Strength of Generated Straight Bevel, ZEROL Bevel, and Spiral Bevel Gear Teeth

AGMA 6013 (2006) Standard for Industrial Enclosed Gear Drives

AGMA 6113 (2006) Standard for Industrial Enclosed Gear Drives (Metric Edition)

AMERICAN WATER WORKS ASSOCIATION (AWWA)

AWWA E101 (1988) Vertical Turbine Pumps - Line Shaft and Submersible Types

ASME INTERNATIONAL (ASME)

ASME B1.1 (2003; R 2008) Unified Inch Screw Threads (UN and UNR Thread Form)

ASME B16.1 (2005) Standard for Gray Iron Threaded Fittings; Classes 125 and 250

ASME B16.5 (2003) Standard for Pipe Flanges and Flanged Fittings: NPS 1/2 Through NPS 24

ASME B40.100 (2005) Pressure Gauges and Gauge Attachments

ASTM INTERNATIONAL (ASTM)

ASTM A 123/A 123M (2008) Standard Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products

ASTM A 153/A 153M	(2005) Standard Specification for Zinc Coating (Hot-Dip) on Iron and Steel Hardware
ASTM A 307	(2007b) Standard Specification for Carbon Steel Bolts and Studs, 60 000 PSI Tensile Strength
ASTM D 975	(2008ae1) Standard Specification for Diesel Fuel Oils
NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)	
NEMA MG 1	(2007; Errata 2008) Standard for Motors and Generators
NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)	
NFPA 20	(2006) Installation of Stationary Pumps for Fire Protection
NFPA 30	(2007; Errata 2008) Flammable and Combustible Liquids Code
NFPA 37	(2006) Installation and Use of Stationary Combustion Engines and Gas Turbines

## 1.2 SUBMITTALS

\*\*\*\*\*

NOTE: Review submittal description (SD) definitions in Section 01 33 00 SUBMITTAL PROCEDURES and edit the following list to reflect only the submittals required for the project. Submittals should be kept to the minimum required for adequate quality control.

A "G" following a submittal item indicates that the submittal requires Government approval. Some submittals are already marked with a "G". Only delete an existing "G" if the submittal item is not complex and can be reviewed through the Contractor's Quality Control system. Only add a "G" 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.

\*\*\*\*\*

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, [\_\_\_\_]]

Detail drawings consisting of a complete list of equipment and materials. Detail 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 on the Drawings proposed layout and anchorage of equipment and appurtenances, and equipment relationship to other parts of the work including clearances for maintenance and operation.

#### SD-03 Product Data

##### Vertical Turbine Pumping Units

Manufacturer's descriptive data and technical literature, performance charts and curves, catalog cuts, and installation instructions.

##### Spare Parts

Spare parts data for each different item of material and equipment specified.

Posted Instructions[; G][; G, [\_\_\_\_]]

Proposed diagrams, instructions, and other sheets, prior to posting.

#### SD-06 Test Reports

##### Testing

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. Indicate in each test report the final position of controls.

#### SD-10 Operation and Maintenance Data

##### Vertical Turbine Pumping Units

[Six] [\_\_\_\_] complete copies of operating manual outlining the step-by-step procedures required for system startup, operation and shutdown. Include in the manual the manufacturer's name, model

number, service manual, parts list, and brief description of all equipment and their basic operating features. [Six] [\_\_\_\_\_] complete copies of maintenance manual listing routine maintenance procedures, possible breakdowns and repairs, and troubleshooting guide. Include in the manuals simplified wiring, layout, and control diagrams of the system as installed.

### 1.3 DELIVERY, STORAGE, AND HANDLING

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

### 1.4 EXTRA MATERIALS

#### 1.4.1 spare parts

Submit 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. include in the data a complete list of parts and supplies, with current unit prices and source of supply, and a list of the parts recommended by the manufacturer to be replaced after [1] [and] [3] year(s) of service.

#### 1.4.2 Special 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. Tools shall be high-grade, smooth, forged, alloy, tool steel. Special tools shall be delivered at the same time as the equipment to which they pertain. Properly store and safeguard such special tools until completion of the work, at which time they shall be delivered to the Contracting Officer.

## PART 2 PRODUCTS

### 2.1 MATERIALS AND EQUIPMENT

#### 2.1.1 Standard Products

Provide materials and equipment which are the standard products of a manufacturer regularly engaged in the manufacture of the products and that essentially duplicate items that have been in satisfactory use for 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 site. Provide pumps of the same type which are the product of one manufacturer.

#### 2.1.2 Nameplates

Each major item of equipment shall have the manufacturer's name, address, type or style, model, serial number, and catalog number on a plate secured to the item of equipment. Submersible pumps and motors shall also have identical nameplates affixed in a conspicuous place to the pumphouse wall or discharge piping. In addition, the nameplate for each pump shall show the capacity in L/second gpm at rated head in meters feet and speed in revolutions per minute. [Nameplate for each electric motor shall show the wattage horsepower, speed in revolutions per minute, full load current,



voltage, frequency, phases, time rating, maximum ambient temperature, insulation class code letter, and service factor.] [Nameplate for each [gasoline] [diesel] engine shall show the wattage horsepower and speed in revolutions per minute.]

### 2.1.3 Equipment Guards

Equipment driven by open shafts, belts, chains, or gears shall be provided with all-metal guards enclosing the drive mechanism. Guards 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.

## 2.2 PUMP AND DRIVER REQUIREMENTS

### 2.2.1 Type of Installation

\*\*\*\*\*  
NOTE: Coordinate information carefully between specified requirements and schedules on the drawings especially to account for different data applicable to pump numbers indicated on the drawings. Refer to AWWA E101 for definition of terms. Line shaft pumps are usually specified for either oil or water lubrication. Use oil lubrication only if the quality of the water being pumped contains abrasive particles or for other special reasons. On short settings or on close-coupled pumps, grease lubrication of enclosed shafts may be considered. If grease lubrication is used, separate grease lines should connect each line shaft or pump shaft bearing to a grease connection at the pump head assembly.  
\*\*\*\*\*

The work shall include furnishing, installing, and testing [line shaft] [and] [submersible] vertical turbine pumping units and their appurtenances as indicated. Pumps shall be [utilized for a potable water supply and] installed in a [well] [wet pit] [can] [and arranged for fire service]. [Line shaft lubrication shall be [oil] [water].]

### 2.2.2 Pump Drivers

Pumps shall have the type of drive units indicated.

### 2.2.3 Well Data

\*\*\*\*\*  
NOTE: If wells are involved, the schedule on the drawings should indicate the minimum inside diameter of well casing down to pump setting in mm (inches), the total depth of well below datum in meters (feet), the static water level below datum in meters (feet), and the drawdown in meters (feet) at a designated L/second (gpm) rate. Pumping water levels are usually (but not necessarily) specified at the same liters per second (gallons per minute) rates as those specified for the pump operating

conditions.

Except for shallow wells of small capacity, the well casing will be not less than 200 mm (8 inches) in diameter. For wells more than 150 m (500 feet) deep, the well casing will be at least 250 mm (10 inches) in diameter. The following table shows minimum inside diameter (I.D.) of well casing recommended for various flows.

Well casing min. I.D., mm	Flow, L/second	
	Minimum	Maximum
150	6.3	18.9
200	12.6	37.9
250	25.2	75.71
300	50.5	126.2
350	75.7	189.3

  

(Well casing min. I.D., inches	Flow, gpm	
	Minimum	Maximum
6	100	300
8	200	600
10	400	1,200
12	800	2,000
14	1,200	3,000)

\*\*\*\*\*

Pumps shall be suitable for installation in the well casings and under the conditions indicated.

### 2.3 PUMP PERFORMANCE

\*\*\*\*\*

NOTE: The schedule on the drawings should indicate the discharge pipe size in mm (inches), maximum pump speed in revolutions per minute, a single pump rating point consisting of capacity in liters per second (gallons per minutes), total head in meters (feet) and, where appropriate, the minimum efficiency. Also indicate the head in meters (feet) above and below datum at rating point, overall length from datum to inlet of suction case in meters (feet) and, if applicable, the length of suction pipe in feet. For multiple pump systems or where the normal operating point is different from the primary rating point, an alternate rating point with stated minimum efficiency may be indicated to

improve efficiency for normal operation. In this case, the best efficiency may be required at the alternate rating point, the minimum efficiency at the primary point should be deleted and the primary rated capacity should be changed to minimum capacity. Other rating points may be called for such as minimum or maximum capacities at a given head or the range of heads over which the pump will be expected to operate. Fire pumps by NFPA regulation must furnish not less than 150 percent of rated capacity at a total discharge head of not less than 65 percent of total discharge head and the shut-off total head must not be greater than 140 percent of total rated head.

\*\*\*\*\*

Pumps shall be capable of discharging quantities of water at maximum pump speed and total pump head with the minimum efficiency indicated. Total pump head in meters feet shall consist of the pumping level below datum and the static and friction head above datum at design capacity. [Additional operating conditions to be met are indicated.]

## 2.4 LINE SHAFT VERTICAL TURBINE PUMPS

\*\*\*\*\*

**NOTE: Delete NFPA reference if fire protection flows are not involved.**

\*\*\*\*\*

Line shaft vertical turbine pumps shall be constructed in accordance with [AWWA E101] [\_\_\_\_\_] [and NFPA 20 standards] except as modified. Pumps shall be designed for flanged discharge and the pump setting or location of the pump suction shall be as indicated. [A suction pipe of adequate length as determined by the pump manufacturer shall be provided below the lowermost bowl.] [The [pump suction bowl] [lower end of the suction pipe] shall be equipped with a strainer.]

### 2.4.1 Pump Head Assembly

Pump head assembly shall consist of the pump baseplate, the discharge head, and the driver. Head assemblies shall be of low, rigid construction arranged for bolting to concrete foundations and shall be provided with at least two eyebolts, cast lugs or other means of securing slings to facilitate setting and lifting. Pump discharge head and baseplate shall be capable of withstanding all end and side thrusts imposed by the pump during operation and have adequate strength to resist vibration at any operating speed.

#### 2.4.1.1 Pump Baseplate

\*\*\*\*\*

**NOTE: Baseplates are recommended for a more favorable installation, but can be deleted or left as a manufacturer's option. If deleted, do not delete "cast integrally with the baseplate" in the next paragraph.**

\*\*\*\*\*

Pump head baseplate shall be cast-iron or steel and shall serve as a sole

plate for mounting the discharge head assembly.

#### 2.4.1.2 Discharge Head

\*\*\*\*\*

NOTE: These specifications are based on packed shaft seals. Mechanical seals are available for use with open line shaft vertical turbine pumps. However, because of the many different system requirements and the many different types of mechanical seals available, mechanical seals have not been included. If mechanical seals are desired, the requirements should be added to the specification and the reference to packing deleted. Automatic grease lubricators should be added to the stuffing box specifications if automatic lubricator is needed.

\*\*\*\*\*

Discharge head flanges shall be designed for standard pipe connections conforming to ASME B16.1 and ASME B16.5. Surface-type discharge heads shall be [designed for mounting on the baseplate] [or] [cast integrally with the baseplate]. In underground discharge, the discharge tee shall be separated from the pump discharge head and installed in the column pipe at a distance below the foundation as shown. Discharge head shall be provided with a packed stuffing box with bronze lantern ring, a split gland follower, bronze follower nuts, and a grease lubricator. A lip to collect leakage from the stuffing box shall be provided with drilled and tapped connection for drainage pipe. Discharge head shall be designed to prevent contamination of the well from the surface, and shall accommodate the required driver assembly. Space shall be provided for access to the coupling between the pump shaft and drive shaft. Pipe taps shall be provided on the discharge head as required for prelubrication and discharge gauge connections.

#### 2.4.1.3 Pump Driver

\*\*\*\*\*

NOTE: Select the type of drive system required by the design condition. If the design for electric motor drivers requires bearing life over 8,800 hours, the sentence on bearing life should be included and the required hours inserted. For long term service 100,000 hours is appropriate. Post lubrication is recommended instead of nonreversible ratchets for well settings over 150 to 180 m (500 to 600 feet).

If the design for right angle gear drivers requires a bearing life over 17,600 hours, the basic hours should be deleted and the required hours inserted. A value of 100,000 hours is appropriate for units in long term service.

\*\*\*\*\*

a. Vertical hollow shaft electric motor drivers shall be provided with ball or roller bearings of adequate strength to carry the hydraulic thrust of the pump impellers and the weight of all rotating parts. [The bearings shall have a minimum calculated L-10 rating life of

[\_\_\_\_\_] hours in accordance with ABMA 9.] If there is a potential for pump upthrust during any operating condition, the drive shall be designed for this upthrust. The vertical hollow shaft motor shall be sized to transmit the maximum wattage horsepower required by the pump over the entire operating range of the pump. Motor shall be provided with a nonreversible ratchet device to prevent reverse rotation of the pump and line shafts of pumps with settings of 15 m 50 feet or more. Provisions shall be made for vertical impeller adjustment at the top of the motor.

b. Vertical solid shaft electric motor drivers shall be provided with ball or roller bearings of adequate strength to carry the hydraulic thrust of the pump impellers and the weight of all rotating parts. [Bearings shall have a minimum calculated L-10 rating life of [\_\_\_\_\_] hours in accordance with ABMA 9.] If there is potential for pump upthrust during any operation of the pump, the drive shall be designed to withstand this upthrust. Motor shall be connected to the pump shaft through a solid coupling that incorporates provisions for vertical adjustment of the impellers. Vertical solid shaft motor drivers shall be sized to transmit the maximum horsepower required by the pump over the entire operating range of the pump. A nonreversible ratchet device shall be incorporated to prevent reverse rotation of the pump and line shafts of pumps with settings of 15 m 50 feet or more.

c. Vertical hollow shaft right angle gear drives shall be designed to transmit the maximum wattage horsepower required by the pump from the horizontal shaft of the prime mover to the vertical shaft of the pump. The gear ratio shall be selected to match the optimum speed of the prime mover to the required pump speed. Gears shall be of the helical or spiral bevel type or a combination thereof. Gears, pinions, and shafting shall be made of chrome-nickel steel or other approved alloy steel and shall conform to AGMA 2003, AGMA 2001, and AGMA 6113AGMA 6013 as appropriate for strength and durability. Right angle gear drives shall have a service factor of 1.5 when driven by an engine and 1.25 when driven by an electric motor. Provisions shall be included for vertical adjustment of the impellers at the top of the driver. Anti-friction or roller bearings of adequate strength shall be furnished to carry the thrust load imposed by the thrust load of the pump impellers and the weight of the rotating parts. If there is a potential for pump upthrust during any operation of the pump, the drive shall be designed to withstand this upthrust. Drive bearings shall have a minimum calculated L-10 life of [17,600] [\_\_\_\_\_] hours in accordance with ABMA 9. Gears and bearings shall be oil lubricated [and an oil-to-water heat exchanger shall be provided if required]. If an oil pump is required for proper lubrication, a pressure switch shall be provided to [shut down the unit] [and] [sound an alarm] on loss of oil pressure, and a temperature switch shall be provided to [shut down the unit] [and] [sound an alarm] on high oil temperature. A nonreversible ratchet device shall be incorporated to prevent reverse rotation of the pump and line shafts of pumps with settings over 15 m 50 feet. A suitable spacer shall be installed between the pump discharge head and the right angle gear drive to provide access to the line shaft coupling unless adequate space is provided by the discharge head.

d. Combination drive units shall be designed for use with vertical, hollow-shaft electric motors, and [gasoline] [diesel] engines. Pump shaft shall extend through the hollow shaft of the gear reducer and the motor shall be provided with ball or roller bearings of adequate

strength to carry the hydraulic thrust of the pump impellers and the weight of all rotating parts. If there is a potential for pump upthrust during any operation of the pump, the drive shall be designed to withstand this upthrust. Provisions shall be made for vertical adjustment of the impeller of the top of the motor. During normal operation, the pump shall be driven by the vertical hollow shaft motor. During emergency operation, the pump shall be driven through a right-angle gear drive by a [gasoline] [diesel] engine. Right-angle drive shall be designed to transmit the maximum horsepower required by the pump and shall have a service factor of 1.5. Gear ratio shall be selected to match the required operating speed of the pump to the optimum speed of the engine. Gears shall be of the helical or spiral bevel type or a combination thereof. Gears, pinions, and shafting shall be of chrome-nickel steel or other approved alloy steel and shall conform to [AGMA 2003](#), [AGMA 2001](#), and [AGMA 6113](#) [AGMA 6013](#) as appropriate for strength and durability. Gears and bearings shall be oil-lubricated [and an oil-to-water heat exchanger shall be provided if required]. If an oil pump is required for proper lubrication, a pressure switch shall be provided to [shut down the unit] [and] [sound an alarm] on loss of oil pressure and a temperature switch shall be provided to [shut down the unit] [and] [sound an alarm] on high oil temperature. Right-angle gear drive bearings shall have a minimum calculated L-10 life rating of [17,600] [\_\_\_\_] hours in accordance with [ABMA 9](#). A nonreversible ratchet device shall be incorporated to prevent reverse rotation of the pump and line shafts of pumps with settings over [15 m 50 feet](#). A spacer shall be installed between the pump discharge head and the right angle gear drive to provide access to the line shaft coupling unless adequate space is provided in the discharge head. Clutches shall be provided to permit ready change from one drive to the other.

#### 2.4.2 Oil-Lubricated Column and Shaft Assembly

\*\*\*\*\*

**NOTE:** Coordinate information carefully between specified requirements and schedules on the drawings especially to account for different data applicable to pump numbers indicated on the drawings. Refer to [AWWA E101](#) for definition of terms. Line shaft pumps are usually specified for either oil or water lubrication. Use oil lubrication only if the quality of the water being pumped contains abrasive particles or for other special reasons. On short settings or on close-coupled pumps, grease lubrication of enclosed shafts may be considered. If grease lubrication is used, separate grease lines should connect each line shaft or pump shaft bearing to a grease connection at the pump head assembly.

\*\*\*\*\*

Each section of the discharge column shall consist of a column pipe, a shaft-enclosing tube, line shaft couplings, and bronze bearings spaced not more than [1.5 m 5 feet](#) on centers. [Enclosing tube stabilizers shall be provided as required.] A tube tensioning unit shall be installed at the connection between the shaft enclosing tube and the discharge head to allow tension to be placed on the shaft enclosing tube. Threads of the tensioning nut shall be sealed from the pumped fluid to eliminate corrosion.

#### 2.4.2.1 Lubrication

Lubrication of enclosed line shaft pumps shall be by oil and the pump shall be designed so that there will be no leakage into the pump column. Pumps designed to operate with dry bearings will not be acceptable.

#### 2.4.2.2 Lubricating Device

[Pumps with automatically controlled drivers shall have a solenoid operated lubricating device with sight glass and needle valve feed adjustment mounted on the pump discharge head. Capacity of the device shall provide at least 60 hours of continuous operation without attention. A system of lubrication that requires manual starting or stopping will not be acceptable.] [Pumps with manually controlled drivers shall have a manually operated [or solenoid operated] lubricating device with sight glass and needle valve feed adjustment mounted on the pump discharge head. Capacity of the device shall provide at least 60 hours of continuous operation without attention. A system that wastes the lubricant when the pump is not in operation will not be acceptable.]

#### 2.4.3 Water-Lubricated Column and Shaft Assembly

\*\*\*\*\*

NOTE: Coordinate information carefully between specified requirements and schedules on the drawings especially to account for different data applicable to pump numbers indicated on the drawings. Refer to AWWA E101 for definition of terms. Line shaft pumps are usually specified for either oil or water lubrication. Use oil lubrication only if the quality of the water being pumped contains abrasive particles or for other special reasons. On short settings or on close-coupled pumps, grease lubrication of enclosed shafts may be considered. If grease lubrication is used, separate grease lines should connect each line shaft or pump shaft bearing to a grease connection at the pump head assembly. If shaft sleeves are required at the line shaft bearings, delete the requirement for hardened journal surfaces and include the statement on shaft sleeves.

\*\*\*\*\*

Each section of the discharge column shall consist of a column pipe, line shaft [with hardened journal surfaces], bearing spiders with bearings spaced not more than 3 m 10 feet on centers, and line shaft and discharge column pipe couplings. [Stainless steel shaft sleeves shall be furnished at each bearing location.] Line shaft bearings shall be [fluted rubber] [or] [bronze] and shall be held in place by bronze [or other noncorrodible metal] bearing retainers.

#### 2.4.3.1 Lubrication

\*\*\*\*\*

NOTE: Prelubrication is required when there is danger of operating the pump with dry bearings. This could occur on start up of the pump before the water reaches the upper bearings. Prelubrication is normally furnished for settings over 15 m (50

feet). If a prelube water tank is used, the capacity and auxiliaries should comply with the requirements of AWWA E101.

\*\*\*\*\*

Lubrication of line shaft pumps shall be furnished by the water being pumped. [Prelubrication shall be furnished for all pumps with settings over 15 m 50 feet. Prelubrication water shall be furnished from [the discharge main] [from a storage tank].]

#### 2.4.3.2 Lubricating Device

[Pumps with automatically controlled drivers shall have a solenoid operated valve for prelubrication operation. A time-delay mechanism shall be provided to prevent the pump from starting until all line shaft bearings above the water level have been supplied with prelubrication water.] [Pumps with manually controlled drivers shall have a manual [or automatic] means for lubrication prior to starting.] [Automatic lubrication shall be provided by a solenoid operated valve and a time-delay mechanism to prevent pump operation until all line shaft bearings above the water level have been supplied with prelubrication water.]

#### 2.4.4 Pump Bowl Assembly

Pump bowl assembly shall include the pump bowl, pump impeller, and the pump shaft and bearings and may be of single stage or multistage configuration.

##### 2.4.4.1 Pump Bowls

\*\*\*\*\*

NOTE: Pump bowls will normally be unlined cast-iron, but if the quality of the water or pump characteristics requires bowls to be lined, include the requirement for porcelain enamel lining. Some manufacturers recommend casing wearing rings for pumps with enclosed impellers.

It may be more economical to permit a design of bowls and impellers such that wear rings are not initially required. The pumps will cost less, however, over the years the bowl assembly may have to be replaced rather than replacing rings. In situations where personnel for ring installation is limited, consideration could be given to deleting the requirement for wearing rings.

\*\*\*\*\*

Bowls shall be of close-grained cast-iron and shall have integrally-cast vanes with smooth, streamlined water passageways. [The pump bowls shall be lined with porcelain enamel.] Suction bowl shall contain a bronze bearing permanently packed with nonsoluble grease and fitted with a sand collar to serve as the bottom bearing of the pump shaft. [Casing wearing rings of [bronze] [or] [stainless steel] shall be installed [when recommended by the manufacturers] for pumps with enclosed impellers.]

##### 2.4.4.2 Impellers

\*\*\*\*\*

NOTE: Enclosed impellers are recommended for deep



well settings because of shaft stretch. Semiopen and open impellers should only be used for short settings. Impellers will normally be bronze, but coated cast-iron impellers should be used if the quality of the water or pump characteristic requires coating. On pumps with enclosed impellers, wear rings should be considered for installation on the casing and for large pumps, on both the casing and impeller. If stainless steel wear rings are used, consider use of a hardenable alloy to harden to 450 to 550 BHN.

\*\*\*\*\*

Impellers shall be carefully finished with smooth water passageways and shall not load the prime mover beyond the nameplate rating over the entire performance range of the pump. Impellers shall be of the [enclosed] [or] [semiopen] [or] [open] type and shall be constructed of [bronze] [or] [cast-iron]. [Cast-iron impellers shall be coated with porcelain enamel.] [[Bronze] [or] stainless steel] wear rings shall be installed on enclosed impellers.] Impellers shall be statically [and dynamically] balanced.

#### 2.4.4.3 Pump Shafts

Shafts shall be of stainless steel capable of transmitting the required thrust in either direction and the total torque of the unit.

#### 2.4.4.4 Bearings

Intermediate bowl bearings shall be water lubricated bronze or fluted rubber. Top bowl bearings and suction case bearings shall be grease packed bronze, water-lubricated bronze, or fluted rubber. Grease in grease-packed bearings shall be nonwater-soluble hydraulic type permanently sealed against loss. Grease-packed bearings shall be provided with sand caps to prevent intrusion of abrasive particles.

#### 2.4.5 Suction Pipe and Strainer

Suction pipe shall be not less than [\_\_\_\_\_] mm feet in length. Suction strainer shall be of the [basket] [or] [conical] type, fabricated from [bronze] [or] [stainless steel].

### 2.5 SUBMERSIBLE VERTICAL TURBINE PUMPS

\*\*\*\*\*

NOTE: Submersible pumps should normally operate under fairly constant head conditions. Where the head may possibly vary 25 percent or more above or below the optimum design, due to large well drawdown or operation against a hydropneumatic system or other fluctuating head, the appropriate figure should be inserted in the blank. The sentence should be deleted if the pump does not operate against a variable head of 25 percent or more.

\*\*\*\*\*

Unless otherwise specified, submersible vertical turbine pumps shall be constructed in accordance with [AWWA E101] [\_\_\_\_\_] , driven by a [3.7] [\_\_\_\_\_] kW [5] [\_\_\_\_\_] hp or larger electric motor. Pumps shall be designed for connection to piping as indicated. A strainer shall be

provided at the pump suction. [Pumps shall be operable at heads ranging from [\_\_\_\_\_] percent above or below the normal design head.]

#### 2.5.1 Pump Head Assembly

Pump head assembly shall consist of the surface plate from which the vertical discharge pipe is suspended and an elbow or fitting as required for connecting to the piping system. Head assembly shall be provided with eyebolts, lugs, or other means for securing slings to facilitate setting and lifting.

#### 2.5.2 Pump Bowl Assembly

Pump bowl assembly shall include the pump bowls, impellers, shaft, and bearings and may be of single stage or multistage configuration.

##### 2.5.2.1 Pump Bowls

\*\*\*\*\*

NOTE: Pump bowls will normally be unlined cast-iron, but if the quality of the water or pump characteristics requires bowls to be lined, include the requirement for porcelain enamel lining. Some manufacturers recommend casing wearing rings for pumps with enclosed impellers.

It may be more economical to permit a design of bowls and impellers such that wear rings are not initially required. The pumps will cost less, however, over the years the bowl assembly may have to be replaced rather than replacing rings. In situations where personnel for ring installation is limited, consideration could be given to deleting the requirement for wearing rings.

\*\*\*\*\*

Pump bowls shall have integrally-cast vanes with smooth, streamlined water passageways, and shall be constructed of close-grained cast-iron, [and shall be lined with porcelain enamel]. [Pump bowls shall be equipped with replaceable seal rings on the suction side for pumps with enclosed impellers.]

##### 2.5.2.2 Impellers

\*\*\*\*\*

NOTE: Enclosed impellers are recommended for deep well settings because of shaft stretch. Semiopen and open impellers should only be used for short settings. Impellers will normally be bronze, but coated cast-iron impellers should be used if the quality of the water or pump characteristic requires coating. On pumps with enclosed impellers, wear rings should be considered for installation on the casing and for large pumps, on both the casing and impeller. If stainless steel wear rings are used, consider use of a hardenable alloy to harden to 450 to 550 BHN.

\*\*\*\*\*

Impellers shall be carefully finished with smooth water passageways and shall not load the prime mover beyond the nameplate rating over the entire performance range of the pump. Impellers shall be of the [enclosed] [or] [semiopen] [or] [open] type and shall be constructed of [bronze] [or] cast-iron]. [Cast-iron impellers shall be coated with porcelain enamel.] [Bronze] [or] [stainless steel] wear rings shall be installed on enclosed impellers.

#### 2.5.2.3 Pump Shafts

Pump shafts shall be stainless steel and the pump-motor coupling shall be stainless steel capable of transmitting the required thrust in either direction.

#### 2.5.2.4 Bearings

Intermediate bowl bearings shall be water-lubricated bronze or fluted rubber. Top bowl bearings and suction interconnecting bearings shall be grease packed bronze or water-lubricated bronze or fluted rubber. Grease in grease-packed bearings shall be nonwater-soluble hydraulic type permanently sealed against loss. Grease-packed bearings shall be provided with sand caps to prevent intrusion of abrasive particles. Thrust bearings shall be located in the pump motor.

#### 2.5.2.5 Strainer

A [bronze] [or] [stainless steel] strainer shall be furnished at the pump suction.

#### 2.5.3 Discharge Pipe

\*\*\*\*\*  
NOTE: Delete requirement for discharge column  
spiders where discharge pipe is 15 m (50 feet) or  
less.  
\*\*\*\*\*

Discharge pipe shall be sized as shown. [Discharge column retainers or spiders shall be utilized to maintain the discharge pipe centered in the well casing. A minimum of one retainer shall be provided for each 15 m 50 feet of discharge pipe. Provisions shall be made for fastening the retainer spiders to prevent them from sliding on the pipe and damaging the power cable when the pump is installed in the well.]

#### 2.5.4 Check Valves

\*\*\*\*\*  
NOTE: Vertical check valves may be required to  
prevent pump cavitation or water hammer when  
starting the pump or to limit reverse rotation when  
stopping. If system operation permits, horizontal  
check valves above ground should be considered for  
ease of maintenance. Horizontal valves will not  
form a part of the pump installation. If vertical  
check valves are required, they should be furnished  
with the pump.  
\*\*\*\*\*

Check valves shall be provided in the column pipe located at a pipe joint

[where indicated] [or] [as recommended by the pump manufacturer]. Check valves shall be vertical type, of the same size as the column pipe in which they are installed. Check valves shall be designed to hold the column full of water, or provide bleed-back through the valve, as recommended by the pump manufacturer. Pumps with bleed-back check valves shall be provided with a positive time-delay relay that will not permit the pump to start until bleed-back is complete.

## 2.6 PUMP ACCESSORIES

### 2.6.1 Water-Level Indicator Assembly

\*\*\*\*\*  
NOTE: Include if water level indication is desired  
or where drawdown cannot be observed. Automatic  
air-line level indicators, using compressed air from  
a continuous source, may also be used for alarm or  
pump shut down on low level where the electrode type  
can only be used for level indication.  
\*\*\*\*\*

A water-level indicator assembly shall be provided for each pump installation. Indicator shall be [the air-line type] [or] [the electrode type].

#### 2.6.1.1 Air-line Indicator

Air-line type shall be [manual] [automatic] and shall include a [galvanized pipe] [or] [copper tube] inserted between the well casing and the pump discharge column and shall extend a minimum of 3 m 10 feet below the lowest pumping water level. [Manual water-level indicator assembly shall include a pressure gauge, check or bicycle valve, and hand air pump]. [Automatic water-level indicator assembly shall continuously bleed compressed air into the air line and shall include a pressure gauge, [automatic low level alarm] [and] [automatic low level shut down control] [and] [a compressed air system].] The pressure gauge shall read in feet and shall have a range capable of permitting water-level measurement in the well [under any condition] [as indicated]. A plastic or corrosion-resistant metal plate shall be affixed to the air line pressure gauge or pumphouse wall indicating the exact distance from the centerline of the pressure gauge to the end of the air line.

#### 2.6.1.2 Compressed Air Systems

\*\*\*\*\*  
NOTE: Include paragraph if automatic source of air  
is desired. Bottled air source may also be  
considered. Oil-less type air compressors should be  
considered for potable water systems to prevent  
possible contamination.  
\*\*\*\*\*

System shall include tank-mounted air compressors, pressure switches for control of the air compressors, a pressure reducing station, a constant pressure differential relay, and a flow indicator. Each air compressor shall be a close coupled or belt driven, reciprocating, air-cooled, motor-driven compressor mounted on not less than a 7.6 L 2 gallon tank. Tank shall be designed to withstand a minimum of 689 kPa 100 psi or 345 kPa 50 psi greater than the maximum pressure required by the air line

submergence. Each compressor shall be equipped for unloaded starting, and the unit shall be provided with a pressure relief valve, a pressure gauge, and vibration mountings. Compressor shall have a minimum displacement of 0.000661 standard cubic meter/second 1.4 scfm and shall be driven by an electric motor. [Automatic control shall be provided to [sound an alarm] [and] [shut down the pump] on falling well level.]

#### 2.6.1.3 Electrode Indicator

\*\*\*\*\*  
NOTE: The electrode type water-level indicator is normally used only in line shaft type pump installations.  
\*\*\*\*\*

Electrode type shall include a single- or double-wire electrode, well cable, and battery-activated galvanometer. Well cable shall be of sufficient length to measure the water level in the well under any condition and shall be accurately marked with corrosion-resistant markers at intervals not to exceed 3 m 10 feet. Electrode shall be constructed of corrosion-resistant materials and shall be easily replaceable. Device shall operate by indicating current flow at the galvanometer when the electrode touches the water surface in the well. Means shall be provided for lowering the electrode, wire, and well cable in the well and reading the water-level depth when the electrode contacts the water surface.

#### 2.6.2 Pressure Gauge

A pressure gauge of the direct-reading type, equipped with a shut-off cock [and snubber], shall be provided on the discharge from each pump. Pressure gauge shall conform to ASME B40.100 and shall be calibrated in kPa psi [and mm feet of water] in not more than 13.8 kPa 2 psi and 1.5 m 5 foot increments from zero to a minimum of 34.5 kPa 5 psi and 3 m 10 feet above the shut-off head of the pump. Rating point shall be at approximately the mid-point of the scale.

#### 2.6.3 Air-Vent Valve

Air-vent valve with the necessary pipe connections shall be provided to permit the automatic escape of air from the discharge column when the pump is started. Size of the air-vent valve and piping shall suit the actual requirements of the individual installation and the recommendations of the pump manufacturer.

### 2.7 ELECTRICAL EQUIPMENT

#### 2.7.1 General

Electrical motor-driven equipment specified shall be provided complete with motors, motor starters, and controls. Motor controls, equipment and wiring shall be as specified in Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM. Integral size motors shall be the premium efficiency type in accordance with NEMA MG 1.

#### 2.7.2 Line shaft Vertical Turbine Pumps

##### 2.7.2.1 Electric Motors

\*\*\*\*\*

**NOTE: Select the type of motor and enclosure  
required by the design conditions and environment  
under which motors are to operate.**

\*\*\*\*\*

Each electric motor-driven pump shall be driven by a [weather-protected, Type [I][II]] [totally-enclosed fan cooled] vertical continuous-duty electric motor conforming to **NEMA MG 1**. 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. 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 for fire pumps shall meet the requirements of **NFPA 20**.] Motors shall be rated [\_\_\_\_\_] volts, [\_\_\_\_\_] phase, [\_\_\_\_\_] Hz and such rating stamped on the nameplate.

#### 2.7.2.2 Control Equipment

\*\*\*\*\*

**NOTE: The low-water cutoff should be on the suction  
side of can pumps.**

\*\*\*\*\*

[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.]

#### 2.7.3 Submersible Vertical Turbine Pumps

##### 2.7.3.1 Electric Motors

\*\*\*\*\*

**NOTE: A mechanical seal is called for between the  
shaft and motor housing. If permitted by approving  
authorities for potable or other use, a mercury seal  
would be mechanically satisfactory. The burden of  
proof, if considered, should be on the manufacturer  
proposing a mercury seal.**

\*\*\*\*\*

Submersible motors shall be designed and manufactured expressly for the intended use. Motors shall be rated [\_\_\_\_\_] volts, [\_\_\_\_\_] phase, [\_\_\_\_\_] Hz and such rating shall be stamped on the nameplate. Submersible motors may be the wet-stator type, dry-stator type, or oil-filled stator type. Wet-stator motors shall be filled at the factory with water treated to minimize corrosion, and shall be provided with a seal to keep interchange of cooling water and water being pumped to a minimum. Windings shall be insulated with a waterproof material. Dry-stator motors shall have rotor bearings immersed in a coolant lubricant of water-oil or water-glycol mixture, or a water-grease emulsion. When the coolant is water, it may be

sealed in the motor or allowed to flow through the motor, depending upon design. Stator case shall be hermetically sealed and may be filled with a solid plastic material to help dissipate heat. Oil-filled stator motors shall be completely filled with high-dielectric constant oil. A mechanical seal shall be provided between the shaft and the motor housing and shall be designed to minimize the loss of oil. An oil reservoir shall be provided to replenish the oil loss for the life of the motor. Wet-stator motors and oil-filled stator motors shall employ a system to automatically balance the liquid pressure in the motor at any depth of submergence up to the maximum allowable. Motor bearings shall provide smooth operations under the conditions encountered for the life of the motor. Adequate thrust bearings shall be provided in the motor to carry the weight of all rotating parts plus the hydraulic thrust, and shall be capable of withstanding the upthrust imposed during pump starting.

#### 2.7.3.2 Control Equipment

\*\*\*\*\*  
**NOTE: Select the type of controls required by the  
design conditions. Detail additional needed  
requirements on the drawings.**  
\*\*\*\*\*

[Manually controlled pumps shall have START-STOP pushbutton in cover.][Automatically controlled pumps shall have three-position MANUAL-OFF-AUTOMATIC selector switch in cover.][ A pump low-water cutoff shall be installed in the well and shall shut the pump off when the water level in the well reaches the level shown.][ Additional controls or protective devices shall be as indicated.]

#### 2.7.3.3 Power Cables

Submersible power cables shall be specifically designed for use with submersible pumps, and shall be as recommended by the manufacturer of the motors with which the cables are used. Each cable shall be not less than No. 12 AWG stranded copper and shall have an ampacity of not less than 125 percent of the motor full load current. Each conductor shall be insulated with a heat resistant, moisture resistant synthetic rubber or thermosetting plastic jacket. A separate stranded, green insulated, grounding conductor shall be provided for each circuit. Single- and multiple-conductor cables shall be jacketed with a watertight synthetic rubber, plastic, or metal jacket impervious to oil or water. Metal jackets shall have a polychloroprene covering. Submersible cables shall be suitable for continuous immersion in water at the maximum depth encountered. Multiple-conductor cables may be used for ampacities up to and including 200 amperes; for greater ampacities single-conductor cables or two multiple-conductor cables shall be used. Cables shall be securely supported from the pump column at intervals not to exceed 4.5 m 15 feet by corrosion-resistant bands or clamps designed to prevent damage to the cable jacket. Single-conductor cables shall be laced, cabled together, or clamped at intervals to prevent spreading apart. Except where cables are connected to the motor terminal wiring, cables shall contain no splices in the length from the junction box or motor starter to the motor. Cables shall be terminated at the junction box or motor starter with a watertight cable connector. Splices in cables will be allowed only at the connection to the motor, and may be made at that point only if there is sufficient room in the well casing without interfering with proper pump setting and operation. A waterproof plug and connector or other type of fitting may be provided for connection of the cable at the motor. Such connection shall

be suitable for continuous immersion at the maximum water depth encountered. Splices shall use pressure connectors and shall be cast in an epoxy resin, providing a homogeneous waterproof bond to the outer jacket of the cables. Splices shall be factory fabricated and tested and shall be waterproof and suitable for continuous immersion at the maximum depth encountered. For each 15 m 50 feet of setting depth, 300 mm 1 foot of extra cable length shall be provided to compensate for possible twist or sag of the cable during installation. Where cables pass the pump bowl assembly, cables shall be flat or protected against damage by a corrosion-resistant shield forming a smooth rounded surface. Sharp bends in the cables at the shield or at the connection to the motor will not be allowed.

## 2.8 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 for 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 D 975. 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 or 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 305 m 1000 feet of altitude, and 1 percent for every 6 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 1800 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. Engine jacket water[ and lube oil] heaters shall be provided as recommended by the manufacturer.[ Lube oil heaters shall be of the circulation type.]

## 2.9 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 a type in regular production and shall be complete with all devices specified or 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 1000 feet of altitude, and 1 percent for every 5.6 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 1800 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. 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 antidieseling feature that will shut-off the fuel supply and air to insure positive shut down.

## 2.10 ENGINE EQUIPMENT AND ACCESSORIES

### 2.10.1 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.

### 2.10.2 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][an engine-mounted heat exchanger with a surge 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.

#### 2.10.3 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 the replaceable type and shall be readily accessible.

#### 2.10.4 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.

#### 2.10.5 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. Filters shall be [engine mounted][remote mounted as indicated and furnished with flexible connection for attachment of intake piping to the engine].

#### 2.10.6 Starting Equipment

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

#### 2.10.7 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.]

#### 2.10.8 Battery Charging

Engine shall be equipped with an engine driven battery charging alternator with regulator for use when 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 cranking, 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.

#### 2.10.9 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. Shut down features shall be connected to the annunciator on the instrument panel and each shut down feature will be identified.

#### 2.10.10 Instrument Panel

\*\*\*\*\*  
NOTE: Delete nonapplicable 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.

#### 2.10.11 Engine Control

##### 2.10.11.1 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.

#### 2.10.11.2 Multiple Units

\*\*\*\*\*  
**NOTE: Check drawings to ensure 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 suitably 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. Control circuit shall close the cranking circuit and cause the first engine to be cranked for a period of not less than 15 seconds unless the engine starts before the end of that time. At the end of that period, the starter circuit of the first engine will be de-energized and the remaining units cranked in succession. Starter circuit of each engine shall be automatically de-energized upon starting of the engine. Cyclic operation of the starter motors shall not be provided.] Engines shall be stopped manually with the switch on instrument panel. [Automatic pump controller shall conform to NFPA 20.]

#### 2.10.12 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 fuel system shall be constructed, installed, and tested as specified in Section 33 56 10 FACTORY-FABRICATED FUEL STORAGE TANKS.

### 2.11 EQUIPMENT APPURTENANCES

#### 2.11.1 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 A 307 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 A 123/A 123M or ASTM A 153/A 153M as appropriate. Bolts, nuts, and washers specified or indicated to be stainless steel shall be Type 316.

#### 2.11.2 Shop Painting

All motors, pump casings, and similar parts of equipment customarily finished in the shop shall be given coats of paint filler and enamel, or

other acceptable treatment customary with the manufacturer and suitable for the intended service. Ferrous surfaces obviously not to be painted shall be given a shop coat of grease or other suitable rust-resistant coating.

### PART 3 EXECUTION

#### 3.1 EXAMINATION

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

#### 3.2 INSTALLATION

##### 3.2.1 General

\*\*\*\*\*  
NOTE: For fire service, NFPA 20 recommends having  
at least the impellers set by the manufacturer. Use  
reference to NFPA 30 and NFPA 37 on installation if  
a fuel supply system is used.  
\*\*\*\*\*

Each pump[ and engine] shall be installed in accordance with the written instruction of the manufacturer[ and under the direct supervision of the manufacturer's representative][ and the impellers shall be set by the manufacturer's representative]. Engine fuel supply system shall be installed as indicated and in conformance with NFPA 30 and NFPA 37.

##### 3.2.2 Foundations

Foundations shall be as specified in Section 03 31 00.00 10 CAST-IN PLACE STRUCTURAL CONCRETE. Anchor bolts and expansion bolts shall be set accurately. Where indicated, specified, or required, anchor bolts shall be provided with square plates at least 101.6 by 101.6 by 9.5 mm 4 by 4 by 3/8 inch or shall have square heads and washers and be set in the concrete forms with suitable pipe sleeves, or both. Any templates necessary and all dimensions for setting the anchor bolts shall be furnished at the proper time. Top of the foundation shall be carefully leveled to permit the pump to hang free.

#### 3.3 PAINTING AND FINISHING

Unless otherwise specified all exposed ferrous metal not factory finished shall be painted as specified in Section 09 90 00 PAINTS AND COATINGS. No factory finished equipment or appurtenances shall be painted except that damaged factory finishes shall be retouched in an acceptable manner with paint obtained from the manufacturer. Nameplates shall not be covered with paint but shall be cleaned and legible at completion of the work.

#### 3.4 MANUFACTURER'S FIELD SERVICES

Obtain the services of a manufacturer's representative experienced in the installation, adjustment, and operation of the equipment specified. The representative shall supervise the installing, adjusting, and testing of the equipment.

### 3.5 FIELD TRAINING

\*\*\*\*\*  
NOTE: The number of hours required to instruct a Government representative in operation and maintenance of the system will depend on the complexity of the system specified. Designer is to establish the number of hours of training based on equipment manufacturer recommendations, system complexity and consultation with the installation.  
\*\*\*\*\*

Conduct a training course for the maintenance and operating staff. The training period of [\_\_\_\_\_] hours normal working time shall start after the system is functionally complete but before the final acceptance tests. The training shall include all of the items contained in the operating and maintenance instructions as well as demonstrations of routine maintenance operations. Contracting Officer shall be given at least two weeks advance notice of such training.

### 3.6 POSTED INSTRUCTIONS

Framed instructions under glass or in laminated plastic, including wiring and control diagrams showing the complete layout of the entire system, 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.

### 3.7 TESTING

#### 3.7.1 Factory Pump Test

\*\*\*\*\*  
NOTE: Delete nonapplicable tests. Hydrostatic test of discharge head is not applicable to submersible pumps.  
\*\*\*\*\*

Factory pump performance test shall be made in conformance with [AWWA E101] [\_\_\_\_\_] for the following:

- a. Running test.
- b. Witnessed running test.
- c. Sample calculation from test readings.
- d. Shop inspection.
- e. Hydrostatic test of bowl assembly.
- f. Hydrostatic test of discharge head.

### 3.7.2 Factory Fuel Storage Tank Test

Fuel storage tanks shall be factory tested and proven tight against leakage under a test using air at a pressure of 34.5 kPa 5 psig. Factory testing shall be performed after the various openings are installed.

### 3.7.3 Field Equipment Test

After installation of the pumping units and appurtenances is complete, operating tests shall be carried out to assure that the pumping installation operates properly. [ Make arrangements to have the manufacturer's representatives present when field equipment tests are made. ] [ Field tests for fire service pumps [ and engines ] shall conform to NFPA 20. ] Each pumping unit shall be given 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]. Each pumping unit shall be operated 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. [ Each engine shall be operated for a minimum of 4 hours at a point of maximum wattage horsepower indicated on the pump head-capacity curve or such other point on the curve selected by the Contracting Officer. ] [ 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 be not less than 10 megohms. ]

#### 3.7.3.1 Correct Installation of Appurtenances

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.

#### 3.7.3.2 Deficiencies

If any deficiencies are revealed during any tests, such deficiencies shall be corrected and the tests shall be reconducted.

-- End of Section --