
USACE / NAVFAC / AFCEC UFGS-23 21 23 (May 2025)

Preparing Activity: USACE

Superseding
UFGS-23 21 23 (August 2017)

UNIFIED FACILITIES GUIDE SPECIFICATIONS

References are in agreement with UMRL dated April 2025

SECTION TABLE OF CONTENTS

DIVISION 23 - HEATING, VENTILATING, AND AIR CONDITIONING (HVAC)

SECTION 23 21 23

HYDRONIC PUMPS

05/25

PART 1 GENERAL

- 1.1 REFERENCES
- 1.2 SUBMITTALS
- 1.3 QUALITY ASSURANCE
 - 1.3.1 Manufacturer Services
 - 1.3.2 Standard Products
 - 1.3.3 Conformance with Agency Requirements
- 1.4 DELIVERY, STORAGE, AND HANDLING

PART 2 PRODUCTS

- 2.1 SYSTEM DESCRIPTION
 - 2.1.1 Selection Criteria
 - 2.1.2 System Coordination
 - 2.1.3 Safety Requirements
- 2.2 MATERIALS AND EQUIPMENT
 - 2.2.1 Nameplates
 - 2.2.2 Framed Instructions
 - 2.2.3 Pump Characteristic
 - 2.2.4 Pump Drivers
 - 2.2.5 Equipment Data
- 2.3 HYDRONIC PUMPS
 - 2.3.1 Circulator Pump[s]
 - 2.3.1.1 Seal Assembly
 - 2.3.1.2 Motor Mount
 - 2.3.1.3 Motors
 - 2.3.2 Small In-Line Pump[s]
 - 2.3.2.1 Pump Shaft
 - 2.3.2.2 Bearing
 - 2.3.2.3 Seal Assembly
 - 2.3.2.4 Impeller
 - 2.3.2.5 Volute

- 2.3.2.6 Motor Mount
- 2.3.2.7 Motors
- 2.3.3 Large In-Line Pump[s]
 - 2.3.3.1 Casing
 - 2.3.3.2 Pump Shaft
 - 2.3.3.3 Seal Assembly
 - 2.3.3.4 Spacer Coupling
 - 2.3.3.5 Impeller
 - 2.3.3.6 Motor
- 2.3.4 Base-Mounted, Flexible Coupled, End suction Pump[s]
 - 2.3.4.1 Casing
 - 2.3.4.2 Pump Shaft
 - 2.3.4.3 Bearing
 - 2.3.4.4 Seal Assembly
 - 2.3.4.5 Baseplate
 - 2.3.4.6 Coupler
 - 2.3.4.7 Impeller
 - 2.3.4.8 Motor
- 2.3.5 Base-Mounted, Close Coupled, End Suction Pump[s]
 - 2.3.5.1 Casing
 - 2.3.5.2 Seal Assembly
 - 2.3.5.3 Impeller
 - 2.3.5.4 Motor
- 2.3.6 Base-Mounted, Flexible Coupled, Double Suction[,]
 - [Horizontally Split][and][Vertically Split] Pump[s]
 - 2.3.6.1 Casing
 - 2.3.6.2 Bearings
 - 2.3.6.3 Seal Assembly
 - 2.3.6.4 Coupler
 - 2.3.6.5 Base Plate
 - 2.3.6.6 Impeller
 - 2.3.6.7 Motor
 - 2.3.6.8 Pump Shaft
- 2.3.7 Vertical Lineshaft Turbine Pump[s]
 - 2.3.7.1 Bowl Assembly
 - 2.3.7.2 Pump Shaft
 - 2.3.7.3 Lineshaft
 - 2.3.7.4 Impeller
 - 2.3.7.5 Discharge Head
 - 2.3.7.6 Stuffing Box
 - 2.3.7.7 Mechanical Seal
 - 2.3.7.8 Column Pipe
 - 2.3.7.9 Basket Strainer
 - 2.3.7.10 Motor
- 2.3.8 Cooling Coil Condensate Pump Units
 - 2.3.8.1 Motor
- 2.4 ELECTRICAL WORK
- 2.5 ELECTRICAL EQUIPMENT
 - 2.5.1 Electric Motors
 - 2.5.2 Control Equipment
 - 2.5.3 Variable Speed Control
 - 2.5.3.1 Adjustable Speed Drive
 - 2.5.3.2 Combination Motor and Adjustable Speed Drive
 - 2.5.3.3 Electronically Commutated Motor
- 2.6 PACKAGED PUMP SYSTEM
 - 2.6.1 Pumps
 - 2.6.2 Piping and Appurtenances
 - 2.6.3 Structural Steel Base
 - 2.6.4 Variable Speed Control

- 2.6.4.1 Adjustable speed Drive Systems
- 2.6.4.2 Motor-Drive Unit
- 2.6.4.3 Electronically Commutated Motor
- 2.6.5 Electrical
- 2.6.6 Controls
 - 2.6.6.1 Controller
 - 2.6.6.2 Software
 - 2.6.6.3 Integration
 - 2.6.6.4 Sequence
- 2.6.7 Testing
- 2.7 EQUIPMENT APPURTENANCES
 - 2.7.1 Attachments
 - 2.7.2 Equipment Guards
 - 2.7.3 Tools
 - 2.7.4 Pump Suction Diffuser/Guide
- 2.8 FINISHES
- 2.9 FACTORY TESTS

PART 3 EXECUTION

- 3.1 EXAMINATION
- 3.2 INSTALLATION
 - 3.2.1 Base Mounted, Long-Coupled Pumps
 - 3.2.2 Large Vertical Inline Pumps
- 3.3 FIELD QUALITY CONTROL
- 3.4 FIELD PAINTING
 - 3.4.1 Touch-up painting
 - 3.4.2 Exposed Ferrous Surfaces
- 3.5 CLOSEOUT ACTIVITIES
 - 3.5.1 Operation and Maintenance Manuals
 - 3.5.2 Training
 - 3.5.3 Pump Motor/Alignment Report

-- End of Section Table of Contents --

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SECTION 23 21 23

HYDRONIC PUMPS 05/25

NOTE: This guide specification covers the requirements for hydronic pumps primarily designed for chilled water, hot water and condenser water service in building HVAC systems.

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

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

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

NOTE: Other specification sections have pumps specified as components or packaged with other equipment with detailed pump specifications in those other sections. When there are multiple sections specifying pumps designers must ensure that it is clear in the design documents which specification applies to each pump being provided.

NOTE: Show the following information on the project drawings:

1. Minimum design flow rate
2. Minimum design pressure
3. Motor voltage, phase, and horsepower or KW
4. Pump speed
5. Maximum Pump Efficiency Index (PEI)

6. Minimum pump efficiency
7. Vibration isolation
8. When applicable, indicate variable frequency drive or EC motor for variable speed operation.
9. Pump Type (match to terminology used in specification)

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 Reference Identifier (RID) outside of the Section's Reference Article to automatically place the reference in the Reference Article. Also use the Reference Wizard's Check Reference feature to update the issue dates.

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

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

AMERICAN SOCIETY OF MECHANICAL ENGINEERS (ASME)

- | | |
|------------|--|
| ASME B1.1 | (2024) Unified Inch Screw Threads (UN, UNR, and UNJ Thread Form) |
| ASME B4.1 | (1967; R 1994; R 2004; R 2009; R 2020) Preferred Limits and Fits for Cylindrical Parts |
| ASME B4.2 | (1978; R 1994; R 2004, R 2009; R 2020) Preferred Metric Limits and Fits |
| ASME B16.1 | (2020) Gray Iron Pipe Flanges and Flanged Fittings Classes 25, 125, and 250 |

AMERICAN WATER WORKS ASSOCIATION (AWWA)

- | | |
|-----------|---|
| AWWA E103 | (2021) Horizontal and Vertical Line-Shaft Pumps |
|-----------|---|

ASTM INTERNATIONAL (ASTM)

ASTM A48/A48M	(2022) Standard Specification for Gray Iron Castings
ASTM A53/A53M	(2024) Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless
ASTM A123/A123M	(2024) Standard Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products
ASTM A153/A153M	(2023) Standard Specification for Zinc Coating (Hot-Dip) on Iron and Steel Hardware
ASTM A159	(1983; R 2024) Standard Specification for Automotive Gray Iron Castings
ASTM A307	(2023) Standard Specification for Carbon Steel Bolts, Studs, and Threaded Rod 60 000 PSI Tensile Strength
ASTM A536	(2024) Standard Specification for Ductile Iron Castings
ASTM A582/A582M	(2022) Standard Specification for Free-Machining Stainless Steel Bars
ASTM B584	(2022) Standard Specification for Copper Alloy Sand Castings for General Applications

HYDRAULIC INSTITUTE (HI)

HI 1.3	(2013) Rotodynamic (Centrifugal) Pump Applications
HI 9.6.4	(2009) Rotodynamic Pumps for Vibration Analysis and Allowable Values
HI ANSI/HI 9.6.3	(2024) Rotodynamic Pumps - Guideline for Operating Regions - B120
HI ANSI/HI 14.1-14.2	(2019) Rotodynamic Pumps for Nomenclature and Definitions
HI ANSI/HI 14.6	(2011) Rotodynamic Pumps for Hydraulic Performance Acceptance Tests - A136

MASTER PAINTERS INSTITUTE (MPI)

MPI 23	(2015) Primer, Metal, Surface Tolerant
MPI 76	(2016) Primer, Alkyd, Quick Dry, for Metal
MPI 94	(2016) Alkyd, Exterior, Semi-Gloss (MPI Gloss Level 5)

MPI 141 (2016) Latex, Interior, High Performance Architectural, Semi-Gloss (MPI Gloss Level 5)

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)

NEMA MG 1 (2021) Motors and Generators

NEMA Z535.4 (2023) Product Safety Signs and Labels

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 70 (2023; ERTA 1 2024; TIA 24-1) National Electrical Code

NSF INTERNATIONAL (NSF)

NSF 372 (2022) Drinking Water System Components - Lead Content

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

10 CFR 431.464 Test Procedure for the Measurement of Energy Efficiency, Energy Consumption, and Other Performance Factors of Pumps

10 CFR 431.465 Circulator Pumps Energy Conservation Standards and the Compliance Dates

29 CFR 1910.219 Mechanical Power Transmission Apparatus

UL SOLUTIONS (UL)

UL 778 (2016; Reprint Jul 2024) UL Standard for Safety Motor-Operated Water Pumps

1.2 SUBMITTALS

NOTE: Review submittal description (SD) definitions in Section 01 33 00 SUBMITTAL PROCEDURES and edit the following list, and corresponding submittal items in the text, to reflect only the submittals required for the project. The Guide Specification technical editors have classified those items that require Government approval, due to their complexity or criticality, with a "G." Generally, other submittal items can be reviewed by the Contractor's Quality Control System. Only add a "G" to an item, if the submittal is sufficiently important or complex in context of the project.

For Army projects, fill in the empty brackets following the "G" classification, with a code of up to three characters to indicate the approving authority. Codes for Army projects using the Resident Management System (RMS) are: "AE" for Architect-Engineer; "DO" for District Office

(Engineering Division or other organization in the District Office); "AO" for Area Office; "RO" for Resident Office; and "PO" for Project Office. Codes following the "G" typically are not used for Navy and Air Force projects.

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

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

SD-02 Shop Drawings

System Coordination; G, [_____]

SD-03 Product Data

Base-Mounted, Close Coupled, End Suction Pump[s]; G, [_____]

Base-Mounted, Flexible Coupled, End suction Pump[s]; G, [_____]

Base-Mounted, Flexible Coupled, Double Suction[,] [Horizontally Split][and][Vertically Split] Pump[s]; G, [_____]

Circulator Pump[s]; G, [_____]

Cooling Coil Condensate Pump Units; G, [_____]

Equipment Data; G, [_____]

Installation Instructions; G, [_____]

Large In-Line Pump[s]; G, [_____]

Packaged Pump System; G, [_____]

Small In-Line Pump[s]; G, [_____]

Vertical Lineshaft Turbine Pump[s]; G, [_____]

Training Period; G, [_____]

Framed Instructions; G, [_____]

SD-06 Test Reports

Factory Tests

Field Quality Control

Pump Motor/Alignment Report; G, [_____]

SD-07 Certificates

Manufacturer's Representative

SD-10 Operation and Maintenance Data

Operation and Maintenance Manuals; G, [_____]

Training; G, [_____]

1.3 QUALITY ASSURANCE

1.3.1 Manufacturer Services

Provide the services of a [manufacturer's representative](#) experienced in the installation, adjustment, and operation of the equipment specified. The representative must supervise the installation, adjustment, testing of the equipment, and conduct training.

Submit the names and qualifications of the manufacturer's representative and training engineers and written certification from the manufacturer that the representative and trainers are technically qualified.

1.3.2 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 HVAC operation at least 2 years prior to issuance of this solicitation. Support equipment with a service organization that is reasonably convenient to the jobsite. Pumps [and][motors] of the same types must each be the product of one manufacturer.

1.3.3 Conformance with Agency Requirements

Where materials or equipment are specified to be an approved type, attach the seal or label of approval from a nationally recognized testing agency, adequately equipped and competent to perform such services. A written certificate from the testing agency must accompany the materials or equipment and be submitted 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 must 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 and may be acceptable as evidence that the items conform with agency requirements.

1.4 DELIVERY, STORAGE, AND HANDLING

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

PART 2 PRODUCTS

2.1 SYSTEM DESCRIPTION

Hydronic pumps used for heating and air conditioning applications are defined by the type of impeller, number of impellers, type of casing, method of connection to the driver, and mounting position. Provide centrifugal water pumps of the types indicated and specified. Use an electric motor driving unit for each pump as indicated and specified.

2.1.1 Selection Criteria

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 in the construction design documents. Pumps having impeller diameters larger or smaller than manufacturer's published maximum and minimum impeller diameters for a given impeller casing combination will be rejected. Pump performance data, as shown in performance curves, must be based on factory tests using precision instrumentation and exacting procedures as detailed in [HI ANSI/HI 14.6](#). Pump and motor must meet minimum Department of Energy requirements and must have a maximum Pump Efficiency Index (PEI) of 1.0 in accordance with [10 CFR 431.464](#) and [10 CFR 431.465](#).

2.1.2 System Coordination

Submit drawings containing complete wiring and piping schematic diagrams and any other details required to demonstrate that the system has been coordinated and will properly function as a unit. Show the 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, materials and miscellaneous components including mechanical seals, bearings, and couplings.

2.1.3 Safety Requirements

Fully enclose or guard couplings, projecting set-screws, keys, and other rotating parts, that pose an entangling hazards.

2.2 MATERIALS AND EQUIPMENT

2.2.1 Nameplates

Securely affix a standard nameplate to pumps and motors in a conspicuous place showing the manufacturer's name, address, type or style, model, serial number, and catalog number. In addition, for each pump show the capacity in [L/second](#) [gpm](#) at rated speed in rpm and total head in [mm](#) [feet](#) of water. For each electric motor show at least the minimum information required by [NEMA MG 1](#). Show such other information as the manufacturer may consider necessary to complete identification on the nameplate. Pumps must be listed and labeled by UL, and comply with [UL 778](#) for pumps not using universal motors rated more than 250 volts such as circulating pumps.

2.2.2 Framed Instructions

Submit proposed diagrams, instructions, and other sheets, prior to posting. Post 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, where directed. Provide 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, framed as specified above for the wiring and control diagrams, and posted beside the diagrams. Post the framed instructions before acceptance testing of the systems.

2.2.3 Pump Characteristic

NOTE: Characteristics of each pump are normally 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** are to 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 are to be removed indicating pumps will match the system curve.

Construct hydronic water pumps in accordance with **HI ANSI/HI 14.1-14.2**. The pumps must be capable of discharging quantities at total discharge heads measured at the discharge flange, between the following limits:

Operate pumps at optimum efficiencies to produce the most economical pumping system under the conditions encountered [and size to make optimum match with the system head curve as shown]. [Suction lift on Pump No. [_____] must not be more than [_____] **mm feet**.] [The shutoff total head must not be greater than 120 percent of total rated head.] Operate pumps at specified system fluid temperatures without vapor binding and cavitation. Select pumps to operate within the Preferred Operating Region (POR) related to specific speed in accordance with **HI ANSI/HI 9.6.3**.

2.2.4 Pump Drivers

Provide electric motors as indicated for each pump and in accordance with Section [26 20 00 INTERIOR DISTRIBUTION SYSTEM][_____].

2.2.5 Equipment Data

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**. Provide 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 a complete list of parts and supplies, with current unit prices and local source of supply with contact information.

Submit catalog information, certified pumps curves, rated capacities, final impeller dimensions, and accessories provided for the product indicated. Indicate operating point of each pump on curves. Furnish pump curves for each pump and combination of pumps designed to operate in parallel. The pump curve must show as a minimum; bhp, flow, total dynamic head, efficiency, NPSH, impeller diameter and system curve (individually and in combination for each pump operating in a parallel application). Select pumps operating in parallel operation to cross the system curve while operating in parallel and during single pump operation.

2.3 HYDRONIC PUMPS

NOTE: Clearly correlate the hydronic pump schedule
on the drawings with the pump type terminology used
in this specification.

2.3.1 Circulator Pump[s]

NOTE: These pumps deliver up to 10 L per second 150
gpm and up to 10 m 35 feet head. They are most
often used for low flow rates in small systems and
are available in a wet rotor or three piece oil
lubricated design. Wet rotor circulators use system
fluid for cooling and lubrication. They do not
require oiling and are less expensive; however, the
impeller can stick after a prolonged shutdown.
Three piece circulators are oil lubricated with the
potential for longer life if properly lubricated and
can overcome a stuck impeller after a prolonged
shutdown; however, there is potential maintenance of
mechanical seals and coupling assembly.

Provide pumps with capacities as indicated of a horizontal, [in-line,
three piece oil lubricated] [wet rotor] circulator type specifically
designed for quiet operation. Suitable for 107 degrees C 225 degrees F
operation at [860][] kPa [125][] psig working pressure. The
pump must be single stage with [flanged][union] piping connections. The
pump internals must be capable of being serviced without disturbing piping
connections.

[

NOTE: Insert the following paragraph for three
piece oil lubricated circulator pumps.

- a. The three piece pump must be composed of three separable components a
motor, bearing assembly, and [cast iron][lead free bronze] certified
in accordance with NSF 372 pump end (wet end). The motor shaft must
be connected to the pump shaft via a replaceable flexible coupler.

][

NOTE: Insert the following paragraph for wet rotor
circulators used for potable water service.

- b. Wet rotor circulator for potable water service must be lead content
certified in accordance with NSF 372.

2.3.1.1 Seal Assembly

NOTE: Retain this paragraph for wet rotor
circulators used for potable water service.

Pump must be equipped with an internally flushed mechanical seal assembly. Seal assembly must have a brass housing, Buna bellows and seat gasket, stainless steel spring, and be of a carbon ceramic design with the carbon face rotating against a stationary ceramic face.

2.3.1.2 Motor Mount

NOTE: Include this paragraph for three piece oil lubricated circulators.

To ensure alignment, mount the motor to the bearing assembly via a bolted motor bracket assembly. Use a replaceable resilient rubber motor mount to assist in aligning the motor shaft with the pump shaft.

2.3.1.3 Motors

Motors must meet scheduled horsepower, speed, voltage, and specified enclosure design. Motors must be[open drip proof,][totally enclosed fan cooled,][weather protected type I,][weather protected type II,] maintenance free, premium efficiency and in accordance with **NEMA MG 1**.

[

NOTE: Include the following paragraph for variable speed pumps with ECM motors.

Pump must be driven by an electrically commutated electrical motor (ECM) with permanent magnet rotor. The rotor magnets must be time stable, non-toxic ceramic magnets. Drive the electrically commuted electrical motor by a frequency converter with an integrated active PFC filter.

]

2.3.2 Small In-Line Pump[s]

NOTE: These pumps deliver up to 12.5 L per second 200 gpm and 17 m 55 feet head. Pump motor shaft must stay horizontal, but pump body can be repositioned for horizontal or vertical discharge. These pumps are designed for 1750 rpm and indoor service using open drip proof enclosure electric motors.

Provide pumps with capacities as indicated, suitable for 107 degrees C 225 degrees F operation at [1204][_____] kPa [175][_____] psig working pressure. The pump must be single stage, in-line design, in cast iron bronze fitted construction. The pump internals must be capable of being serviced without disturbing piping connections.

2.3.2.1 Pump Shaft

The pump must have a solid steel shaft with a coupler between the pump and motor shafts. For non-stainless steel shafts, employ a non-ferrous shaft sleeve to completely cover the wetted area under the seal.

2.3.2.2 Bearing

The bearing assembly must house maintenance-free permanently lubricated bearings.

2.3.2.3 Seal Assembly

Equip the pump with an internal self-flushing mechanical seal assembly. Seal assembly must have Buna bellows and seat gasket, stainless steel spring, and be of a carbon ceramic design with the carbon face rotating against a stationary ceramic face.

2.3.2.4 Impeller

Provide impeller of cast bronze or brass material. Impeller must be hydraulically and dynamically balanced to HI 9.6.4 balance grade G6.3, keyed to the shaft and secured by a locking cap screw or nut.

2.3.2.5 Volute

Pump volute must be of cast iron. The connection style on cast iron pumps must be flanged.

2.3.2.6 Motor Mount

To ensure alignment, mount the motor to the bearing assembly via a bolted motor bracket assembly. Use a replaceable resilient rubber motor mount to assist in aligning the motor shaft with the pump shaft.

2.3.2.7 Motors

NEMA MG 1, premium efficiency, non-overloading at any point on the pump curve, maintenance free with permanently lubricated bearings, and resilient mounted for smaller sizes; rigid mounted otherwise.

2.3.3 Large In-Line Pump[s]

NOTE: Large In-Line pumps can deliver up to 158 L per second 2500 gpm and 38 m 125 ft head at 1750 rpm. Large vertical in-line pumps including motor can be more expensive than base-mounted, flexible coupled end suction pumps, however they offer the benefit of being installed in a smaller footprint, not requiring alignment, and have lower vibration issues and when considering other installed components recommended for base-mounted pump installations but not vertical inline pump they may be lower cost. In some cases floor space is limited so large in-line pumps may need to be used. Large In-Line pumps come in two basic configurations - split coupled and close coupled. Split coupled configuration allows mechanical seal maintenance without disturbing the pump or motor. However, split coupled pumps only allow the motor shaft to be oriented vertically with motor shaft down. Close coupled pumps may be mounted with the motor shaft vertical or horizontal but do not allow mechanical seal maintenance without disturbing the pump or

motor. When mounted horizontally, it is critical that adequate support be provided to avoid strain on pump parts and piping.

Provide pumps with capacities as indicated; [split-coupled] [closed coupled], in-line, single stage, for installation in [vertical] [horizontal (where close coupled)] position, and. suitable for 107 degrees C 225 degrees F operation at [1204][_____] kPa [175][_____] psig working pressure. The pump internals must be capable of being serviced without disturbing piping connections.

2.3.3.1 Casing

Provide pump casing complying with ASTM A48/A48M Class 30 cast iron, suitable for [1204][_____] kPa [175][_____] psig working pressure with integral cast iron flanges drilled for ASME B16.1 [ANSI Class 125] [ANSI Class 250] flanges, with an integrally-cast support ring matching an Class 125 flange for pump support. The pump volute must include gauge taps at suction and discharge nozzles along with vent and drain taps at top and bottom.

2.3.3.2 Pump Shaft

Provide carbon or stainless steel pump shaft, guided by a carbon graphite lower throttle bushing. Carbon steel pump shaft must have a bronze shaft sleeve that completely covers the wetted area under the seal.

2.3.3.3 Seal Assembly

Equip the pump with a mechanical seal assembly consisting of a carbon seal rotating ring, stainless steel spring, ceramic seat and flexible bellows and gasket. The liquid cavity must have a tapped flush line with manual valve to remove air from the seal chamber to allow fast initial start-up and ensure mechanical seal cooling.

2.3.3.4 Spacer Coupling

NOTE: Delete paragraph specifying spacer coupling below when close coupled pumps are used.

The axially split spacer coupling must be of high tensile aluminum, split to allow the servicing of the seal. The coupling must allow for servicing the seal without disturbing the pump or motor. Pump coupler must be aligned by the manufacturer before shipment. The motor bracket must contain a carbon steel coupler guard conforming to 29 CFR 1910.219 standards for safety.

2.3.3.5 Impeller

NOTE: Bronze impellers should not be used for pumping temperatures in excess of 120 degrees C 250 degrees F. Consult manufacturer for temperatures exceeding 120 degrees C 250 degrees F.

Hydraulically and dynamically balance the impeller to HI 9.6.4 balance grade G6.3, closed, single suction, fabricated from [cast bronze,][stainless steel,] keyed to the shaft, and secured by a locking capscrew.

2.3.3.6 Motor

NOTE: Motor enclosure is usually open drip proof where motor is located in dry, clean, well ventilated indoor area. Use totally enclosed fan cooled motor enclosure for outdoor service.

Electric motors must meet NEMA MG 1 and the horsepower, speed, voltage, indicated. Motor enclosure must be[open drip proof,][totally enclosed fan cooled],[weather protected type I,][weather protected type II,] with heavy duty grease lubricated ball bearings completely adequate for the maximum load for which the motor is designed. Motor must be non-overloading at any point on the pump curve and premium efficiency. Totally enclosed fan cooled motor efficiencies must be as shown in NEMA MG 1.

Include one-piece combination motor bracket and volute cover plate in the assembly to ensure concentric alignment of the motor to the pump casing.

2.3.4 Base-Mounted, Flexible Coupled, End suction Pump[s]

Provide pumps with capacities as indicated; base mounted, separately-coupled, end suction designed with volute housing mounted to the frame to allow for pump service without relocating the motor or disturbing piping connections. Bearings and seals must be serviceable without disturbing piping. Pump must be factory hydrostatically tested in accordance with Hydraulic Institute standards and thoroughly cleaned.

2.3.4.1 Casing

NOTE: Cast iron casings should not be used for pumping temperatures in excess of 120 degrees C 250 degrees F. Consult manufacturer for temperatures exceeding 120 degrees C 250 degrees F.

Provide radially split pump casing ASTM A48/A48M Class 30 cast iron suitable for [1204][1720][_____] kPa [175][250][_____] psig working pressure with integral cast iron flanges drilled for ASME B16.1 [ANSI Class 125][ANSI Class 250] flanges, with an integrally-cast pedestal support foot. The pump volute must include gauge tapings at suction and discharge nozzles along with vent and drain tapings at top and bottom.

2.3.4.2 Pump Shaft

NOTE: Carbon steel shaft should not be used for pumping temperatures in excess of 120 degrees C 250 degrees F. Consult manufacturer for temperatures exceeding 120 degrees C 250 degrees F.

Carbon steel pump shaft with a replaceable [bronze][stainless steel] shaft sleeve completely covering the wetted area of the shaft under the seal.

2.3.4.3 Bearing

NOTE: Regreasable ball bearings are discouraged. Studies have indicated that contamination and ineffective lubrication are responsible for approximately half of all bearing replacements. Concerns include the following; excessive grease causing bearings to overheat, bearings are required to be regreased on a regular interval (2500 operating hours or every six months), impurities can be introduced when regreasing bearings, and grease added must be compatible with grease applied previously.

Incorporate maintenance free, permanently lubricated and sealed bearings in the pump bearing frame.[Regreasable ball bearing type with provision for purging or flushing through the bearing surface and greased while running after start-up.]

2.3.4.4 Seal Assembly

NOTE: When fluid used to internally flush seals exceeds 107 degrees C 225 degrees F, provide a heat exchanger to decrease the temperature of the seal flushing water to 107 degrees C 225 degrees F in order that the seal life does not get shortened.

Equip with an integrally flushed mechanical seal assembly or a positive pressure external seal flushing line. Provide a mechanical seal with ceramic seal seat and carbon seal ring. Seal assembly must be rated up to 107 degrees C 225 degrees F.

2.3.4.5 Baseplate

Baseplate must be of steel construction fully enclosed at sides and ends with welded cross members and fully open grouting area for field grouting. Minimum base plate stiffness must conform to HI 1.3 for horizontal baseplate design standards.

2.3.4.6 Coupler

Provide a flexible-type coupler between the pump and motor, capable of absorbing torsional vibration and variable speed operation between the pump and motor. The coupler must allow replacement with no need to move the hubs. Coupler must have natural rubber or neoprene type element materials with a maximum misalignment capability of 4 degrees angular and 3 mm 0.125 inches parallel. Provide donut shaped elastomer element with preassembled flanges mechanically clamped to reinforced element and preassembled spacer center assembly. Secure flexible donut shaped element of coupler in place with radial clamp ring screws. Couplers must be rated for required maximum rpm, amperage horsepower and torque. The coupler

must be shielded by a coupler guard securely fastened to the base. Provide coupler guard in compliance with current national safety standards including 29 CFR 1910.219 and NEMA Z535.4. Guards cannot have gaps greater than 6 mm 0.250 inches, must be bright in color, and have an NEMA Z535.4 compliant warning label.

2.3.4.7 Impeller

NOTE: Cast bronze impellers should not be used for
pumping temperatures in excess of 120 degrees C 250
degrees F. Consult manufacturer for temperatures
exceeding 120 degrees C 250 degrees F.

Hydraulically and dynamically balance to HI 9.6.4 balance grade G6.3,
closed, overhung, single suction, fabricate from [cast bronze][stainless
steel], key to shaft and secured by a locking cap screw.

2.3.4.8 Motor

NOTE: Motor enclosure is usually open drip proof
where motor is located in dry, clean, well
ventilated indoor area. Use totally enclosed fan
cooled motor enclosure for outdoor service.

Electric Motors must meet NEMA MG 1 and be the wattage horsepower, speed,
and voltage indicated. Motor enclosure must be [open drip proof,][
totally enclosed fan cooled,] [weather protected type I,][weather
protected type II]. Motor must have heavy duty grease lubricated ball
bearings completely adequate for the maximum load for which the motor is
designed. Motor must be non-overloading at any point on the pump curve
and premium efficiency.[Totally enclosed fan cooled motor efficiencies
must comply with NEMA MG 1.]

2.3.5 Base-Mounted, Close Coupled, End Suction Pump[s]

NOTE: Use of base-mounted, close coupled, end
suction pumps is discouraged. This type of pump
takes up less floor space than base-mounted,
flexible coupled, end suction pumps and should only
be considered when floor space is extremely
limited. Close coupled pumps do not have a pump
shaft and pump bearing assembly. Motor bearings
must be able to handle both motor rotating element
and impeller forces. This requires a special motor
with bearings designed to handle additional impeller
loads and shaft that extends into the volute. This
type of pump can be about the same cost as the
preferred base-mounted, flexible coupled, end
suction pump.

Provide pumps with capacities as indicated. Pump must be base mounted,
close coupled, single stage, end suction design capable of being serviced
without disturbing piping connections.

2.3.5.1 Casing

Provide pump volute of Class 30 cast iron suitable for [1204][_____] kPa [175][_____] psig working pressure. Include vent, drain and gauge taps.

2.3.5.2 Seal Assembly

Seal off the liquid cavity at the motor shaft by an internally flushed mechanical seal or a positive pressure external seal flushing line with ceramic seal seat and carbon seal ring, suitable for continuous operation at 107 degrees C 225 degrees F. A replaceable shaft sleeve of bronze alloy must completely cover the wetted area under the seal.

2.3.5.3 Impeller

Provide cast bronze or 304 stainless steel impeller, enclosed type, hydraulically and dynamically balanced to HI 9.6.4 balance grade G6.3, keyed to shaft and secured by a locking cap screw.

2.3.5.4 Motor

NOTE: Motor enclosure is usually open drip proof
where motor is located in dry, clean, well
ventilated indoor area. Use totally enclosed fan
cooled motor enclosure for outdoor service.

Electric Motors must comply with NEMA MG 1 and be the wattage horsepower, and voltage indicated. Motor enclosure must be [open drip proof,][totally enclosed fan cooled,] [weather protected type I][weather protected type II]. Provide with heavy duty grease lubricated ball bearings completely adequate for the maximum load for which the motor and pump impeller is designed. Motor must be non-overloading at any point on the pump curve and premium efficiency. Totally enclosed fan cooled motor efficiencies must be as shown in NEMA MG 1.

2.3.6 Base-Mounted, Flexible Coupled, Double Suction[,][Horizontally Split][and][Vertically Split] Pump[s]

Provide pumps with capacities as indicated; base mounted, flexible coupled, double-suction, [horizontal][and][vertical] split case design, single stage centrifugal pump. Construction must be cast iron - bronze fitted, equipped with mechanical seals. Bearings and seals must be serviceable without disturbing piping or motor. Factory hydrostatically test the pump in accordance with Hydraulic Institute standards and thoroughly clean.

2.3.6.1 Casing

NOTE: Cast iron casings should not be used for
pumping temperatures in excess of 120 degrees C 250
degrees F. Consult manufacturer for temperatures
exceeding 120 degrees C 250 degrees F.

Provide ASTM A48/A48M Class 30 or ASTM A159 cast iron pump casing, suitable for [1204][_____] kPa [175][_____] psig working pressure, with

integral cast iron flanges drilled for ASME B16.1 [ANSI Class 125] [ANSI Class 250] flanges. Supply the pump volute with plugged vent, drain, and gauge tapss.

2.3.6.2 Bearings

NOTE: The use of regreasable ball bearings are discouraged. Studies have indicated that contamination and ineffective lubrication are responsible for approximately half of all bearing replacements. Concerns include the following: excessive grease causing bearings to overheat, bearings are required to be regreased on a regular interval (2500 operating hours or every six months), impurities can be introduced when regreasing bearings, and grease added must be compatible with grease applied previously.

Incorporate maintenance free, permanently lubricated and sealed bearings with an L10 life of 60,000 hours minimum in the pump bearing frame.

[
Incorporate regreasable ball bearing type pump bearing frame with provision for purging or flushing through the bearing surface and greased while running after start-up.]

2.3.6.3 Seal Assembly

NOTE: When fluid used to internally flush seals exceeds 107 degrees C 225 degrees F, provide a heat exchanger to decrease the temperature of the seal flushing water to 107 degrees C 225 degrees F so that the seal life does not get shortened.

[Seal off liquid cavity by an internally flushed seal assembly. Seal assembly must have a brass housing, Buna bellows and seat gasket, stainless steel spring, and be of a carbon face rotating against a stationary silicon carbide seat. Provide replaceable mechanical seals without disturbing the upper casing half and system piping. Seals must be suitable for continuous operation at 107 degrees C 225 degrees F.][
Equip pumps with cartridge mechanical seal assemblies consisting of a carbon seal rotating ring, stainless steel spring, and ceramic seat. Cartridge seals must be easily replaceable without disturbing the pump assembly, enhancing reliability and reducing maintenance downtime. Ensure seals are suitable for continuous operation at 107 degrees C 225 degrees F.]
Arrange to assure that seal leakage cannot enter the bearing housings.

2.3.6.4 Coupler

Provide a flexible-type coupler between the pump and motor capable of absorbing torsional vibration and variable speed operation. The coupler must allow replacement with no need to move the hubs. Coupler must have natural rubber or neoprene type element materials with a maximum misalignment capability of 4 degrees angular and 3 mm 0.125 inches parallel. Provide donut shaped elastomer element and with preassembled flanges mechanically clamped to reinforced element and preassembled spacer

center assembly. Secure flexible donut shaped element of coupler in place with radial clamp ring screws. Couplers must be rated for required maximum rpm, wattage horsepower and torque. Shield the coupler by a coupler guard securely fastened to the base. Coupler guard must comply with current national safety standards including 29 CFR 1910.219, and NEMA Z535.4. Provide guards with gaps no greater than 6 mm 0.250 inches, of bright in color, and have an NEMA Z535.4 compliant warning label.

2.3.6.5 Base Plate

Provide baseplate of steel construction fully enclosed at sides and ends with welded cross members and fully open grouting area for field grouting. Minimum base plate stiffness must conform to HI 1.3 for horizontal baseplate design standards.

2.3.6.6 Impeller

NOTE: Cast bronze impellers should not be used for
pumping temperatures in excess of 120 degrees C 250
degrees F. Consult manufacturer for temperatures
exceeding 120 degrees C 250 degrees F.

[Bronze][Stainless steel] enclosed double suction type, both hydraulically and dynamically balanced in accordance with HI 9.6.4 grade G6.3, keyed to shaft and fixed in an axial position. Hub must have sufficient metal thickness to allow machining for installation of impeller rings.

2.3.6.7 Motor

NOTE: Motor enclosure is usually open drip proof
where motor is located in dry, clean, well
ventilated indoor area. Use totally enclosed fan
cooled motor enclosure for outdoor service.

Provide electric motor conforming to NEMA MG 1 and of the wattage horsepower, and voltage indicated. Motor enclosure must be [open drip proof,] [totally enclosed fan cooled,] [weather protected type I][weather protected type II]; with heavy duty grease lubricated ball bearings completely adequate for the maximum load for which the motor is designed. Motor must be non-overloading at any point on the pump curve and premium efficiency. Totally enclosed fan cooled motor efficiencies must be as shown in NEMA MG 1.

2.3.6.8 Pump Shaft

Provide pump shaft of solid 416 stainless steel shaft or solid carbon steel shaft with replaceable bronze or 304 stainless steel shaft sleeve covering wetted area of shaft.

2.3.7 Vertical Lineshaft Turbine Pump[s]

Provide pumps with capacities as indicated. Pump must be vertical lineshaft turbine manufactured for lubrication of the line-shaft bearings by the water being pumped. Design and manufacture the pumping unit in accordance with HI ANSI/HI 14.1-14.2 standards AWWA E103.

2.3.7.1 Bowl Assembly

Flange type construct the intermediate bowls, discharge cases and suction bowls from **ASTM A48/A48M** Class 30 close grain cast iron. They must be free of defects and accurately machined and fitted to **ASME B4.2 ASME B4.1** close tolerances. Epoxy enamel coat the intermediate bowls waterways for maximum efficiency. Thread all threaded discharge cases for water lubricated column assembly. All assembly bolting must be stainless steel. Provide intermediate bowl bearings.

2.3.7.2 Pump Shaft

Construct the bowl shaft from **ASTM A582/A582M** type 416 stainless steel, precision ground and polished with surface finish better than 40 RMS.

2.3.7.3 Lineshaft

Vertical pump lineshaft must be [open][enclosed] and constructed from **ASTM A582/A582M** type 416 stainless steel. Straighten lineshaft sections per manufacturer tolerances. Lineshaft sections must not exceed **3 m 10 feet** in length and must be coupled with threaded stainless steel couplings. Design the diameter of the lineshaft and coupling in accordance with **AWWA E103**.

2.3.7.4 Impeller

Provide impellers of **ASTM B584** silicon bronze or stainless steel, the enclosed type. They must be free from defects, machined, and balanced to **HI 9.6.4** balance grade G6.3 for optimum efficiency and performance. Securely fasten to the bowl shaft with stainless steel taper lock collets. The impellers must be adjustable by means of a top shaft adjusting nut or adjustable solid shaft coupling.

2.3.7.5 Discharge Head

Construct the discharge head, sized for pump capacity, of **ASTM A48/A48M** Class 30 high grade ductile iron or fabricated steel of the high profile type with an integral motor base which allows the head shaft to be coupled to the top shaft above the stuffing box. A separate motor stand is not acceptable. The discharge head must have an **ASME B16.1** (for cast iron) or Class 150 (for steel) discharge flange supplied with dual **6 mm 1/4 inch** NPT ports at the top. Thread the head to accept the column pipe.

2.3.7.6 Stuffing Box

NOTE: Stuffing box is recommended over mechanical seals for vertical turbine pumps due to the many variables encountered in mechanical seal applications with this type of pump. Abrasives are commonly found in condenser water open loop systems, where this type of pump is used, that cause premature mechanical seal failure.

Provide stuffing box of cast or ductile iron, **ASTM A536** class 65, and containing a minimum of five rings of packing; with an available fitting for pressure relief. The packing follower gland must be stainless steel

and secured in place by stainless steel studs and nuts. The packing box bearing must be bronze. Provide a water slinger to operate on the top shaft, above the packing gland.

2.3.7.7 Mechanical Seal

Provide a mechanical seal.

2.3.7.8 Column Pipe

Provide column pipe of **ASTM A53/A53M** grade B steel pipe not less than Schedule 30. Machine the column ends with threads and faced parallel to the threads to ensure proper alignment. Connect the pipe with threaded sleeve type ductile iron couplings or flanges that accept **20 mm 3/4 inch** stainless steel or bronze bearing retainers. Lineshaft bearings must be fluted rubber retained in a centering spider retainer.

2.3.7.9 Basket Strainer

Provide and attach a stainless steel basket strainer of a suitable size to the pump suction with stainless steel fasteners. Strainer must have a net inlet area equal to at least three times the impeller inlet area. The maximum opening must not be more than 75 percent of the maximum opening of the water passage through the bowl or impeller.

2.3.7.10 Motor

Electric motor must meet **NEMA MG 1** and be the size and voltage indicated. Provide [1800RPM] [_____] motor with NEMA Class B or Class F insulation. The motor must have a vertical hollow (or solid) shaft motor with space heaters and a non-reverse ratchet (or self-release coupling) to prevent reverse rotation. The motor must have an angular contact thrust bearing to meet the designed pump's hydraulic thrust load plus the weight of the rotating parts under operating conditions. Provide high efficiency motor with a weather protected type I enclosure, [230/460][_____] volt, [3][1] phase, 60HZ, and a [1.15][_____] service factor. Motor must be non-overloading at any point on the pump curve and premium efficiency. Provide motor with efficiencies in compliance with **NEMA MG 1**.

2.3.8 Cooling Coil Condensate Pump Units

Provide pumps with capacities as indicated. Cooling Coil Condensate Pump Unit must be a packaged unit including a corrosion-resistant pump, plastic tank with cover, and automatic controls. Include [factory] [field] installed check valve.[Provide a **1800 mm 72 inch** minimum, electrical power cord with plug for 120V/1PH/60HZ electrical service.][Provide hard wired power connection.]

2.3.8.1 Motor

Electric motor must comply with **NEMA MG 1** and be the size, and voltage indicated.

2.4 ELECTRICAL WORK

Provide electrical motor driven equipment specified herein complete with motors, motor starters, and controls. Provide electric equipment and wiring in accordance with Section **26 20 00 INTERIOR DISTRIBUTION SYSTEM**. Electrical characteristics must be as indicated. Provide motor starters

complete with properly sized thermal overload protection in each phase and other appurtenances necessary for the motor control specified. Each motor must 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 indicated must be provided under this section of the specifications.

2.5 ELECTRICAL EQUIPMENT

Provide electrical equipment in conformance with Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM. Provide electrical motor driven equipment herein specified complete with motors, motor starters, and controls. Motor controls, equipment, and wiring must be in accordance with NFPA 70.

2.5.1 Electric Motors

Drive each electric motor-driven pump by a continuous-duty electric motor with enclosure type for specific service as defined in paragraph HYDRONIC PUMPS. Motor must have a [1.5][_____] service factor. Provide [squirrel-cage induction][synchronous][electronically commutated] motors having normal-starting-torque and low-starting-current characteristics, and of sufficient size so that the nameplate wattage horsepower rating must not be exceeded throughout the entire published pump characteristic curve. Integral size motors must be the premium efficiency type in accordance with NEMA MG 1. Motor bearings must provide smooth operations under the conditions encountered for the life of the motor. Provide adequate thrust bearing in the motor to carry the weight of all rotating parts plus the hydraulic thrust and be capable of withstanding upthrust imposed during pump starting[and under variable pumping head conditions specified]. Motors must be rated [_____] volts, [_____] phase, 60 Hz and such rating must be stamped on the nameplate. Provide motors in conformance with NEMA MG 1.

2.5.2 Control Equipment

[Manually controlled pumps must have START-STOP pushbutton in cover.][Automatically controlled pumps must have three-position "MANUAL-OFF-AUTOMATIC" selector switch in cover.] Provide additional controls or protective devices as indicated. [Install a pump low-water cutoff [in the well][on the suction pipe] and must shut the pump off when the water level in the well reaches the level shown.]

2.5.3 Variable Speed Control

NOTE: If any of the motors have a variable speed control, then include appropriate paragraph below. Provide AC motors used with VFD's as inverter-ready or inverter-capable general-purpose motors. It is generally not necessary to specify an inverter duty rated motor for variable torque loads such as occurs with centrifugal pumps.

[2.5.3.1 Adjustable Speed Drive

The variable speed motor controllers must be in accordance with Section 26 29 23 ADJUSTABLE SPEED DRIVE SYSTEMS UNDER 600 VOLTS.

]2.5.3.2 Combination Motor and Adjustable Speed Drive

Combination motor and variable speed motor controller provided by the pump manufacturer. Include provisions in the motor-drive unit to disconnect the drive and motor independently. Fit the motor-drive unit with a menu-driven graphical keypad display for drive control and provide a rated enclosure with an environmental protection rating of NEMA4/IP55. The drive unit must integrate[into the building automation system in accordance with [Section 23 09 00 INSTRUMENTATION AND CONTROL FOR HVAC][Section 23 09 23.01 LONWORKS DIRECT DIGITAL CONTROL FOR HVAC AND OTHER BUILDING CONTROL SYSTEMS][or][Section 23 09 23.02 BACNET DIRECT DIGITAL CONTROL FOR HVAC AND OTHER BUILDING CONTROL SYSTEMS]][into the existing building automation system] and allow control by Direct Digital Control (DDC) sytem control signal. The motor-drive unit must be capable of multi-pump control up to four pumps in parallel.

]2.5.3.3 Electronically Commutated Motor

The pump is to be driven by an electronically commutated electrical motor (ECM) with permanent magnet rotor. The rotor magnets must be time stable, non-toxic ceramic magnets. Drive the electronically commutated motor by a frequency converter with an integrated PFC filter.

]2.6 PACKAGED PUMP SYSTEM

NOTE: Packaged pump systems are generally most useful in existing facilities where existing pumping systems must be replaced in the same basic location while limiting total system downtime due to an operating facility. One tradeoff is that they have their own packaged control system separate from the DDC system contractor.

Provide packaged pump system which includes pumps[, variable frequency drives], piping, valves, complete wiring and controls systems, and accessories as specified.

2.6.1 Pumps

Pumps must be [large vertical in-line][base-mounted, flexible couple, end section][base-mounted, close couple, end suction][base-mounted, flexible coupled, [double suction][horizontally split][vertically split][vertical lineshaft turbine]]. Indicate pump capacities on the drawings.

2.6.2 Piping and Appurtenances

Ship the pump package pump system with all internal piping installed. The piping includes pumps, suction piping, discharge piping, pressure sensing, and gauge piping. When flanged field connections are required, module piping must terminate with a mechanical grooved type flange to facilitate alignment. The piping must consist of fabricated welded steel headers with cast iron fittings in and out of pumps. Provide an ANSI flange at

the suction and discharge connection for the system, with same pressure class as the piping system, but not less than 150 psig. Provide butterfly valves on the suction and discharge of each pump. Support piping independently of pump connections. Pipe all control sensing lines and gauge connections with shut-off valves. Provide pressure gauges mounted on a panel for indication of suction and discharge pressure. Install a check valve on the discharge of each pump. Install a suction strainer on the suction of each pump. The strainer must be of the type mounted directly to the pump suction or inline "Y" type. Components must be in accordance with Section 23 05 15 COMMON PIPING FOR HVAC.

2.6.3 Structural Steel Base

Mount pumps on the structural steel base free of distortion caused by flexing of the system piping by providing flexible coupling on pump suction and discharge connection.

[2.6.4 Variable Speed Control

2.6.4.1 Adjustable speed Drive Systems

The variable speed motor controllers must be in accordance with Section 26 29 23 ADJUSTABLE SPEED DRIVE SYSTEMS UNDER 600 VOLTS.

2.6.4.2 Motor-Drive Unit

Combination motor and variable speed motor controller provided by the pump manufacturer. Include provisions in the motor-drive unit disconnect the drive and motor independently. Provide the motor-drive unit with a menu-driven graphical keypad display for drive control and provide a rated enclosure with an environmental protection rating of NEMA4/IP55. The drive unit must integrate [into the building automation system in accordance with [Section 23 09 00 INSTRUMENTATION AND CONTROL FOR HVAC][Section 23 09 23.01 LONWORKS DIRECT DIGITAL CONTROL FOR HVAC AND OTHER BUILDING CONTROL SYSTEMS][or][Section 23 09 23.02 BACNET DIRECT DIGITAL CONTROL FOR HVAC AND OTHER BUILDING CONTROL SYSTEMS]][into the existing building automation system] and allow control by DDC system control signal. The motor-drive unit must be capable of multi-pump control up to four pumps in parallel.

2.6.4.3 Electronically Commutated Motor

Drive the pump by an electronically commutated electrical motor (ECM) with permanent magnet rotor. The rotor magnets must be time stable, non-toxic ceramic magnets. Drive the electronically commutated motor by a frequency converter with an integrated PFC filter.

]2.6.5 Electrical

Completely wire the pump package, in accordance with the NEC, from the main service disconnect to all the associated equipment. Include the following equipment: main service disconnect, [variable frequency drives,] pump controller, and transformer. Provide all equipment with overcurrent protection where required by NEC.

2.6.6 Controls

2.6.6.1 Controller

Control the packaged pump system by a direct digital controller, microcomputer based and must hold its keep memory in the event of power failure. Store in non-volatile memory on-line programmable data entries, such as set point. The controller must be capable of receiving up to ten differential input analog signals and comparing them to their individual set points. Utilize the analog signal that has deviated the greatest amount from its setpoint. This selected signal and its associated setpoint must be used as the command feedback inputs to perform a closed-loop-control function. The analog input signal must be the feedback or process and the setpoint must be the command. Control loop function must have the capability of performing a self-tuning algorithm to maintain the process variable at setpoint regardless of process loading conditions. The control cubicle must be single compartment construction. Controls must be 115 volt including run light and "Hand-Off-Automatic" switch for each pump, power on light, lead pump selector switch for manual alternation or automatic through the DDC system, pump sequencing logic, and necessary interface controls for variable frequency drives. Provide a control panel in compliance with the requirements of Underwriters Laboratories. All wiring and electrical construction within the panel must conform to Underwriters Laboratories' requirements.[The controller must be designed for remote mounting.]

2.6.6.2 Software

Provide the controller with off-line or on-line diagnostics software. The on-line diagnostics must perform such functions as "alarm definitions displayed". It must have as an integral part of its hardware designed a watchdog timer reset function and must be powered by 115 VAC, 60 HZ. The incoming power and input/output circuitry design must facilitate rejection of EMI (electromagnetic interferences) and RFI (radio-frequency interferences).

2.6.6.3 Integration

The pump package must be fully coordinated with and integrated [into the building automation system in accordance with [Section 23 09 00 INSTRUMENTATION AND CONTROL FOR HVAC][Section 23 09 23.01 LONWORKS DIRECT DIGITAL CONTROL FOR HVAC AND OTHER BUILDING CONTROL SYSTEMS][or][Section 23 09 23.02 BACNET DIRECT DIGITAL CONTROL FOR HVAC AND OTHER BUILDING CONTROL SYSTEMS]] [into the existing building automation system]. The following inputs and outputs must be interfaced between the pump system controller and the DDC system.

- a. Pump System Controller input from the DDC system.
 - (1) Secondary Pump System Start/Stop digital input.
 - (2) Pump 1 / 2 Lead/Lag.
 - (3) Primary Pump 1 Start/Stop.
 - (4) Primary Pump 2 Start/Stop.
- b. Pump System Controller Outputs to the DDC system.

- (1) Secondary Pump #1 on/off status digital output.
- (2) Secondary Pump #2 on/off status digital output.
- (3) Pump fail to start - digital output (alarm).
- (4) Secondary Pump #1 speed indication (4-20 ma).
- (5) Secondary Pump #2 speed indication (4-20 ma).
- (6) System Flow (4-20 ma).
- (7) Primary Pump 1 Flow status digital output.
- (8) Primary Pump 2 Flow status digital output.

2.6.6.4 Sequence

The pump system controller must receive a run enable from the DDC system and control the VFD to maintain the control point at the setpoint. Provide optimized control of the pumping system through the controller to provide the "best efficiency" of the pumping system. Primary pumps must start and stop based on command from the DDC System.

2.6.7 Testing

Hydrostatically test the entire module piping assembly at same pressure as the piping system but not less than 150 psig. Repair any leaks found and retest before module shipment.

Factory test the packaged pumping system at full flow conditions prior to shipment. Testing must include operation of the pumps, motors, variable frequency drives, controls and accessories. Certified test results to be provided to the [Engineer][Owner]. Notify the Engineer two weeks prior to factory test so that they may witness the same.

2.7 EQUIPMENT APPURTENANCES

2.7.1 Attachments

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

2.7.2 Equipment Guards

Provide equipment driven by open shafts, belts, chains, or gears with all-metal guards enclosing the drive mechanism. Secure guards in position with steel braces or straps that permit easy removal for servicing the equipment. Coupler guards must comply with current national safety standards including [29 CFR 1910.219](#) and [NEMA Z535.4](#). Provide guards with gaps no greater than [6 mm 0.250 inches](#), safety orange in color, and have an [NEMA Z535.4](#) compliant warning label.

2.7.3 Tools

Furnish a complete set of all special tools which may be necessary for the adjustment, operation, maintenance, and disassembly of all equipment. 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 must be high-grade, smooth, forged, alloy, tool steel. Furnish one pressure grease gun for each type of grease required. Deliver all tools 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 deliver them to the Contracting Officer.

[2.7.4 Pump Suction Diffuser/Guide

NOTE: Provide pump suction diffuser/guide when
manufacturers required suction inlet conditions are
not met.

Coordinate with rep on material. Carbon steel and
stainless steel are used for higher pressure
applications such as class 250 flanges.

Provide a [cast iron or ductile iron][carbon steel][stainless steel]
pump suction diffuser/guide with flanges confirming to ASME B16.1, Class
[125][250]. The pump suction guide must provide inlet condition
enhancement to the pump by guide vanes.

]2.8 FINISHES

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

[2.9 FACTORY TESTS

NOTE: Factory Tests for specific pumps shipped to
construction site are not normally required unless
the pumps are used for a critical application where
precise performance is required. Manufacturers'
performance data is based on factory tests using
precision instrumentation and exacting procedures as
detailed in Hydraulic Institute Standard ANSI/HI 1.6
Centrifugal Pump Tests for each typical pump model.
Delete the following paragraph unless required.

Pumps must be tested by the manufacturer or a nationally recognized
testing agency in compliance with HI 1.3. Submit certified test results.

]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

NOTE: Pump and driver shaft alignment on base mounted, long-coupled pumps is critical to reduce vibration, increase bearing life, increase coupler life, and increase mechanical seal life. Although shafts are typically aligned at the factory, some misalignment occurs during shipping and lifting. Dial indicators or laser devices are called out to accurately perform final alignment of pump and driver shafts. Scales, straight edges and calipers provide less accurate alignment and are only suitable for initial alignment.

Install each pump and motor in accordance with the written instructions of the manufacturer[and under the direct supervision of the manufacturer's representative]. Provide access space around the device for servicing no less than the minimum recommended by the manufacturer. All recommendations in the written instructions of the manufacturer are mandatory requirements.

[3.2.1 Base Mounted, Long-Coupled Pumps

Set the pump baseplate as follows.

- a. Place two sets of shims or wedges for each foundation bolt. Lower baseplate onto foundation bolts and level baseplate both lengthwise and across by adding or removing shims or mount wedges. A maximum difference of 3 mm 0.125 inches lengthwise and 1.5 mm 0.059 inches across is allowable.
- b. Mount pump and driver on baseplate if not already mounted at factory. Pump and driver shafts must have an initial cold (pump and driver at ambient temperature) alignment check and final hot (pump and driver at operating temperature) alignment check. Perform cold alignment check before baseplate is grouted, after baseplate is grouted, and after piping is connected. Perform final alignment check when pump and driver are at operating temperature. Move or shim only the driver to make adjustments to prevent strain on the piping installations. Initial alignment may be performed with scales, straight edges and calipers. Final alignment must be done with dial gauges or laser alignment devices. Final alignment misalignment may not exceed coupling manufacturer's maximum parallel and angular misalignment values. When using variable frequency drives, reduce the manufacturer's misalignment values by 50 percent. Remove flexible coupling when performing alignment.
- c. Support the connecting piping to ensure that there are no piping loads at the pump flange connections and connecting piping is not forced

into position.[Use concrete for equipment foundations in accordance with Section 03 30 00 CAST-IN-PLACE CONCRETE. Provide concrete foundations that are 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 pre-molded filler strip between the foundation and floor slab as shown. Furnish foundation bolts, as required, for proper positioning during the placement of the concrete.]

3.2.2 Large Vertical Inline Pumps

Support Large inline pumps by hangers on connected piping. Size pipe hangers for the additional weight of the pumping unit and other hydronic system components. Additional floor supports must be stanchion plates or pipe-stool. Install neoprene isolation pads under the floor supports.

3.3 FIELD QUALITY CONTROL

After installation of the pumping units and appurtenances, including coupling guard, is complete, carry out operating tests to assure that the pumping installation operates properly.[Make arrangements to have the manufacturer's representatives present when field equipment tests are made.] Give each pumping unit a running field test in the presence of the Contracting Officer for a minimum of 2 hours. 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. Tests must 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, correct such deficiencies and reconduct the tests.

Provide a pump start-up report and 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 must 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 must be thoroughly cleaned of all foreign material, and primed and top coated with the manufacturer's standard factory finish.

3.4.2 Exposed Ferrous Surfaces

Paint exposed ferrous surfaces with two coats of enamel paint in accordance with Section 09 90 00 PAINTINGS AND COATING. For interior ferrous metal, apply High Performance Latex System. Prime in accordance with MPI 76 and apply intermediate and topcoat in accordance with MPI 141. For exterior ferrous metal, apply Alkyd system. Primer per MPI 23 and apply intermediate and topcoat per MPI 94.

3.5 CLOSEOUT ACTIVITIES

3.5.1 Operation and Maintenance Manuals

Submit one complete set at the time the tests procedure is submitted; remaining sets before the contract is completed. Permanently bind each in 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. Use 216 by 279 mm 8-1/2 by 11 inches paper for instruction sheets, with large sheets of drawings folded in.

Include, but do not limit to, the following in the Instructions:

- a. System layout showing piping, valves, and controls.
- b. Approved wiring and control diagrams[including variable frequency drives].
- c. A control sequence describing startup, operation, and shutdown.
- d. Operating and maintenance instructions for each piece of equipment, including task list for routine maintenance, routine inspections, intermediate inspections, and annual inspections; lubrication instructions; and troubleshooting guide.
- e. Manufacturer's bulletins, cuts, and descriptive data; and parts list and recommended spare parts.

3.5.2 Training

Upon completion of the work, and at a time designated by the Contracting Officer, provide the services of one or more competent engineers 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 must cover all the items contained in the bound instructions. Submit the training course curriculum and training instructions 14 days prior to the start of training.

3.5.3 Pump Motor/Alignment Report

Provide a pump motor/alignment report for base mounted pumps showing alignment of the motor and driver with initial cold alignment check prior to grouting, after grouting, and after piping connection, and final hot alignment check. Include in the alignment reports the parallel and angular alignment values and manufacturer's maximum allowable values.

-- End of Section --