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USACE / NAVFAC / AFCEC **UFGS-35 45 01 (February 2021)**

Change 3 - 08/23

Preparing Activity: USACE **Superseding**
UFGS-35 45 01 (February 2016)

UNIFIED FACILITIES GUIDE SPECIFICATIONS

References are in agreement with UMRL dated July 2024
****

SECTION TABLE OF CONTENTS

DIVISION 35 - WATERWAY AND MARINE CONSTRUCTION

SECTION 35 45 01

VERTICAL PUMPS, AXIAL-FLOW AND MIXED-FLOW IMPELLER-TYPE

02/21, CHG 3: 08/23

ATTACHMENTS:

-- End of Section Table of Contents --

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SECTION 35 45 01

VERTICAL PUMPS, AXIAL-FLOW AND MIXED-FLOW IMPELLER-TYPE
02/21, CHG 3: 08/23

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NOTE: This guide specification covers the requirements for vertical axial-and mixed-flow impeller-type pumps, having a pump discharge diameter up to and including 2100 mm 84 inches, for flood control and hurricane protection projects. This section was originally developed for USACE Civil Works projects.

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

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

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

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Go to
http://www.wbdg.org/ffc/dod/unified-facilities-guide-specifications-ufgs/for

****

PART 1 GENERAL

****

NOTE: Figure 1, System Loss Curve (May be provided by the Designer). The Specifier should insert Figure 2 and Figure 3 at the end of this section as applicable to the design. (See paragraphs BEARING HEAT SENSORS, TEST SETUP, and VALUE OF NPSHR.)

This specification is written to obtain reliable, long-lasting pumps that are suited for the purpose intended at the most economical price. It requires the use of grease-, water- or oil-lubricated bearings and packing glands, and permits the manufacturer to use his standard castings for the suction bell and the bowls.

Alternate specifications for the "FACTORY TEST" have been provided in this specification. Alternate 1 gives the manufacturer the option of testing either the prototype pump or a homologous model of the pump. This alternative should be used for all pumps having a diameter up to and including 1200 mm 48 inches. Alternate 2, which requires a homologous model of the pump be tested for performance and NPSHR characteristics, should be used for pumps having a diameter greater than 1200 mm 48 inches. Alternate 2 can also be used for pumps smaller than 1200 mm 48 inches in diameter if the expected annual operating time is greater than 500 hours per year or for the special case when there is no published NPSHR curve available.

If this guide specification is used for a supply contract, the flexible mechanical couplings and harness bolts should be obtained under the construction contract, except when the pump manufacturer is required to furnish the discharge piping.

With a construction contract, it is the prime Contractor's responsibility to have equipment delivered when ready for installation. Inevitably, delays occur. Some storage will most likely be required. These requirements may be modified as required, but in no case should they be deleted when the storage of equipment is contemplated.

With a supply contract, the delivery of the equipment being furnished should be arranged to coincide with the date of installation, when possible. This will obviate the need for long-term storage of the equipment in Government-furnished space.

This specification has been prepared on the basis that it will be used in construction contracts. If this guide specification is to be used for supply contracts, paragraphs to be included in Part IV - TECHNICAL PROVISIONS should be arranged to follow the format listed below. Section 5 should be deleted when a reduction gear is not to be furnished, and the word "DELETED" should be substituted in lieu thereof. Section 1 should include appropriate provisions of Section 09 97 02 PAINTING: HYDRAULIC STRUCTURES, Section 05 50 14 STRUCTURAL METAL FABRICATIONS and Section 05 50 15 CIVIL WORKS FABRICATIONS.

Section 1 Materials and Fabrication
Section 2 Vertical Pumps
Section 3 Factory Test
Section 4 Electric Motor or Diesel Engine
Section 5 Reduction Gear
Section 6 Services of Erecting Engineer
****

1.1 PRICES

****
NOTE: If Section 01 20 00 PRICE AND PAYMENT PROCEDURES is included in the project specifications, this paragraph title (PRICES) should be deleted from this section and the remaining appropriately edited subparagraphs below be inserted into Section 01 20 00.
****

1.1.1 Vertical Pumps, Axial-Flow and Mixed-Flow Impeller-Type

1.1.1.1 Payment

Payment will be made for costs associated with [furnishing][furnishing and installing][installing] the vertical pumps, axial-flow and mixed-flow impeller-type, as specified.

1.1.1.2 Unit of Measure

Unit of measure: lump sum.

1.1.2 Contractor's Erection Engineer(s)

1.1.2.1 Payment

Payment will be made for costs associated with the services of the Contractor's erection engineer(s) for the period of time that erecting engineers are in service of the Government within the Continental United States, including time required by them to travel. No payment will be made for days the erecting engineers are absent from the jobsite, except for non-work days, National Legal Holidays, and authorized travel time. No additional or overtime payment will be made to the Contractor when the erecting engineers are required to work in excess of 8 hours per calendar day or 40 hours per week. If delays occur during periods of assembly, erection, or testing, wherein services of erecting engineers are not required, the Contracting Officer may direct the engineers to return to their home station, in which case they will not be paid for time they are not at the site of work, except for travel time; or direct engineers to remain at the site of work, in which case they will be paid as provided by contract.

1.1.2.2 Measurement

Services of the Contractor's erection engineer(s) will be measured for payment based upon contract unit price per calendar day for the number of calendar days that their services are required, including Sundays and National Legal Holidays. Time for travel will be measured for payment by the most direct commercial airline or rail route from their home station or port of entry, or from their duty station when travel time from the duty station is less than that required from home station or port of entry, to site of erection and return. When travel time from the duty station is greater than that required from home station or port of entry, only time from home station or port of entry will be allowed. Travel time will be allowed only from time of the first available transportation after release for return to home station or port of entry.

1.1.2.3 Unit of Measure

Unit of measure: per calendar day.

1.1.3 Transportation Expenses of Contactor's Erecting Engineer(s)

1.1.3.1 Payment

Payment will be made for costs associated with the travel and transportation expenses of the Contractor's erecting engineer(s). No payment will be made for daily commuting expenses or subsistence or other personal expenses while in route or at the jobsite. Also, no payment will be made for fare and transportation expenses outside of continental limits of the United States. Payment may be made for travel by privately owned conveyance if used in lieu of travel by common carrier.

1.1.3.2 Measurement

Travel and other necessary transportation expenses of the Contractor's erecting engineer(s) will be measured for payment based upon the travel fare by scheduled airline using less than first class accommodations, when available, or railroad and sleeping car fare when air travel accommodations are not available. Payment for travel by privately owned conveyance is made at the applicable mileage rate of [_____] cents per km mile, provided that such payment do not exceed the constructive cost of air coach accommodations, including consideration of the cost to the Government for the rate per calendar day bid for the services of the erecting engineer and regardless of whether space would have been available. When air accommodations are not available, the mileage reimbursement will be limited to the constructive cost of first class rail, when the elapsed time of rail travel is more than 4 hours; coach class when the elapsed time of rail travel is 4 hours or less; or when neither air nor rail accommodations are provided, the mileage reimbursement will be limited to the constructive cost of bus transportation.

1.1.3.3 Unit of Measure

per km mile.

1.2 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 PETROLEUM INSTITUTE (API)

API RP 686	(2009) Recommended Practice for Machinery Installation and Installation Design

AMERICAN SOCIETY OF MECHANICAL ENGINEERS (ASME)

ASME B16.5	(2020) Pipe Flanges and Flanged Fittings NPS 1/2 Through NPS 24 Metric/Inch Standard
ASME B17.1	(1967; R 2017) Keys and Keyseats
ASME B31.1	(2022) Power Piping
ASME B36.10M	(2022) Welded and Seamless Wrought Steel Pipe
ASME B46.1	(2020) Surface Texture, Surface Roughness, Waviness and Lay
ASME BPVC SEC IX	(2017; Errata 2018) BPVC Section IX-Welding, Brazing and Fusing Qualifications

AMERICAN WATER WORKS ASSOCIATION (AWWA)

AWWA C200	(2023) Steel Water Pipe - 6 In. (150 mm) and Larger
AWWA C203	(2020) Coal-Tar Protective Coatings and Linings for Steel Water Pipelines - Enamel and Tape - Hot-Applied
AWWA C207	(2023) Standard for Steel Pipe Flanges for Waterworks Service, Sizes 4 in. through 144 in. (100 mm through 3600 mm)
AWWA C208	(2022) Dimensions for Fabricated Steel Water Pipe Fittings
AWWA M11	(2017; Errata 2018, Addendum 2019) Steel Pipe: A Guide for Design and Installation

AMERICAN WELDING SOCIETY (AWS)

AWS D1.1/D1.1M	(2020; Errata 1 2021) Structural Welding Code - Steel

ASTM INTERNATIONAL (ASTM)

ASTM A27/A27M	(2020) Standard Specification for Steel Castings, Carbon, for General Application
ASTM A36/A36M	(2019) Standard Specification for Carbon Structural Steel
ASTM A48/A48M	(2022) Standard Specification for Gray Iron Castings
ASTM A108	(2024) Standard Specification for Steel Bar, Carbon and Alloy, Cold-Finished
ASTM A126	(2004; R 2023) Standard Specification for Gray Iron Castings for Valves, Flanges, and Pipe Fittings
ASTM A217/A217M	(2022) Standard Specification for Steel Castings, Martensitic Stainless and Alloy, for Pressure-Containing Parts, Suitable for High-Temperature Service
ASTM A242/A242M	(2024) Standard Specification for High-Strength Low-Alloy Structural Steel
ASTM A269/A269M	(2024) Standard Specification for Seamless and Welded Austenitic Stainless Steel Tubing for General Service
ASTM A276/A276M	(2024) Standard Specification for Stainless Steel Bars and Shapes
ASTM A285/A285M	(2017) Standard Specification for Pressure Vessel Plates, Carbon Steel, Low- and Intermediate-Tensile Strength
ASTM A312/A312M	(2022a) Standard Specification for Seamless, Welded, and Heavily Cold Worked Austenitic Stainless Steel Pipes
ASTM A351/A351M	(2024) Standard Specification for Castings, Austenitic, for Pressure-Containing Parts
ASTM A352/A352M	(2021) Standard Specification for Steel Castings, Ferritic and Martensitic, for Pressure-Containing Parts, Suitable for Low-Temperature Service
ASTM A516/A516M	(2017) Standard Specification for Pressure Vessel Plates, Carbon Steel, for Moderate- and Lower-Temperature Service

ASTM A576	(2023) Standard Specification for Steel Bars, Carbon, Hot-Wrought, Special Quality
ASTM A609/A609M	(2012; R 2023) Standard Practice for Castings, Carbon, Low-Alloy, and Martensitic Stainless Steel, Ultrasonic Examination Thereof
ASTM A668/A668M	(2023) Standard Specification for Steel Forgings, Carbon and Alloy, for General Industrial Use
ASTM A743/A743M	(2021) Standard Specification for Castings, Iron-Chromium, Iron-Chromium-Nickel, Corrosion Resistant, for General Application
ASTM B98/B98M	(2013) Standard Specification for Copper-Silicon Alloy Rod, Bar, and Shapes
ASTM B148	(2014) Standard Specification for Aluminum-Bronze Sand Castings
ASTM B584	(2022) Standard Specification for Copper Alloy Sand Castings for General Applications
ASTM D2000	(2018) Standard Classification System for Rubber Products in Automotive Applications
ASTM E165/E165M	(2023) Standard Practice for Liquid Penetrant Examination for General Industry
ASTM E709	(2021) Standard Guide for Magnetic Particle Testing
ASTM F1476	(2007; R 2019) Standard Specification for Performance of Gasketed Mechanical Couplings for Use in Piping Applications

HYDRAULIC INSTITUTE (HI)

HI 9.1-9.5	(2021) Pumps General Guidelines for Materials, Sound Testing, and Decontamination - B117
HI 9.6.4	(2009) Rotodynamic Pumps for Vibration Analysis and Allowable Values
HI ANSI/HI 9.8	(2014) Rotodynamic Pumps for Pump Intake Design - A123
HI ANSI/HI 14.6	(2011) Rotodynamic Pumps for Hydraulic Performance Acceptance Tests - A136

INTERNATIONAL ELECTRICAL TESTING ASSOCIATION (NETA)

NETA ATS	(2021) Standard for Acceptance Testing Specifications for Electrical Power

Equipment and Systems

INTERNATIONAL ORGANIZATION FOR STANDARDIZATION (ISO)

ISO 1940-1	(2003; R 2008) Mechanical Vibration - Balance Quality Requirements for Rotors in a Constant (Rigid) State - Part 1: Specification and Verification of Balance Tolerances
ISO 10816-3	(2017, AMD 1) Mechanical Vibration - Evaluation of Machine Vibration by Measurements on Non-rotating Parts - Part 3: Industrial Machines with Nominal Power above 15 kW and Nominal Speeds Between 120 r/min and 15 000 r/min when Measured in situ AMENDMENT 1 - Second Edition
ISO 20816-3	(2022) Mechanical Vibration - Measurement and Evaluation of Machine Vibration - Part 3: Industrial Machinery with a Power Rating Above 15 kW and Operating Speeds Between 120 r/min and 30 000 r/min

INTERNATIONAL SOCIETY OF AUTOMATION (ISA)

ISA RP2.1	(1978) Manometer Tables

U.S. ARMY CORPS OF ENGINEERS (USACE)

EM 1110-2-3105	(2020) Engineering and Design -- Mechanical and Electrical Design of Pump Stations

U.S. DEPARTMENT OF DEFENSE (DOD)

UFC 3-301-01	(2023; with Change 1, 2023) Structural Engineering

U.S. ENVIRONMENTAL PROTECTION AGENCY (EPA)

EPA 800-R-11-002	(2011) Environmentally Acceptable Lubricants

1.3 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-01 Preconstruction Submittals

Contractor Selected Manufacturers; G, [_____]

SD-02 Shop Drawings

Detail Drawings; G, [_____]

SD-03 Product Data

Humidity-Controlled Storage

Materials; G, [_____]

Spare Parts

Shipping Bills

Pump Curves; G, [_____]

Preliminary Pump Curves; G, [_____]

Installation and Erection Instructions Manual

Field Tests

Impeller Weight

In Water Bearing Lubrication; G, [_____]

Grout; G, [_____]

SD-04 Samples

Materials; G, [_____]

SD-05 Design Data

Dynamic Analysis; G, [_____]

Stress-Relieving Procedure; G, [_____]

FSI Connection; G, [_____]

Centralized Pressure Lubrication System; G, [_____]

Piping; G, [_____]

Baseplates and the Anchoring Bolts

Computations Of Total Head And Losses; G, [_____]

SD-06 Test Reports

Witness Test

Factory Test

Balancing Procedure; G, [_____]

Results Of Impeller Balancing

Field Test Results

SD-07 Certificates

Qualified Welders

Examination Procedure And Qualification Of The Examiner; G, [_____]

Qualifications Of Erecting Engineer; G, [_____]

SD-09 Manufacturer's Field Reports

Record Of Measurements Taken During Erection; G, [_____]

SD-10 Operation and Maintenance Data

Operation and Maintenance Instructions Manual; G, [_____]

1.4 QUALITY ASSURANCE

Provide one or more competent erecting engineers who is knowledgeable about the installation of vertical pumps and associated drive machinery. Erecting engineers provided by this section must include those from the Contractor's suppliers. This Contractor's erecting engineers are responsible for providing complete and correct direction during initial starting and subsequent operation of equipment until field tests are completed. The Contractor's erecting engineer must initiate instructions for actions necessary for proper receipt, inspection, handling, uncrating, assembly, and testing of equipment. The erecting engineer(s) must keep a record of measurements taken during erection, and submit one copy to the Contracting Officer on request or on completion of installation of the assembly or part. The erecting engineer must instruct the Contracting Officer in operation and maintenance features of work. Submit qualifications of erecting engineer for approval.

1.4.1 Detail Drawings

****
NOTE: Select appropriate alternate paragraph "d". The first paragraph choice may be used for pump with discharge diameters up to and including 1350 mm 54 inch. The second paragraph choice should be used for pumps with discharge diameters above 1350 mm 54 inch.
****

Submit drawings of sufficient size to be easily read, within [90] [_____] days of notice of award of contract. Submit information in the English language. Provide with English (IP) dimensions[, or metric with English conversion].[Submit drawings requiring changes as a result of model test within 45 days after approval of model test.] Drawings must consist of complete designs of the pump, pump installation instructions, performance charts, brochures, and other information required to illustrate that the entire pumping system (including the pump, [engine] [motor] [and speed reducer] has been coordinated and will function as a unit.

a. Outline drawings of the pump showing pertinent dimensions and weight of each component of the pump. Prepare drawings to scale.

b. Drawing showing details and dimensions of pump mounting design or layout including any embedded items[and the FSI].

c. Cross-sectional drawings of the pump showing each component. Show major or complicated sections of the pump in detail. Indicate on each drawing an itemized list of components showing type, grade, and class of material used and make and model number of standard component used.

[d. Detail and assembly drawings required for manufacturing showing dimensions, tolerances, and clearances of shafts, [sleeve journals], bearings, including dimensions of grooving, couplings, and packing gland, and diameter and tip clearance of propeller.]

[d. Detail and assembly drawings of entire pump. Include all dimensions required to manufacture pump.]

e. Drawings covering erection and installation, that are intended to be furnished to the erecting engineer.

f. Drawings of the pump; base plate showing its dimensions.

1.4.2 Welding

Weld structural members in accordance with Section 05 05 23.16 STRUCTURAL WELDING. For all other welding, procedures and welders must be qualified in accordance with ASME BPVC SEC IX. Welding procedures qualified by others, and welders and welding operators qualified by a previously qualified employer may be accepted as permitted by ASME B31.1. Perform welder qualification tests for each welder whose qualifications are not in compliance with the referenced standards. Notify the Contracting Officer 24 hours in advance of qualification tests. Perform the qualification tests at the work site if practical. The welder or welding operator must apply their assigned symbol near each weld made as a permanent record.

The names of all qualified welders, their identifying symbols, and the qualifying procedures for each welder including support data such as test procedures used, and standards tested to.

1.5 DELIVERY, STORAGE, AND HANDLING

1.5.1 General

Outfit major pump components with lifting lugs or eye bolts to facilitate handling. Design and arrange lugs or bolts to allow safe handling of pump components singly or collectively as required during shipping, installation, and maintenance. Submit copies of certified shipping bills to the Contracting Officer or memorandums of all shipments of finished pieces or members to designated site, giving designation mark and weight of each piece, number of pieces, total weight, and if shipped by rail in carload lots, car initial and number.

1.5.2 Processing for Storage

Prepare pumps [and spare parts] for storage indoors. Indoor storage consists of a permanent building that has a leak-proof roof, full walls to contain stored equipment, and a concrete floor or temporary trailers. A temporary structure may also be built at the job site for equipment storage that will contain features of the permanent building above except that provision for ventilation must be provided and floor may be crushed rock. Provide a vapor barrier below the crushed rock. Use cribbing below equipment stored on crushed rock so that equipment does not come in contact with crushed rock. Provide a plastic barrier between equipment and wood cribbing. Submit a list of equipment and materials requiring humidity-controlled storage to the Contracting Officer no later than 30 days prior to shipment of pumping units. Store long term (greater than 6 months) in accordance with Contractor selected pump specifications.

1.6 PROJECT/SITE CONDITIONS

1.6.1 Datum

****
NOTE: Datum Selection
NAVD 1988 Datum is required for new projects. NGVD is only appropriate if this contract is for, or relates to, an existing project where National Geodetic Vertical Datum (NGVD) was used originally.
****

Elevations shown or referred to in this contract, are above [plus] or below [minus] [mean sea level] North American Vertical Datum of 1988 (NAVD) [_____].

[Elevations shown or referred to in this contract, are above [plus] or below [minus] [mean sea level] National Geodetic Vertical Datum (NGVD)

[_____].]

1.6.2 [Static][Pool-To-Pool][Bowl] Head

****

NOTES: Select appropriate alternate paragraph.

Static head (1st alternate) is generally used for pumping stations having discharges over the protection, free discharge or a discharge chamber type pumping station. If this alternate is selected, the Specifier should attach FIGURE 1, SYSTEM LOSS CURVE to the end of this section.

Pool-to-pool heads (2nd alternate) are usually specified when the discharge and suction systems are complex and total head is found by model test or determined by the Contractor.

Bowl Head (3rd alternate).

****

[Static head is the difference, in meters feet, between water surface elevation in the [sump bay] [sump] [immediately inside trash rack] and [top of discharge pipe at highest elevation] [water surface elevation of [river] [lake] [discharge chamber] [centerline of discharge flap gate in discharge chamber] [_____]]. Total head includes static head, friction losses outside of equipment being furnished, plus velocity head loss. [A curve showing friction losses plus velocity head for pumped capacities is included at the end of this section.]]

[Pool-to-pool head is the difference in meters feet between the water surface elevation in the [sump bay] [sump] and water surface elevation in [discharge chamber] [discharge channel] [river] [_____]. Submit computations of total head and losses. Total head includes losses from the water surface on the suction side of the pump to discharge water surface.]

[Bowl head is the difference in meters feet between the water surface elevation in the [sump bay] [sump] [immediately inside of trash rack] and the elevation of the diffuser exit plus head of water occurring at the diffuser exit. The Contractor must determine total head. Total head includes losses beyond the pump diffuser plus velocity head loss.]

1.7 MAINTENANCE

1.7.1 Special Tools

****

NOTE: Add applicable sections for drive units used.

****

Include one set of special tools required to completely assemble, disassemble, or maintain the pumps. Special tools refer to oversized or specially dimensioned tools, special attachments or fixtures, or any similar items. If required, provide a device for temporarily supporting the pump shaft and impeller during assembly, disassembly, and reassembly of the [motor] [gear reducer] when the thrust bearing is not in place. Provide lifting devices required for use in conjunction with [the overhead] [a truck] crane. [Provide a portable steel cabinet large enough to accommodate all special tools included under this paragraph and as required by Section(s) [26 29 01.00 10 ELECTRIC MOTORS, 3-PHASE VERTICAL INDUCTION TYPE] [26 29 02.00 10 ELECTRIC MOTORS, 3-PHASE VERTICAL SYNCHRONOUS TYPE], [41 65 10.00 10 [DIESEL][NATURAL GAS] FUELED ENGINE PUMP DRIVES] and [35 45 03.00 10 SPEED REDUCERS FOR STORM WATER PUMPS]. Mount the cabinet on four rubber-tired casters. Provide drawers to accommodate tools. Fit front of cabinet with doors hinged to swing horizontally. Furnish doors with necessary stops, catches, and hasps for completely securing the cabinet with a padlock. Furnish the padlock complete with three keys. Pack special tools in wooden boxes if the size and weight do not permit storage in the tool cabinet. Provide slings if the box and tools are heavier than 34 kg 75 pounds.]

[1.7.2 Extra Materials

****

NOTE: Spare parts should be required if estimated station operating hours are greater than 500 hours per year. Spare parts should also be considered for pumps located in remote locations and for pumps with unusual design. Spare parts for pumping stations having more than three pumps of identical construction should be considered, since acquisition of these spares will be more economical when purchased with the pumping units. Decisions on requiring spare parts can also be based on including spare parts for stations in remote areas or having unusually designed pumps where parts could take considerable time to obtain. When spare parts are included as part of the original supply contract, their cost would probably be half of their cost if obtained after original construction. When spare parts are included as part of the original purchase of the pumping units, their cost could be less than one half of the cost when obtained at a later date.

Select appropriate alternate paragraphs for subparagraphs "d" and "f", below.

****

Provide the following spare parts:

a. One complete replacement set of bearings, bearing shells, journal sleeves, shaft coupling, if applicable, and seals for each size pump.

b. One complete replacement set of wearing parts for the packing gland for each size pump, and sufficient packing for all pumps.

c. Fifty percent of each size and length of bolt, nut, and washer used on each size pump assembly.

d. [One lube pump, complete with motor and timer control, for the centralized lubrication system.] [One complete manually operated centralized lubrication system.] [One oil storage container including drip device and solenoid oil valve.]

e. One complete main pump shaft, including keys and thrust collars.

f. [One complete pump impeller for each size pump.] [One complete main pump impeller bowl assembly for each size pump, consisting of the impeller bowl, diffuser bowl, suction bell if so equipped, impeller shaft with sleeves, bearings, impeller, and all fasteners required to make a complete assembly.] All spare parts must be duplicates of the original parts furnished and be interchangeable therewith. Pack spare parts in crates as specified in paragraphs under DELIVERY, STORAGE, AND HANDLING. Provide slings if the crates and parts are heavier than 34 kg 75 pounds.

g. Provide copies of complete parts list showing all parts, spare parts, and bulletins for each size pump. Clearly show all details and parts, and adequately describe parts or have proper identification marks.

][1.8 WARRANTY

****

NOTE: Consider including an extended warranty for the pumping equipment if there is a likelihood that the pumping equipment will be operated very little during the first years due to a lack of water, ongoing interconnected projects, or permitting issues.

****

Provide a warranty for all equipment included under this section against defective workmanship, materials, design, and performance for a period of [_____] years from the date the equipment is accepted. If the equipment or part does not conform to these warranties, and the Government notifies the Contractor within a reasonable time after its discovery, the Contractor must promptly correct such nonconformity by repair or replacement. Coordinate the down time and repair for the equipment with the Contracting Officer. The Contractor is liable during the warranty period for the direct cost of removal of the equipment from the installed location, transportation for repair, and reinstallation on site. The expense of removing adjacent apparatus, installing spare equipment, costs of supplying temporary service, is not included in this warranty provision.

]PART 2 PRODUCTS

2.1 SYSTEM DESCRIPTION

Design and provide [_____] [identical] vertical [axial-flow] [or] [mixed-flow], single [or two-]stage impeller-type pumps, as indicated. The pumping systems include pumps, [diesel engine pump drives], [electric motor pump drives], [and reduction gears].

2.1.1 Design Requirements

****

NOTE: Delete the reference to the pump operating in the dry if the pump is product- water lubricated. Select appropriate alternate paragraph for subparagraph "d". A discharge line is used for all applications, except for stations that have the discharge system integral with the wall of the pumping station.

****

a. Pumps are for the purpose of pumping [_____] from [_____] into [_____]. Water pumped will not exceed [_____] degrees C F, will be relatively turbid, and may contain sand, silt, and vegetative trash capable of passing through the trash rack. Trash racks will have [_____] mm inch clear openings. [Design pumps to operate in the dry.]

b. Drive the pumps with the [vertical] [horizontal] [induction] [synchronous] [motors described in Section [26 29 01.00 10 ELECTRIC MOTORS, 3-PHASE VERTICAL INDUCTION TYPE] [26 29 02.00 10 ELECTRIC MOTORS, 3-PHASE VERTICAL SYNCHRONOUS TYPE]] [horizontal crankshaft diesel engines described in Section [41 65 10.00 10 [DIESEL][NATURAL GAS] FUELED ENGINE PUMP DRIVES],] [through right angle, vertical shaft, reducers described in Section [35 45 03.00 10 SPEED REDUCERS FOR STORM WATER PUMPS]] as indicated.

c. Design pumps so that no major modifications, alterations, or additions will be required to the pumping station or suction bays to accommodate them. Design pumps so that pump parts will fit within the limiting horizontal and vertical dimensions shown and that installation and maintenance can be accomplished by the [interior; overhead traveling crane,] [truck crane using hatch in roof.] Pumps, [or pump parts assembled at pumping station] must be capable of being lowered through floor openings shown with a minimum of 25 mm 1 inch clearance around each side.

[d. Each pump must discharge into discharge system shown. System loss curve, which includes friction losses from pump discharge elbow to [end of discharge line], [beginning of down [riverward] leg of discharge line], including bend losses, exit loss, and velocity head, is included as Figure 1 at end of this section to permit determination of total head. Determine losses within the pump.]

[d. Each pump discharge system downstream of pump [discharge elbow] [diffuser] must be compatible with Contractor selected pumps. It must be of type shown and fit within limiting dimensions and elevations shown. Determine all losses for discharge system and submit for approval.]

[d. Each pump must discharge into discharge chamber shown. System loss curve(s) furnished includes all losses beyond the discharge elbow. Determine losses within the pump.]

[e. Accomplish priming of siphon [with] [without] assistance of vacuum equipment.]

[f. Design the pump and column to be installed and removed using the [_____] kg ton overhead crane indicated. Design the pump and column section lengths with the indicated crane lift as a limiting factor.]

[g. Design documents must be signed and sealed by a professional engineer.]

2.1.2 Capacities

****

NOTE: Select appropriate alternate paragraphs. Capacities are those determined from earlier design studies for the station. If hydrology/hydraulic studies indicate that gross over-capacity may cause

a problem, as in certain discharge chambers, a maximum capacity should be specified. If a siphon discharge system is to be used, there should be a minimum of two design points listed; one for the priming condition and one for the design operating condition.
****

Each pump must:

[a. The guarantee point for the pump is [[_____] L/s gal/min] with a differential head pressure of [_____] m feet with water surface in sump at Elevation [_____] m feet.]

[b. Be capable of constant-speed operation from a total head corresponding to a [pool-to-pool][static][bowl] head of [_____] m feet down to total head corresponding to a [pool-to-pool][static][bowl] head of [_____] m feet[with water surface in the sump at Elevation [_____]].]

[2.1.2.1 Primed Condition

Each pump must discharge more than [[____] m3/scfs [_____] L/sgal/min] against a total head corresponding to a [pool-to-pool][static][bowl] head of [_____] m feet. This rated condition is based on an intake canal elevation of [_____] m feet and a discharge pool elevation of [_____] mfeet. These pumps must be capable of constant speed operation from a pool-to-pool head of [_____] m feet down to and including a pool-to-pool head of [_____] m feet with water surface in the intake sump ranging from elevation [_____] m feet to elevation [_____] m feet. Once the system is primed, the water level in the discharge impoundment can range from elevation [_____] m feet to elevation [_____] m feet.

][2.1.2.2 Start-Up Condition

Upon startup, each pump must discharge sufficient water for the pumps to become primed and siphon recovery to begin. Since the head conditions will be higher prior to the pump discharge pipe becoming filled, the pump may be operated at a higher speed for a short period of time. The pump flow must be sufficient to result in a flow velocity in the discharge pipe of no less than 2 m per second 7 feet per second. The pump speeds may be changed during the pump priming period, but after priming is accomplished, the pumps must operate as constant-speed pumps. Siphon breaker valves will be used to help prime the pumps.

]2.1.3 Pump Curves

Indicate on the pump curves for the submitted pumps that the pumps are capable of operating over the entire total head corresponding to the [full pool-to-pool] [static head range]. [Also provide pump curves for the startup condition for pumps that are operated at a different speed during startup.]

Submit preliminary pump curves with the initial pump submittal. Indicate the pump's expected total head, static heads, brake horsepower, and efficiency, as ordinates. Plot against the pump discharge as the abscissa. The curves must indicate that the pump meets all specified conditions of capacity, head, brake horsepower, and efficiency.

2.2 MATERIALS

****

NOTE: The Designer should discuss materials and design details for specific site application with pump manufacturers; and the Designer should edit Sections 05 50 14, 05 50 15, and 08 31 00 as appropriate.

The use of corrosion resistant materials for pump fabrication such as composite impellers or components may be appropriate on a case by case basis. If a designer believes conventional pump materials are not suitable or reliable. The Designer should specifically consult pump fabricators while developing contract documents when considering the use of composite material. Some standards which govern structural composite materials are ASTM D638, ASTM D790, ASTM D695, ASTM D2344, ASTM D3846, ASTM D3433, ASTM D696, ASTM D2583, ASTM D785 and ASTM D570.

****

If not specified, materials and fabrication must conform to the requirements of Section [08 31 00 ACCESS DOORS AND PANELS] [05 50 14 STRUCTURAL METAL FABRICATIONS] and Section 05 50 15 CIVIL WORKS FABRICATIONS. Material selection not specified is guided by HI 9.1-9.5 for corrosion, erosion, and abrasion resistance. Submit copies of purchase orders, deviations from the specified materials, mill orders, shop orders for materials, and work orders, including orders placed or extended by each supplier. Furnish a list designating materials to be used for each item at time of submittal of drawings. Within 60 days of notice of award submit names of Contractor selected manufacturers of machinery and other equipment contemplated to be incorporated in the work, together with performance capacities and other relevant information pertaining to the equipment. Submit samples of materials as directed. Equipment, materials, and articles installed or used without the approval of the Contracting Officer are at risk of subsequent rejection.

a. Identify each pump by means of a separate nameplate permanently affixed in a conspicuous location. The plate must bear the manufacturer's name, model designation, serial number if applicable, and other pertinent information e.g. horsepower, speed, capacity, type, direction of rotation. Make the plate of corrosion-resisting metal with raised or depressed lettering and a contrasting background.

b. Equip each pump with suitably located instruction plates, including any warnings and cautions, describing any special and important procedures to be followed in starting, operating, and servicing the equipment. Make the plates of corrosion-resisting metal with raised or depressed lettering and contrasting background.

c. Provide safety guards and/or covers wherever necessary to protect the operators from accidental contact with moving parts. Make guards and covers of sheet steel, expanded metal, or another acceptable material and removable for disassembly of the pump.

2.3 METALWORK FABRICATION

2.3.1 Designated Materials

Designated materials must conform to the following specifications, grades, and classifications.

MATERIALS	SPECIFICATION	GRADE, CLASS
Aluminum-Bronze	ASTM B148	Alloy No. C95500 Castings
Cast Iron	ASTM A48/A48M	Class Nos. 150A 150B, and 150C; 30A, 30B, and 30C
Cast Steel	ASTM A27/A27M	Grade 65-35, annealed
Cast Stainless Steel	ASTM A743/A743M	CF8
Coal Tar Protective Coatings	AWWA C203	
Cold-Rolled Steel Bars	ASTM A108	min, Wt. Strm 450 MPa 65,000 psi
Copper Alloy Castings	ASTM B584	Alloy No. C93700
Corrosion-Resistant Alloy Casting	ASTM A217/A217M	Grade CA15
	ASTM A352/A352M	CA6NM
	ASTM A351/A351M	CF8M
Dimensions for Steel Water Piping Fittings	AWWA C208	
Hot-Rolled Stainless	ASTM A576	Graded G10200 and G11410
Ring Flanges	AWWA C207	Class B
Rubber Products in Automotive Applications	ASTM D2000	
Seamless and Welded Austenitic Stainless Steel Pipe	ASTM A312/A312M	
Stainless Bars and Shapes	ASTM A276/A276M	Grades S30400 and S41000
Steel Forging	ASTM A668/A668M	Class F
Cast Stainless Steel	ASTM A743/A743M	CF8
Steel Pipe 150 mm 6 inch and Larger	AWWA C200	
Steel Plates, Pressure Vessel	ASTM A516/A516M	Grade 55
Steel Plates, Pressure Vessel	ASTM A242/A242M	
Steel Plate, Structural Quality	ASTM A285/A285M	Grade B
Structural Steel	ASTM A36/A36M	

MATERIALS	SPECIFICATION	GRADE, CLASS
Surface Texture (Surface Roughness, Waviness, and Lay)	ASME B46.1	

2.3.2 Bolted Connections

2.3.2.1 Bolts, Nuts, and Washers

Bolts, nuts, and washers must conform to requirements of paragraphs under METALWORK FABRICATION, and paragraphs under VERTICAL PUMPS for types required. Use beveled washers where bearing faces have a slope of more than 1:20 with respect to a plane normal to bolt axis.

2.3.2.2 Materials Not Specifically Described

Materials not specifically described must conform to latest ASTM specification or to other listed commercial specifications covering class or kinds of materials to be used.

2.3.3 Metalwork

2.3.3.1 Flame Cutting of Material

Flame cutting of material other than steel is subject to approval of the Contracting Officer. Shear accurately, and neatly finish all portions of work. Steel may be cut by mechanically guided or hand-guided torches, provided an accurate profile with a smooth surface free from cracks and notches is secured. Prepare surfaces and edges to be welded in accordance with AWS D1.1/D1.1M. Do not chip or grind except where specified and as necessary to remove slag and sharp edges of mechanically guided or hand-guided cuts not exposed to view. Visible or exposed hand-guided cuts must be chipped, ground, or machined to metal free of voids, discontinuities, and foreign materials.

2.3.3.2 Alignment of Wetted Surfaces

Exercise care to assure that correct alignment of wetted surfaces being joined by a flanged joint is being obtained. [Where plates of the water passage change thickness, transition on the outer surface, leaving inner surface properly aligned.] When welding has been completed and welds have been cleaned, but prior to stress relieving, carefully check joining of plates in the presence of the Contracting Officer for misalignment of adjoining parts. Localized misalignment between inside or wetted surfaces of an adjoining flange-connected section of pump or formed suction intake cannot exceed the amount shown in Column 4 of Table 1 for the respective radius or normal distance from the theoretical flow centerline. Correct misalignments greater than the allowable amount by grinding away offending metal, providing the maximum depth to which metal is to be removed does not exceed amount shown in Column 5 of Table 1. Do not remove metal until assuring the Contracting Officer that no excessive stresses will occur in the remaining material and that excessive local vibration will not result from removal of the material. Where required correction is greater than the amount in Column 5 of Table 1, reject pipe for use. Proposed procedure for all corrective work, other than minor grinding, must be approved by the Contracting Officer prior to start of corrective work.

Finish corrective work by grinding corrected surface to a smooth taper. Length of the taper along each flow line element must be 10 times the depth of the offset error at the flow line. Wetted surface irregularities that might have existed in an approved model cannot be reason for accepting comparable surface irregularities in the prototype pump.

TABLE 1				
(1)	(2)	(3)	(4)	(5)
Pipe Diameter (mm) (inches)	Pipe Radius or Distance (mm) (inches)	Pipe Thickness (mm) (inches)	Maximum Offset (mm) (inches)	Grind-Not More Than (mm) (inches)
60024	30012	103/8	1.61/16	2.43/32
75030	37515	103/8	1.61/16	2.43/32
90036	45018	103/8	2.43/32	2.43/32
105042	52521	131/2	2.43/32	3.21/8
120048	60024	131/2	3.21/8	3.21/8
135054	67527	131/2	3.21/8	3.21/8
150060	75030	193/4	4.05/32	4.05/32
180072	90036	251	4.05/32	4.05/32
210084	105042	291-1/8	4.83/16	6.41/4

2.3.3.3 Stress-Relieving Procedure

After all fabrication welding is completed, and prior to any machining, stress-relieve the bell and the impeller (if it is fabricated) by heat treatment. Submit proposed stress-relieving procedure.

2.3.4 Examination of Castings

Clean and carefully examine all castings for surface defects. Examine all discovered defects by nondestructive means. Examination personnel must be qualified/certified in accordance with applicable ASTM requirements. Submit the examination procedure and qualification of the examiner. Conduct examination tests in the presence of the Contracting Officer. Choose the examination procedure best suited for the application.

2.3.4.1 Examination Procedures

2.3.4.1.1 Ultrasonic

Conform inspection to the applicable provisions of ASTM A609/A609M.

2.3.4.1.2 Magnetic Particle

Conform inspection to the applicable provisions of ASTM E709.

2.3.4.1.3 Liquid Penetrant

Conform inspection to the applicable provisions of ASTM E165/E165M.

2.3.4.2 Acceptance and Repair Criteria

Acceptance and repair criteria must be in accordance with Section [08 31 00 ACCESS DOORS AND PANELS] [05 50 14 STRUCTURAL METAL FABRICATIONS].

2.4 VERTICAL PUMPS

2.4.1 Speed

****

NOTE: Select appropriate alternate paragraph. Alternate 1 is used when cavitation testing is part of the contract. Alternate 2 is used when the pump will not be tested to determine the cavitation characteristics and the designer has determined the maximum speed to be specified based on the NPSHA. The following criteria should be used by the designer in determining the maximum rotative speed:

$$N_{ss} = \frac{(SS) \times (NPSHA)^{3/4}}{Q^{1/2}}$$

where:

N_{ss} = pump rotative speed, in revolutions per minute
SS = suction-specific speed
Q = flow, in gallons per minute
NPSHA = net positive suction head available

Maximum value of SS to be used in the formula:

SS = 8,500

A more conservative value of suction specific speed may be used when operating for extended periods of time above or below the optimum efficiency point.

****

[Rotative speed of pump must be no greater than [_____] r/min rpm. Verify that rotative speed of pump at which the NPSH is produced is no less than required, as determined by cavitation tests specified in paragraph FACTORY TEST (Alternate 2).][

Rotative speed of pump must be no greater than [_____] r/min rpm.]

2.4.2 Reverse [Rotation] [Flow]

****

NOTE: Select appropriate alternate paragraph: Reverse Rotation (1st alternate) and Reverse Flow (Alternate 2). 1st alternate (bracketed paragraph) is used when the pumping unit does not have a non-reverse device. 2nd alternate (bracketed

paragraph) is used when the pumping unit is equipped with a non-reverse device.

****

[Each pump must withstand, with no damage, full rotative speed caused by subjecting the pump to reverse flow. The head used to determine this reverse rotative speed is calculated from specified highest discharge side water elevation and lowest pump intake side water elevation.[Each pump and its connected electric motor must be capable of full reverse rotative speed when acting as a turbine by reverse water flow. Use the highest head specified in paragraph [STATIC][POOL-TO-POOL][BOWL] HEAD to determine the reverse speed.][Provide a non-reverse device for drive systems containing reduction gears or engines with .]][

The pump(s) must withstand, with no damage, the full force exerted on it, with the impeller subjected to reverse flow and the upper end locked in place by a backstop. Calculate the head to determine the force developed by this reverse flow from the specified highest discharge side water elevation and lowest pump intake side water elevation. Reverse rotative speed must be [0.0][_____] with instantaneous activation of the backstop.]

2.4.3 Efficiency

****

NOTES: Select appropriate alternate paragraph.

All pump specifications should require some minimum efficiency at the primary or normal operating design point. This minimum efficiency should be based on the pump selections made during pump station layout and design.

Alternate 1 is used when pool-to-pool head is specified in paragraph PROJECT/SITE CONDITIONS, and the pump manufacturer is required to model the discharge system (Alternate 2). Alternate 2 is a measure of pump efficiency as defined in HI ANSI/HI 14.6. The stated efficiency is based on the pump selection made during station layout and design.

****

[Pool-to-pool efficiency at head-capacity condition(s) specified in paragraph CAPACITIES must not be less than [_____] percent when calculated as follows:

$$\text{Efficiency} = \frac{Q \times H}{366 \times BKW} \times 100$$

Where: Q = Discharge, cubic meter/hour
H = Pool-to-pool total head, meters
BKW = Pump brake kilowatt

$$\text{Efficiency} = \frac{Q \times H}{3960 \times BHP} \times 100$$

Where: Q = Discharge, gallons per minute
H = Total head, feet
BHP = Pump brake horsepower

]
[Pump efficiency, as defined in HI ANSI/HI 14.6, must include losses from the suction bell to the discharge elbow outlet and must not be less than [_____] percent at the head-capacity condition(s) specified in paragraph CAPACITIES.]

2.4.4 Suction Bell

****

NOTE: The recommended minimum thickness of steel pipe to be specified is:

DISCHARGE DIAMETER mminch	MINIMUM THICKNESS mm inch
Up to and including 750 30	103/8
Above 750 30 and up to and including 1200 48	131/2
Above 1200 48 and up to and including 2100 84	165/8

More detailed procedure for computing minimum pipe thickness can be found in AWWA M11 Steel Pipe or ASME B31.3 Process Piping. If a formed suction inlet (FSI) is specified, this paragraph should be deleted.

****

Make each suction bell of [either cast iron, cast steel, or welded steel plate,] [stainless steel plate]. Provide a flanged connection for mating with the impeller bowl with a rabbet fit or four equally spaced dowels installed in the vertical position for initial alignment purposes and to maintain concentric alignment of the pump. [Steel plate, if used,][Stainless steel plate] must have thickness of not less than [_____] mm inch. Each suction bell must be [made in one piece][split vertically with bolted flanges joining the two pieces together. Maintain alignment by use of dowels]. Support each suction bell entirely by the pump casing. Supports from sump floor will not be acceptable, [except those that are part of a formed suction intake].[Support umbrellas, if used, by the suction bowl. Construct the umbrella in two pieces if a single piece umbrella could not be removed using the pump opening in the operating floor. Provide bolted flanges on each half of the umbrella and provide for and easily removable bolted connection to the suction bowl. Provide sufficient lifting lugs on the umbrella to aid in handling.]

2.4.5 Impeller Bowl

****

NOTE: The recommended minimum thickness of steel plate to be specified is:

DISCHARGE DIAMETER mminch	MINIMUM THICKNESS mminch
Up to and including 750 30	**131/2**
Above 750 30 and up to and including 1200 48	**165/8**
Above 1200 48 and up to and including 2100 84	**193/4**

****

Make each impeller bowl of [either cast iron, cast steel, welded steel plate or a combination of cast steel and steel plate] [stainless steel plate][cast stainless steel]. [Steel plate, if used,][Stainless steel plate] must have thickness of not less than [_____] mm inch after machining is completed. Heat-treat and stress-relieve welds before final machining. Provide flanges for mating with the [suction bell][formed suction intake] and the impeller bowl or two-piece construction of the impeller. Provide flanged connections with the suction bell and the diffuser or split construction with a rabbet fit or four equally spaced dowels installed in the vertical position for initial alignment purposes and to maintain concentric alignment of the pump. Machine finish the impeller-swept area in the impeller bowl to at least 3.2 μm 125 microinch rms and concentric with the impeller axis. For mixed-flow impellers, the angle in the impeller bowl must equal the outside angle of the impeller blade tips. Tolerance for concentricity of the impeller with the impeller axis is not greater than 20 percent of the operating clearance between the impeller and the impeller bowl.

2.4.6 Diffuser Bowl

****
NOTE: Use the same thickness for the steel plate as specified in paragraph IMPELLER BOWL.
****

Make each diffuser bowl of [cast iron, cast steel, welded steel plate, or a combination of cast steel and steel plate][stainless steel plate][cast stainless steel]. [Steel plate, if used,][Stainless steel plate] must have a thickness of not less than [______] mm inch after machining is completed. The diffuser must contain support for the upper impeller shaft bearing and have vanes to guide the pumped flow. Equip the diffuser bowl with a bypass drain, if required, to outside of the pump from the diffuser cavity located between the enclosing tube connection and the impeller. Furnish throttle bushing located in the cavity immediately above the impeller. Design bypass drain and throttle bushing to reduce water pressure on the lower seal. Impeller back-wear rings can also be used to reduce water pressure on the lower seal.

2.4.7 Pump Column and Discharge Elbow

2.4.7.1 Column and Discharge Elbow

****
NOTE: Use the same thickness for the steel plate as specified in paragraph IMPELLER BOWL, above. For most pumps, space should be provided for using a long radius type elbow. Unless the elbow is made of

cast materials, the elbow will be the mitered type. The roundness tolerance should be specified when the flexible coupling is not part of the contract. Turning vanes must be used in pumps having an access door to inspect/remove trash.

The following tolerance should be used for specifying the tolerance for the plain end of the elbow.

NOMINAL PIPE SIZE mminch	**TOLERANCE ON ACTUAL O.D. mminch**
Less than or equal to 400 16	**Plus/minus 1.5 0.06**
Above 400 16 and up to and including 600 24	**Plus/minus 2.0 0.08**
Above 600 24 and up to and including 1050 42	**Plus/minus 2.5 0.10**
Greater than 1050 42	**Plus 3.0 0.12/Minus 1.5 0.06**

****

Make each column and discharge elbow of [either cast iron, cast steel, or welded steel plate] [stainless steel plate]. [Steel plate, if used,][Stainless steel plate] must have a thickness of not less than [_____] mm inch after machining is completed. Provide elbow of [short radius type][long radius type][mitered type].[Do not use turning vanes.][Space turning vanes, if used, at least twice the space of clear space of the trash rack.] If turning vanes made of welded steel plate are used, provide an access door in the discharge elbow to allow personnel to inspect turning vanes and remove trash if necessary. Design column and discharge elbow to withstand internal pressures and external loadings associated with various conditions of pump operation. Provide flanges for mating individual segments together and for mating the pump column to the diffuser bowl. Flanges must have rabbeted fits or four equally spaced dowels installed in flanges for initial alignment purposes and to maintain concentric alignment. Terminate the elbow in a plain-end circular section. Diameter tolerance of plain end is [_____] mm inch. Provide diameter of discharge end of elbow as indicated and allow standard diameter flexible couplings to be used. Use adjustable thrust rods and thrust lugs to transfer the load by bridging the coupling between the pump discharge elbow and discharge piping. Determine the size and number of thrust rods needed for the expected loading. Use a minimum of four thrust rods. Maintain complete access to the discharge piping until the discharge pipe installation is complete, inspected, and approved.

2.4.7.2 Column and Discharge Elbow Support

****

NOTE: Select appropriate alternate paragraph. Pump Column and Discharge Elbow (1st alternate) is used for conventional pumps supported from the base-plate. Design Pump Unit (2nd alternate) is used for large stations having pumps over 1800 mm 72

inches in discharge diameter and supported from different floors.
****

[Design pump column and discharge elbow for suspension from a baseplate assembly specified in paragraph BASEPLATE AND SUPPORTS and located at operating floor level.]

[Design each pumping unit for installation as indicated. Install the baseplate for supporting the [electric motor] [gear reducer] at elevation of operating floor, EL [_____]. Support the pump casing at intermediate floor, EL [_____]. Provide the [support system] [support system consisting of columns extending from baseplate to intermediate floor]. The support system must transfer the entire load on the baseplate to the intermediate floor. Design the support system to maintain proper alignment of the pumping unit and propeller blade setting. Include the support system in the dynamic analysis.]

2.4.7.3 Pumps Discharge Diameter

****
NOTE: A manhole is used if the pump has a shaft enclosing cover that can be removed without disassembly of the pump.
****

Pumps having a discharge diameter greater than 1500 mm 60 inches must contain a manhole. Provide a structural steel bracket with a platform of raised-pattern floor plate similar to the one(s) indicated as a support for maintenance personnel for access to the pump through a manhole. Provide a manhole 600 by 750 mm 24 by 30 inches, or largest practicable size with a gasketed cover, in the column above the diffuser bowl. Provide jack bolts in the cover together with eye bolts to facilitate removal.

[2.4.7.4 Formed Suction Intake

****
NOTE: Select appropriate alternate paragraph.

Alternate 1 should be used when a rectangular sump is designed using criteria established by U.S. Army Engineer Research and Development Center (ERDC).

The use of a Formed Suction Intake (FSI) (Type 10), Alternate 2, is determined during the design phase of the station/pump. The Government will furnish all dimensions and be responsible for the design. The FSI was developed by ERDC and is now included in HI ANSI/HI 9.8.

The sump floor elevations should be determined in the design of the pumps/station. The impeller datum elevation should allow the necessary submergence as determined by the computations in EM 1110-2-3105, and verified with pump manufacturers' data.

The Designer should contact at least 3 pump manufacturers early in the project design phase to

verify the Designer's pump size estimate. Normally the eye of the impeller is located at minimum sump elevation, and the geometry of the FSI determines sump floor elevation. The early verification is important for the pump house structural design FSI hydraulics are very sensitive to change, and the pump diameter determines the dimensions of the FSI.

In designs where the FSI is not constructed of concrete, it is recommended that all materials indicated, or combination of these materials, should be specified. A hatch in the operating floor is generally provided in each pump bay to permit the placement of the FSI sections into the sump. If the station design/size does not have space for a hatch, then the opening for the pump is used for placement and removal of the FSI or is designed so that it can be removed using the sump gates and trash rack. The minimum thickness of fabricated material for the FSI should be:

EXIT DIAMETER OF FSI mminch	THICKNESS mminch
Up to and including 450 18	103/8
Above 450 18 and up to and including 900 36	131/2
Above 900 36 and up to and including 1350 54	165/8
Above 1350 54 and up to and including 2100 84	193/4

When a FSI is used, paragraphs SUCTION BELL and IMPELLER BOWL should be changed to coordinate with the FSI requirements.

The thickness of the rubber gasket must be as follows:

FSI EXIT DIAMETER mminch	THICKNESS mminch
Up to and including 1200 48	131/2
Above 1200 48 and up to and including 2100 84	193/4

****

[Sump has been designed using information obtained by sump model testing. Changes to sump layout will not be permitted.]

[Formed Suction Intake (FSI):

a. Provide the FSI water passage with the pump, sized to fit within the limiting elevations and dimensions indicated. Do not locate bearing below the impeller when an FSI is used.

b. Dimensions of the intake elbow and conical transition section of the FSI are relative to the diameter at the top of the cone, as defined on the drawings. The diameter at top of the cone and related dimensions are determined to accommodate the size of pump, providing limiting values for discharge and submergence are not exceeded, the floor of the FSI remains at elevation [_____], and impeller datum is set no higher than elevation [_____]. The rectangular transition section of the FSI upstream of the elbow can be modified in length to match the width of the individual pump bay or sump intake. Any modification must be limited to surfaces and dimensions indicated, and must be approved.

c. Construct each FSI of [fabricated steel,][cast iron,][cast steel,][or a combination of these materials embedded in concrete][formed concrete as indicated]. Stiffeners used must be on the outside of the FSI to allow smooth flows in the FSI. Size subassemblies of the FSI, unless constructed of formed concrete, to permit placement and removal through [a hatch in operating floor] [the pump opening in the operating floor] [through the sump gate and trash rack]. Bolts used to connect flanges must be stainless steel with bronze nuts. Minimum thickness of fabricated material must be [10][13][16][19] mm [3/8][1/2][5/8][3/4] inch for fabricated portions. Provide grout holes in floor of the FSI to permit full grouting. [FSIs formed in concrete must meet the surface requirements specified in Section 03 30 00 CAST-IN-PLACE CONCRETE and conform to the construction tolerances given in TABLE 1.][FSIs constructed of iron or steel must conform to the construction tolerances given in Section 05 50 14 STRUCTURAL METAL FABRICATIONS.]

TABLE 1
TOLERANCES FOR FORMED SURFACES

1.	Variations from the plumb		
	a. In the lines and surfaces of columns, piers, walls and in arises	In any 3 m 10 feet of length	6 mm 1/4 inch
		Maximum for entire length	25 mm 1 inch
2.	Variation from the level or from the grades indicated:		
	a. In slabs, ceilings, and in arises, measured before removal of supporting shores	In any 3 m 10 feet of length	6 mm 1/4 inch
		In any bay or in any 9 m 20 feet of length	10 mm 3/8 inch
		Maximum for entire length	20 mm 3/4 inch
	b. In exposed slab, floors and other conspicuous lines	In any bay or in any 9 m 20 feet of length	6 mm 1/4 inch
		Maximum for entire length	13 mm 1/2 inch

TABLE 1 TOLERANCES FOR FORMED SURFACES			
3.	a. Variation of the linear building lines from established position in plan	In any 9 m 20 feet	13 mm 1/2 inch
		Maximum	25 mm 1 inch
	b. Variation of cornered		6 mm 1/4 inch
4.	Variation of distance between walls partitions.	6 mm 1/4 inch per 3 m 10 feet of distance, but not more than 13 mm 1/2 inch in any one bay, and not more than 25 mm 1 inch total variation	
5.	Variation in the sizes and locations of pump throats, floor openings, and wall openings	Minus	6 mm 1/4 inch
		Plus	13 mm 1/2 inch
6.	Variation in cross-sectional dimensions of pump throat and in the thickness of slabs and walls	Minus	6 mm 1/4 inch
		Plus	13 mm 1/2 inch
7.	Footings:		
	a. Variation of dimensions in plan	Minus when formed	13 mm 1/2 inch
		Plus when formed	50 mm 2 inches
		or plus 75 mm 3 inches when placed against unformed excavations	
	b. Misplacement of eccentricity	2 percent of the footing width in the direction of misplacement but not more than 50 mm 2 inches	
	c. Reduction in thickness of specified thicknesses	Minus	5 percent
8.	Variation in steps:		
	a. In a flight of stairs	Riser	3 mm 1/8 inch
		Tread	6 mm 1/4 inch
	b. In consecutive steps	Riser	2 mm 1/16 inch
		Tread	3 mm 1/8 inch

d. FSI connection to pump impeller bowl flange must be designed by the Contractors selected pump supplier and be rigid or flexible as indicated by results of the dynamic analysis required in paragraph DYNAMIC ANALYSIS. Submit design and drawings indicating materials of construction and method of assembly of the FSI for approval.]

]2.4.7.5 Flanges

****
NOTE: The recommended minimum flange thickness to be specified is:

INSIDE DIAMETER OF JOINT mminch	THICKNESS mminch
Up to and including 600 24	321-1/4
Above 600 24 and up to and including 1050 42	381-1/2
Above 1050 42 and up to and including 2100 84	502

See AWWA C207 for additional flange thickness details.
****

Machine flanges and drill bolt holes concentric with pump shaft vertical centerline, having a tolerance of plus or minus one fourth of the clearance between the bolt and bolt hole. When fabricated from steel plate, flanges must not be less than [25][32][38][50] mm [1][1-1/4][1-1/2][2] inch thick after machining. Flange thickness after machining cannot vary more than 10 percent of greatest flange thickness. Provide external stiffeners, if needed. Construct fabricated flanges, as a minimum, to the dimensions of AWWA C207, Class B. Design flanges on major components of pump casing (suction bell, impeller bowl, diffuser bowl, and column and elbow piping) such that blind holes necessitating use of cap screws or stud bolts are not used. Design flanges for connection to column pipe by at least two continuous fillet welds. Connect the inside diameter of the flange to pump column with one weld, and connect the outside diameter of the pump column to the flange with the other weld. Final design of welds rests with the manufacturer, and specified welds are the minimum requirement. Parallel machine, when provided on each end of the same component, and mount parallel to a plane that is normal to pump shaft centerline. Flanges on each end of the same component must have parallel tolerance of 0.051 mm 0.002 inch. Finish machine mating surface on flange to 3.2 µm 125 microinch finish or better. Provide flanges with a minimum of three jacking bolts to aid in disassembly of the pump.

2.4.7.6 Flanged Joints

Design flanged joints to be air-and water-tight, without the use of preformed gaskets, against positive and negative operating pressures that will be experienced, except that permanent gasketing compound will be permitted. Provide mating flanges, unless of the male-female rabbet type, with not less than four tapered dowels equally spaced around each flange. If rabbeted fit is not used, then provide the method used to determine concentricity of connected pieces.

2.4.7.7 Nuts and Bolts

Use 300 series stainless steel for bolts used in assembling the pump and its supporting members, including anchor bolts and dowels. Use only bronze nuts and hexagonal bolts and nuts. Also use 300 series stainless steel washers.

2.4.7.8 Galvanic Protection

****

NOTE: Select appropriate alternate paragraph.

Alternate 1 should be used for pumps having discharge diameters of 500 mm 20 inches or less.

Alternate 2 should be used for pumps having a discharge diameter greater than 500 mm 20 inches. This may also be used for pumps with sidecharge diameters of 500 mm 20 inches or less when manufacturers' information indicates that this method will be the least expensive. The total weight of anodes to be used for each pump is:

DISCHARGE DIAMETER mm inch	MINIMUM NUMBER OF ANODES USED	TOTAL WEIGHT OF ANODES USED kg lbs
From 500 20 up to and including 900 36	2	1840
Above 900 36 up to and including 1200 48	4	3680
Above 1200 48 up to and including 2100 84	7	68150

****

[When dissimilar metals are used, electrically isolate dissimilar parts. Verify isolation by checking joint with an ohmmeter.] [When dissimilar metals are used, use zinc anodes. Provide machined mounting pads and install anodes on carbon steel or cast iron parts. Fasten anodes to bare material on the pump so that continuity is obtained between the anode and the pump. Verify continuity by checking the joint with an ohmmeter. Locate anodes on the exterior of the pump below normal sump level. Total weight of anodes used per pump must be [18][36][68] kg [40][80][150] pounds. Electrically bond pump joints at the joints.]

2.4.7.9 Harnessed Coupling

****

NOTE: This alternative is used when the flexible coupling is to be furnished by the pump Contractor. The applicable connection should be stated.

****

Provide a flexible mechanical coupling or split-sleeve type coupling that either conforms to ASTM F1476, Type II, Class 3, stainless steel or ASTM F1476, Type 1, to connect the pump discharge elbow to the [transition section] [wall thimble] [discharge piping]. Install a minimum of four harness bolts (sized by the pump manufacturer) at each coupling.

2.4.7.10 Wall Thimble

****

NOTE: This alternative is used when the discharge piping includes the piece that will be embedded in the wall of the station. The size of vent to be used is determined from information in EM 1110-2-3105.

****

Provide each wall thimble with one plain end to accommodate the flexible mechanical coupling and one flanged end to mate with the [flap gate] [multiple shutter gate] [discharge piping]. The plain end must match the pump discharge elbow in thickness and diameter and drill the flanged end to match, and be capable of supporting without distortion, the [flap gate] [multiple shutter gate]. Provide the seal ring on the wall thimble located so that it is centered in the wall when embedded. In addition, provide a [_____] mm inch flanged vent nozzle equipped with an ASME B16.5 Standard 125 pound flange and locate where indicated. Fabricate the wall thimble from steel plates.

2.4.7.11 Discharge Piping

****

NOTE: Include applicable discharge pipe description.

****

[Provide discharge piping consisting of a transition section and a wall thimble. Provide a transition section with one plain end and one flanged end, and have a change in cross section from round to [square] [rectangular]. On the plain end, match the pump discharge elbow in thickness and diameter. Arrange the wall thimble for embedment and with the flanges on each end. Mate one end with the flange on the transition section and mate the other end with the flap gate. Fabricate the discharge flange with a minimum dimension of AWWA C207, Class D, and drill to match. The discharge flange must be capable of supporting without distortion, the multiple shutter gate. Provide a seal ring on the wall thimble and locate it so that it is centered in the wall when embedded. In addition, provide a [_____] mm inch flanged vent nozzle equipped with an ASME B16.5 Standard 125 pound flange and locate where indicated. Fabricate the discharge piping from steel plate.]

[Install the discharge piping as indicated. Match the plain end of each discharge pipe with the pump discharge elbow in thickness and diameter and be able to allow a flexible mechanical coupling to connect it to the pump discharge elbow. [Terminate the discharge piping in a flanged end to mate with a flap gate. Drill the flanged end to match, and be capable of supporting the flap gate without distortion.] [Terminate the discharge piping in an open end.] Provide the discharge pipe with pipe supports or cradles as recommended by the pump manufacturer. Locate the supports between the flexible coupling and the wall, as indicated. Provide suitably-sized thrust restraints at each flexible coupling as indicated. The supports must provide support for the weight of the pipe, the water that will pass through the pipe, and any dynamic forces that may develop due to water flowing through the pipe. Furnish a minimum [_____] mm inch flanged vent nozzle equipped with an ASME B16.5 standard 125 pound flange and locate where indicated. The discharge pipe must be non-galvanized piping of welded or seamless pipe or welded steel plate. Use steel pipe conforming to AWWA C200 with dimensional requirements as given in ASME B36.10M. Provide fittings in compliance with AWWA C208.]

[2.4.7.12 Flap Gate

Design the flap gate for pump discharge service with flange-frame with a resilient seat of neoprene or BUNA-N to prevent closing shock. Make the size of the flap gate the same as the discharge pipe size. [Use cast iron for the body of the valve and the flap in compliance with ASTM A126. Use high-tensile bronze ASTM B584- CA 865 for the hinge arms. Design the hinge pins in double shear and of silicon bronze, ASTM B98/B98M- CA 655.] [Fabricate the flap gate entirely of stainless steel. Use only stainless steel hardware.] Provide lubrication fittings on the hinge arms. Extend the grease lines to a convenient location for lubricating. Provide an anti-locking bar to prevent excessive rotation about the lower hinge pin. Provide a stainless steel leaf spring with rubber pad to safely limit the travel of the flap gate during pumping.

]2.4.8 Impeller

****

NOTE: Cast steel and aluminum bronze are normally used when pumps are less than 2100 mm 84 inch. Fabricated steel impellers are used with pumps having discharge diameters 2100 mm 84 inch or greater. Cast stainless steel is used for pumps where the difference between pump NPSHA and NPSHR is small (less than 600 mm 2 feet) or, when severe corrosion is expected.

****

Make the impeller of [cast steel,] [cast stainless steel,] [aluminum bronze] or [fabricated of welded steel plate].

2.4.8.1 Removal and Prior To Finishing

After removal from mold, and prior to finishing of surface imperfections, the Contracting officer will inspect castings. Fill and grind minor surface imperfections as necessary to preserve correct contour and outline of impeller and to restore surface imperfections to the same degree of finish as surrounding surfaces. Correct surface pits, depressions, projections, or overlaps showing greater than 2 mm 1/16 inch variation from the general contour for that section. Method and procedure for accomplishing repair must be as required in Section [08 31 00 ACCESS DOORS AND PANELS] [05 50 14 STRUCTURAL METAL FABRICATIONS]. Castings that exhibit surface imperfections (as defined above) covering an area of more than 10 percent of blade surface will be rejected.

2.4.8.2 Balance

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NOTE: The maximum operating speed is used for driver/pumps which operate at different speeds. The rated operating speed is used with a single speed driver. The g-mm oz-inch used in this paragraph are determined from ISO 1940-1 for grade G6.3. Impellers for pumps having a discharge diameter

greater than 600 mm 24 inch must have the impeller weighted. The amount of allowable unbalance or the level of balance in the acceptable standards must be chosen and included in this guide specification. This includes choosing acceptable standard(s). A suggested standard is balance quality grade G6.3 in accordance with ISO 1940-1.
****

Balance each impeller by the two-plane balancing technique. Balance each impeller at [maximum] [rated] operating speed. Check the balance at 110 percent of balance speed, and make needed corrections. Amount of allowable unbalance is in accordance with grade G6.3 of ISO 1940-1. Securely fasten weights needed to obtain the required level of balance to the inside cavity of the impeller hub. In no case can portions of the impeller be removed or weights be added to the outside of the hub, vanes, or water passages. Submit balancing procedure at least four weeks prior to the date of balancing. Weigh each finished impeller and weight stamped on the bottom of the hub with weight accurate to 0.5 percent of the total weight of the impeller. Weighing and balancing will be witnessed by the Contracting Officer. Submit all impeller weights and the results of impeller balancing.

2.4.9 Shafting

2.4.9.1 Shaft

****
NOTE: Stainless steel shafting should be used when the potential for corrosion is high such as a pump used in a station where the pump/station sump is not capable of being dewatered. The shaft lengths are limited in length by the headroom available. Shaft sections are usually less than 3000 mm 10 feet in length. Vertical adjustment of the shaft should be performed above the operating floor. The motor and gear reducer are normally specified to be hollow shaft type to allow the pump shaft to pass concentrically through the reducer and motor allowing finite impeller elevation adjustments.
****

Each impeller shaft must be stainless steel and intermediate shaft(s) must be [cold-rolled carbon steel] [same material as the impeller shaft]. Design shafting so that [shaft sections do not exceed [_____] mm feet in length and that] any necessary vertical adjustment of the impeller can be made [from the operating room floor] without interfering with shaft alignment. Also provide for removal of the impeller from below without disassembly of the pump above the impeller bowl. If the pump is multi-staged, design to permit the lower bowls and impeller to be easily removed for in-place inspections of upper propeller and bowl. Design shafts for two different design cases. The first uses a factor of safety of 5 based on ultimate tensile strength of the shaft material and rated wattage horsepower of the [motor] [engine]. The second uses 75 percent of the yield strength of the shaft material and [the locked rotor torque of the motor] [maximum wattage horsepower of the engine].

2.4.9.2   Couplings

****

NOTE: Rigid flange couplings should be specified only for pumps having discharge diameters greater than 1800 mm 72 inch. The rigid flange coupling may be specified as an option for all pumps less than 1800 mm 72 inch. Sleeve type couplings should be used for pumps having discharge diameters from 600 mm 24 inch to 2100 mm 84 inch. Threaded shaft couplings can be used for pumps with discharge diameters less than 600 mm 24 inch.

****

Couple the pump and [motor] [gear reducer] shafts[and pump shaft sections] together using rigid flanged coupling capable of transmitting the forces and torques involved. Bolt coupling halves together and maintain concentric with each other, by means of a rabbet fit, to within 500 µm 0.002 inch. Retain a shaft coupling nut, if used, by fitted bolts, and comply with all tolerances specified for the coupling. Finish machine the flange and bore in one setup to insure that the flange of the coupling is true to the bore. Each flange must be perpendicular to the bore, and parallel to the opposite end and mating flanges to within 500 µm 0.002 inch. Each flange must be concentric to the centerline of the shaft to within 0.50 mm 0.002 inch. [Join together pump shaft sections with [sleeve-type couplings capable of taking rotation in either direction. Threads, except on fasteners, cannot be employed in construction of sleeve-type couplings] [threaded couplings in which the threaded shaft ends are threaded into the coupling].] Construct couplings, including keys and fasteners, of stainless steel materials. All keys and keyseats (keyways) must meet the requirements of ASME B17.1. The finished shaft assembly must be concentric about the shaft centerline to within 100 µm 0.004 inch. Shop assemble couplings and the pump shaft, and inspect for compliance with contract requirements. After inspection, matchmark parts, including fitted bolts, to their mating pieces.

2.4.9.3   Journals

****

NOTE: Select the appropriate alternate paragraph. The first alternate is used when plain steel shafting is used for the intermediate shafting. The second alternate is used when all the shafting is stainless steel. If self-lubricated bearings are used ensure to specify those in 35 05 40.17.

****

[Provide replaceable stainless steel one-piece journal sleeves at each guide bearing, packing gland and seal locations. [For self-lubricated bearings see 35 05 40.17 SELF-LUBRICATED MATERIALS, FABRICATION, HANDLING, AND ASSEMBLY]. Finish sleeves at all bearings and packing gland locations to at least 32 rms and finish sleeves at seal locations to 16 rms. Securely fasten sleeves to the shaft to prevent movement. Make keys and fasteners, if used, from corrosion resisting steel; fastening by adhesive or welding is not acceptable. All keys and keyseats (keyways) must meet the requirements of ASME B17.1. The surface hardness of the sleeves at the bearing and packing gland locations must be as recommended by the pump manufacturer.

][Finish the shaft journal at all guide bearing and packing gland locations to at least 32 rms and finish the shaft at seal journal locations to 16 rms. The option exists to install replaceable stainless steel one-piece sleeves at each bearing, packing gland, and seal locations with the finishes stated above. Securely fasten sleeves to the shaft to prevent movement. Make keys and fasteners, if used, from corrosion resisting steel; fastening by adhesive or welding is not acceptable. All keys and keyseats (keyways) must meet the requirements of ASME B17.1. The surface hardness at the seal locations must be as recommended by the seal manufacturer.

]2.4.9.4 Circumferential Line

****
NOTE: The circumferential line with pointer should be used for pumps having 1200 mm 48 inch and greater discharge diameters. The following information will be used for determining whether the pump driver is specified as using a hollow or solid shaft.

Pump drivers with rating less than 745 kW 1000 horsepower are equipped with hollow shafts permitting vertical shaft adjustment from the top of the driver.

Pumps drivers over 745 kW 1000 horsepower are equipped with hollow shafts whenever possible but as a minimum the pump will have a means of vertical adjustment above the operating floor.
****

Inscribe or etch a circumferential line on the shaft above the stuffing box and mount an adjustable pointer opposite this line in order to indicate a change in vertical position of shaft and to permit realignment after [motor] [gear reducer] removal.

2.4.10 Shaft Enclosure

****
NOTE: Shaft enclosure tubes are tensioned for pumps with discharge diameters less than 1350 mm 54 inch. Rigid enclosing tubes are used on pumps having discharge diameters 1350 mm 54 inch and greater. External supports or bracing located in the pump water passage are used for pumps with tensioned enclosing tube of 6000 mm 20 ft in length or greater. Self-supported enclosing tubes 4500 mm 15 feet length or greater should have external supports. The enclosing tube is split when pump size is 1800 mm 72 inch or larger. Select appropriate bracketed statements based on the type of pump lubrication being called for.
****

Provide a shaft enclosure to cover the intermediate shaft and coupling. It [must be placed in tension or]must be rigid enough to be self-supporting. [Do not use external supports or bracing located in the pump water passage for support of the enclosing tube unless necessary to support intermediate bearings or indicated to be necessary or advantageous by the dynamic analysis required in paragraph DYNAMIC ANALYSIS. Consider the effect of external supports, including rubber inserts, in the dynamic analysis required in paragraphs under TEST, INSPECTIONS, AND VERIFICATIONS.] Design each enclosure [to be watertight and] for easy assembly and disassembly in the field.[Split each enclosure longitudinally to permit easy removal without removing or disassembling the pump shaft.] [Perforate each enclosure tube sufficiently to allow a free flow of pump discharge water (i.e., product water) to lubricate the shaft bearings.] Construct enclosing tubes, constructed with screw type joints and using tension in the tube to hold alignment, to prohibit the tension tube from unscrewing when the packing gland adjustments are made. [Provide a shaft enclosure for grease-lubricated pumps with a drain having a shut-off valve located outside of the pump to permit draining the enclosure between operation periods. Locate the drain at the bottom of the shaft enclosure.] [On oil-lubricated pumps, fit the enclosing tube below the lowest bearing and above the oil seals with an oil/water drain line to the outside of the pump. The drain line must have a check valve outside of the pump to preclude the entrance of sump water.]

2.4.11 Guide Bearings and Seals

****

NOTE: The Clean Water Act requires all in water bearings to meet the standard EAL criteria (Vessel General Permit (VGP), or EPA 800-R-11-002). Confirm submitted EAL product data conforms to EM 1110-2-1424. Grease lubrication can be used with all size pumps. Oil lubrication may be used in pumps having discharge diameters of 900 mm 36 inch or smaller. Select appropriate bracketed statements based on the type of pump lubrication being called for. The first water-lubricated bearing alternative is for product lubricated bearings. The second water-lubricated alternative if for externally-provided water.

****

2.4.11.1 Guide Bearings

All in water bearing lubrication must conform EPA 800-R-11-002 for environmental acceptability. Submit in water bearing lubrication product data to show bearings meet environmental, performance, and comparability requirements for the application.

[Provide each pump with sleeve-type bearings designed for [grease] [oil] lubrication. Each bearing must have a bronze lining in contact with shaft journal and must be replaceable type. Arrange the bearing liner for maximum distribution of [grease] [oil] for lubrication of journal surface. Bearings must have a surface finish of 0.80 µm 32 microinches rms or better to match the journal finish. Since pumped water may contain some fine sand and silt in suspension, give special attention to the design and selection of bearing parts, especially seal rings, to preclude entrance of foreign material between the bearing and journal due to differential water pressure.

][Provide elastomeric polymer alloy bearings, sealed in the shaft enclosure. Support the bearings in threaded bronze sleeves acting as an enclosing tube. Ensure the bearings are submerged in water when the pump is in operation. Accomplish lubrication by pump discharge water (product water) free-flowing through perforations in the shaft enclosure tube.

][Provide each pump with bearings that are grooved and continuous. Machine the bearings to marine clearances for strained canal water lubrication and of sufficient length and diameter to keep bearing pressure to the allowable design. Select bearing thicknesses and marine clearances to allow for material swell from water submergence. Shaft bearings may be located as the design dictates with the following exceptions. Provide no fewer than three bearings in the pump with a maximum bearing spacing of 1.5 m 5 feet. Locate bearings at the top of the diffuser section, above the impeller, and near the baseplate. Bearings in the right angle gear, other than the thrust bearing, are not acceptable for use as pump shaft support. Support the line shaft bearing by the diffuser inner cone fabricated assembly. Secure tubing for bearing lubrication water to and routed on the outside of the casing for each bearing. The tubing must be continuously welded to a diffuser vane or bearing support to cross from the outside of the casing to the bearing mounting assembly.

Bearings must be easily removable for servicing in the field.]

2.4.11.2 [Oil][Grease] Lubrication Shaft Seals

****

NOTE: Select appropriate alternate paragraph. The designer must select the appropriate seal material which is compatible with the selected oil lubrication.

****

[Pumps designed for oil lubrication must have a shaft seal system located below the upper pump shaft bearing. The seal system consists of a seal containing two lip elements. The element facing the bearing must have a stainless steel garter spring back-up and be constructed of [tetrafluoroethylene][fluoropolymer elastomer][Buna N]. The secondary element faces the impeller and is constructed of tetrafluoroethylene. Use a bullet-shaped assembly tool or other special tool over the end of the shaft or grooves in the shaft to preclude damage to the lip element during assembly. Assembly tools used are considered a special tool and must be furnished to the Government as part of special tools specified in paragraph SPECIAL TOOLS. Pumps having two stages must have seals to protect the extra bearings required by two stages of construction.

][Pumps designed for grease lubrication must have a shaft seal consisting of lip seals. The seal system consists of a lip-type seal located on each end of the bearing. Each seal must contain a lip element having a stainless steel garter spring back-up and be constructed of [tetrafluoroethylene][fluoropolymer elastomer][Buna N]. Face the lip element out, away from the bearing to keep water from intruding into the bearing chamber. The lowest bearing must have an additional grease seat with the lip facing away from the bearing. Use a bullet-shaped assembly tool or other special tools over the end of the shaft and shaft grooves to preclude damage to the lip element during assembly. The assembly tool used is considered a special tool and must be furnished to the Government as part of special tools specified in paragraph SPECIAL TOOLS.

][2.4.11.3 Product Lubricated Pump Bearings

Submerged pump bearing must be [product lubricated][externally supplied water lubricated] and meet the following requirements:

a. Fabricated from an elastomeric material or polymer composite material and not require petroleum lubricants for operation.

b. Operate in [brackish][fresh] water that may contain [sand] [silt] [vegetative trash].

c. Does not require service or replacement for [50,000] [_____] operating hours.

]2.4.12 Bearing Heat Sensors

****
NOTE: Bearing heat sensors may be used in pumps having a discharge diameter larger than 600 mm 24 inches. Pumps with large discharge diameters should be furnished with heat sensors for the impeller bearings only, when the estimated annual operation is less than 100 hours per pump. Pumps with greater operating hours per year may be equipped with bearing heat sensors for all bearings in the pump. Schedule 80 guard pipes must be used when the unsupported length is 450 mm 18 inches or less. Schedule 120 should be used for greater unsupported lengths.
****

Fit [the impeller shaft bearings] [each bearing] with temperature-sensing elements, inserted in the bearings to within 3 mm 1/8 inch of shaft. Provide these temperature-sensing elements with temperature readouts mounted [on the [engine] [motor] instrument board] [at a central location as shown]. Provide a visual and audible alarm system to warn of bearing overheating. Provide temperature indicator with dual outputs that have setpoints that are separately adjustable. Support leads and protect them from water and mechanical damage. Terminate the leads outside of the pump casing in a waterproof connection head and cap until final connections are made in the field. The connection head must be rated watertight to 175 kPa 25 psi. Lead protection consists of pipes fastened to the pump with brackets using bolts and nuts to permit their removal, and constructed with enough unions to be completely disassembled. Leads passing through the pump water passage in the pump must either be contained in a guide vane or be protected by [Schedule 80] [Schedule 120] pipe. Make protection pipe removable if connected to the shaft-enclosing tube. Install bearing heat sensors as [shown in Figure 2 at end of the section] [indicated]. Run leads and wiring to a junction box located on the baseplate. Provide a terminal strip in the junction box for connection of wiring to temperature readouts.

2.4.13 Thrust Bearing

Provide a thrust bearing in the [speed reduction gear][motor] to carry total thrust load[as specified in [_____]].

2.4.14 Packing Gland

Provide [grease-] [water-]lubricated packing gland split longitudinally to facilitate removal or renewal. Arrange it to permit inspection, repair, removal, or replacement of packing without entering pump from below operating room floor. Provide eye bolts and tapped holes in each half of the split gland if halves weigh over 14 kg 30 pounds each.

[2.4.15 Siphon Breaker Valve

Provide a siphon breaker valve assembly for each of the vertical axial-flow pumps. Provide [mechanical, self-actuating] [electrically-operated] valves. Install each assembly at the top (summit) of the discharge pipe and must vent air from the discharge pipe when the pump is started. The assembly must also permit air to enter the discharge pipe through the siphon breaker valve to prevent reverse siphoning of water when the pump is stopped. Size the valves based on the pumping conditions (e.g. flow, head, discharge pipe diameter) of the specific system. If a mechanically-actuated valve is chosen, size the valve to allow air to relieve at a maximum of 90 m per second 300 feet per second. Provide a means to operate the valve manually to stop back-siphoning through the pump in case the normal operator of the siphon breaker valve fails.

]2.5 LUBRICATION SYSTEM

****

NOTE: Select appropriate alternate paragraph. Oil lubrication may be used for pumps with discharge diameters up to and including 900 mm 36 inch. Grease lubrication may be used for all size pumps. The centralized pressure lubrication system will be used when grease lubrication is selected. Select the water-lubricated bearings bracketed information if this type of lubrication is being used. The Clean Water Act requires all in water bearings to meet the standard EAL criteria (Vessel General Permit (VGP), or EPA 800-R-11-002). Confirm submitted EAL product data conforms to EM 1110-2-1424.

****

All in water bearing lubrication must conform EPA 800-R-11-002 for environmental acceptability. Submit in water bearing lubrication product data to show bearings meet environmental, performance, and comparability requirements for the application.

[Oil lubrication of shaft bearings consists of introducing oil at the top line shaft bearing and allowing oil to run down the shaft for the lubrication of the lower bearings. Oil lubrication consists of an oil reservoir mounted on the pump baseplate or pump driver at such height to permit gravity flow of oil to the highest lubrication point of the pump shaft. Construct the reservoir of transparent material to permit observation of the quantity of oil in the reservoir. The oil reservoir must have a minimum capacity of 1 L 1 quart. The reservoir must have a solenoid valve to permit oil flow whenever the pump driver is in operation. The flow rate from the oil reservoir must be adjustable from five drips per minute to constant flow. The reservoir valve must permit manual flow of oil when the pump driver is not operating for prelubrication of the shaft bearing. Construct the oil line from the oil reservoir to the pump line shaft of stainless steel tubing and support at sufficient locations to preclude vibration of tubing when the pump is operating. If the pump has a bearing located below the impeller, this bearing must be grease-lubricated. Provide a grease line with a grease fitting from this bearing to a location on top of the baseplate. Provide a grease reservoir with this bearing configuration for containing extra grease. Lubricate shaft packing by grease. Run the grease lines to a location outside of the driver pedestal and provide with a fitting for manual lubrication.

][Support grease lines to each bearing and protect them from water and mechanical damage. Grease line protection consists of channels fastened to the pump with brackets, using bolts and nuts to permit removal. Grease lines passing through the pump water passage must either be contained in a guide vane or be protected by Schedule [80] [120] pipe. This protection pipe must be removable if connected to the shaft-enclosing tube. Prefill grease lines before connection to bearings. Terminate grease lines above baseplate for connection to the lubricating grease pump.

][Provide lubrication for the bearings from the water being pumped (i.e., product water) by means of perforations in the shaft enclosure. Design the perforations such that the shaft tube is constantly filled with water during pump operation, thereby continually covering the contact surfaces of the bearings. If upper bearings will not receive sufficient pumped water for lubrication, use another means to provide sufficient water to these bearings using either product water or water from the intake canal. Provide a means to indicate visually that the upper bearing(s) and packing gland are obtaining sufficient lubrication water.

2.5.1 Supplemental Lubrication Water

If it is determined that the pumped product water cannot be lifted sufficiently to lubricate the upper bearing(s), it is the Contractor's responsibility to design and provide a complete water lubrication system. Provide a separate water lubrication system for each pump. The water cannot come from the potable/well water system. This water lubrication system must include a means for providing sufficient lubrication water to the upper bearing(s). The supplemental lubrication water system must include an alarm and shutdown in case of low-flow or no-flow to the upper bearing(s), along with electrical input to the [engine] [motor] control panel and SCADA/PLC systems as needed. Provide any necessary filtering, flow switches, time delays, to ensure that the upper bearings are satisfactorily lubricated. Coordinate any additional electrical power and controls requirements with Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM and other electrical sections. The supplemental lubrication water system must be fully maintainable. If the supplemental lubrication water system is needed, provide shop drawings, operations and maintenance data, and as-built drawings as required.

][2.5.2 Centralized Pressure Lubrication System

[2.5.2.1 General

Provide each pump with its own individual electric motor-driven centralized pressure lubrication system, designed to deliver the proper predetermined or metered quantity of lubricant to each individual bearing and stuffing box. Positively indicate proper or improper functioning of any individual metering device. Mount the pressure pump, individual metering devices, and any required auxiliary operating accessories on the baseplate. Furnish the system complete and ready for operation, including sufficient lubricant to fill each pressure pump lubricant reservoir. Submit the complete centralized pressure lubrication system for review and approval. Provide the lubricant recommended for the selected pumps, subject to approval of Contracting Officer.

][2.5.2.2 Pumping Unit

Provide an electric motor-driven central pumping unit as a complete assembly, consisting of a positive displacement type pump, flow-directing valve (if required), lubricant reservoir, suitable pressure gage to indicate pump discharge pressure, operation counter, pressure protective device, and other auxiliary accessories as required to give a complete and workable unit conforming to the requirements specified. The pump must be of multiple individual piston, positive displacement type utilizing hardened steel pistons, closely fitted to the cylinder bores to eliminate the need for packing. Spring-actuated check valves is not be required for its operation. The pump must deliver not less than 100 mL 6 cubic inches of lubricant per minute against a pressure of not less than 13.8 MPa 2000 psi measured at the most remote bearing connection. The lubricant reservoir must be of a suitable metallic construction, with a capacity of not less than 11 kg 24 pounds of lubricant, and provided with a means that will ensure positive priming of the pump at all times (such as an atmospheric or spring-loaded follower plate), an indicator to show quantity of lubricant in the reservoir, and a screened fill connection to permit filling the reservoir by a transfer pump without exposing the lubricant to the atmosphere. Provide the pump unit with a fully automatic control system, capable of suitable or proper scheduling by an adjustable synchronous motor-driven timing device, and other required auxiliaries necessary to give a complete and workable system. Provide the controller with a "Hand-Off-Automatic" selector master switch to permit selection between push button manual and automatic time clock operation, and to deenergize the system. Supply electric power at 115 volts single phase, 60 cycles. Use the time clock setting recommended for the selected pumps.

][2.5.2.3 Metering Valves

Provide a metering or measuring valve for each bearing and stuffing box. It must be fully hydraulic in its operation, requiring no internal springs or check valves. Size the valve based on requirements of the selected pumps.

][2.5.2.4 Piping

The system piping must be stainless steel tubing (ASTM A269/A269M, Type 410 or equal) using flared or compression-type connectors. Adequately protect and rigidly support the piping located below the operating room floor in a manner approved by the Contracting Officer. Provide each individual grease line with a "Tee" fitting, located immediately below the respective metering valve and accessible from the operating room. Provide the piping with a standard 6 mm 1/4 inch grease fitting so that each individual line may be fully charged without using the lubricating system pump. The size, strength of pipe, and type and strength of fittings must be as recommended and guaranteed by the Contractor for the selected pumps, but in no case can the bursting pressure of the pipe or tubing used be less than three times the maximum working pressure. Provide a check valve located between the discharge outlet of the measuring valve and the "Tee" fitting specified above in each bearing lubricating line that is exposed to water pressure to prevent entrance of water into the respective measuring valves.

]]2.5.3   Lubrication System Accessories

2.5.3.1   Grease Gun

Provide a hand operated, heavy duty lever grease gun for charging lubrication lines and for emergency lubrication. Provide grease as recommended for the Contractor's selected pumps.

[2.5.3.2   Service Facilities

Provide a service facility consisting of a portable hand operated transfer pump, a hand-towed dolly, and a 55 kg 120 pound drum of lubricant, all assembled and ready for operation. The pump must be self-contained and designed for mounting on the grease drum to protect the contents from the entrance of foreign matter. The pump must deliver not less than 0.45 kg one pound in not more than eight strokes of the pump handle under normal temperature conditions. Provide the necessary hose and quick disconnect coupling for a complete system. The hand-towed dolly must have a rigid platform with four anti-friction bearing mounted wheels, a towing handle, and a provision for securing the lubricant barrel. Use the type of lubricant recommended for the Contractor's selected pumps.

]2.6   PAINTING

****

NOTE: The painting paragraph refers to Section 09 97 02 PAINTING: HYDRAULIC STRUCTURES. Edit UFGS Section 09 97 02 to require the use of System No. 21-A-Z Formula 151 for ferrous parts of the pump located above the finish floor. For the interior and exterior surfaces of the pump located below the baseplate, except for stainless steel or galvanized, the required paint system should be System No. 6-A-Z. Contact the CERL Paint Lab for all painting questions.

****

Perform painting in accordance with Section 09 97 02 PAINTING: HYDRAULIC STRUCTURES.

2.7   FACTORY ASSEMBLY

The pump must be assembled at the Contractor's selected manufacturer's plant[in a vertical position] to assure proper fitting and alignment of all parts. Tolerances cannot exceed those specified or shown on the the manufacturing drawings. Check rotating elements for binding. The suction bell, impeller housing, diffuser, and the discharge elbow must be properly match marked and have their centerlines clearly marked on the outside of all flanges to facilitate erection and alignment in the field. Notify the Contracting Officer sufficiently in advance to permit a representative of the Contracting Officer to inspect and witness the pump assembly. Matchmark all parts disassembled for shipment.

2.8   BASEPLATE AND SUPPORTS

****

NOTE: If Alternate 2 or 3 of paragraph [CRITICAL SPEEDS] [DYNAMIC ANALYSIS] is part of the contract, the results of the dynamic analysis are included as

a load.

Seismic design criteria are provided in UFC 3-301-01 SEISMIC DESIGN FOR BUILDINGS.
****

Design and proportion the [soleplate and] baseplate to support the entire pump assembly, the [reduction gear] [motor] and the loads (including the results of the dynamic analysis) to which it may be subjected during operation.[Support and anchor is as indicated.] Furnish lifting lugs or eye bolts, special slings, strongbacks, or other devices necessary to handle the pump during loading, unloading, erection, installation, and subsequent disassembly and assembly. [Provide a sole plate [as indicated] under the baseplate. Install, level and grout the sole plate in accordance with API RP 686, Chapter 5 - Mounting Plate Grouting.] Provide [leveling nuts][jacking bolts] for leveling the baseplate assembly. Provide an anchor bolt layout to aid in placement of anchor bolts.[Back off all leveling jacking bolts after grouting so that they do not support any of the load.] The pedestal supporting the [motor][right-angle reduction gear] must contain a 25 mm 1-inch lip to contain water leakage from the shaft packing. [Provide a sole plate [as indicated] under the baseplate.][Seismic requirements must be in accordance with UFC 3-301-01 and Sections 13 48 73 SEISMIC CONTROL FOR MECHANICAL EQUIPMENT and 23 05 48.19 [SEISMIC] BRACING FOR HVAC.] Provide the calculations used in the design of the baseplates and the anchoring bolts to ensure that the proper forces (e.g. shear, torsion, bending) have been considered. Submit product data for grout used as pump supports. The baseplates must be structural steel plate of adequate thickness to support the weight of the pump and right angle hear or motor (as applicable) plus the maximum hydraulic thrust of the pump. Provide plates of the length, width, and thickness as determined by the Contractor.

2.9 TESTS, INSPECTIONS, AND VERIFICATIONS

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NOTE: Testing, inspections, and verifications should take place with the pump(s) installed on the baseplate(s). Typically after successful testing is complete, pumps can remain on baseplates for shipment to the Government.
****

2.9.1 Pump Testing

****
NOTE: When specifying well established pumps which are mass produced and exist in catalogs, the designer may chose to simply require pumps be tested in accordance with HI 14.6 "Rotodynamic Pumps for Hydraulic Performance Acceptance Tests". Table D.1 in HI 14.6 provides recommendations for which tests are appropriate for given conditions. For pumps which are highly custom, irregular, or unconventional the following alternate paragraphs may be included.
****

Test specified pumps in accordance with HI ANSI/HI 14.6. For all pumps include [Performance][hydrostatic][NPSH][and mechanical] testing as described in HI ANSI/HI 14.6.

[2.9.2 [Critical Speeds][Dynamic Analysis]

****

NOTE: For the case of custom, irregular, or unconventional pumps, select appropriate alternate paragraph.

Alternate 1, Critical Speeds is used when the estimated operating hours for the pumping station is less than 50 hours per year.

Alternate 2, Dynamic Analysis is used when operating hours are greater than 50 hours per year and the pump is driven by an electric motor. The motor described is a vertical shaft type without a speed reducer. If the decision is made to use a horizontal shaft motor, then Alternate 2 needs to be revised to include the speed reducer in the analysis as described in Alternate 3. Select the first and second bracketed paragraphs for Alternate 2.

Alternate 3, Dynamic Analysis, is used when operating hours are greater than 50 hours per year and the pump is driven by a diesel engine/gear reduction unit or when an FSI is used. Select the first bracketed paragraph and the TORSIONAL ANALYSIS and LATERAL FREQUENCY ANALYSIS paragraphs.

The designer should specify performance testing of the assembled pump in the factory to check that the requirements of the specification have been met.

The Performance Test is a required test, whereas the Cavitation, Hydrostatic, Submersible Motor Integrity, and Vibration tests are optional. The designer should be familiar with ANSI/HI 14.6 to determine which tests are needed to balance technical adequacy and cost.

The Cavitation test, or NPSHR test, is costly due to the complexity. The designer should include cavitation testing whenever the cavitation characteristics of the proposed pump have not been determined (by test) by any one of the prospective suppliers. Testing should be conducted on a full-scale (prototype) pump. It should also establish the structural and operating integrity of the complete pumping unit. The prototype pump would be the first pump built. This test may not be necessary if there is sufficient inlet head pressure and the pump has a stated NPSHR that would be acceptable with a suitable margin (see ANSI/HI 9.6.1). The pump could be tested at the minimum design head pressure to verify that the guaranteed head and power at the specific rate of flow instead of performing the NPSHR test. HI ANSI/HI 14.6 provides guidance for testing in Appendix D.

****

[The assembled pumping unit, consisting of the [motor] [,] [engine] [,] [speed reducer] and pump must be free from critical speeds or harmful torsional vibrations at all speeds encountered within the operating range.]

[Before the pump and motor, furnished under Section(s) [26 29 01.00 10 ELECTRIC MOTORS, 3-PHASE VERTICAL INDUCTION TYPE] [26 29 02.00 10 ELECTRIC MOTORS, 3-PHASE VERTICAL SYNCHRONOUS TYPE], [41 65 10.00 10 [DIESEL][NATURAL GAS] FUELED ENGINE PUMP DRIVES] and [35 45 03.00 10 SPEED REDUCERS FOR STORM WATER PUMPS] are released for manufacture, the pump/motor structure must be analyzed by the Contractor for harmful natural frequencies in the lateral and torsional directions. A natural frequency that occurs within 25 percent above or below normal operating speed is unacceptable. Construct a dynamic analysis model using a commercially available program such as Ansys, Cosmos/M, or equivalent, which utilize finite element methods. Incorporate effects of column pipes, cover pipes, shafts, bearings, mass concentrations, and other such features as necessary to accurately model the pump structure. Analyze the structure in the run (wet) condition and consider the effect of water mass in the column and damping effect of water in the sump (vertical units only) at highest and lowest sump water levels. Incorporate Reed critical frequency and mass elastic diagram information for the Contractor's selected motors. If the Contractor cannot demonstrate to the satisfaction of the Contracting Officer (based on impact tests of similar units) that the Reed critical frequency value is accurate, the Contractor must conduct a dynamic analysis using finite element methods as described to determine motor Reed critical frequency for use with the Contractor selected pumps. Submit the complete detailed dynamic analysis report including the following information:

a. Computer program used.

b. Schematic diagram of the model depicting nodes and elements.

c. Input data consisting of node coordinates, element types, material properties, element characteristics, element connectivities, and specified displacements.

d. Motor mass elastic and Reed critical information (or dynamic analysis, if required).

e. Analysis results, including significant natural frequencies.

f. Interpretation of results.

Impact the test motor provided before shipment to determine actual Reed critical frequency of motor. Include results of impact tests included in motor test data to be submitted. The Contractor must address any discrepancy between calculated and actual motor Reed critical frequency values to determine whether design changes are required to prevent harmful natural frequencies in the pump/motor structure. Incorporate any design changes which are required to correct these discrepancies.]

[2.9.2.1 Torsional Analysis

Before the pump, gear drive, and engine are released for manufacture, the Contractor must analyze the system for harmful torsional natural frequencies using mass elastic information for the selected pump(s) and gear drive(s). A natural frequency that occurs within 25 percent above or below [normal operating speed][any of the operating speeds required for pump operating conditions] is considered to be unacceptable.

][2.9.2.2 Lateral Frequency Analysis

Before each pump, engine, and gear drive provided under Section(s) [41 65 10.00 10 [DIESEL][NATURAL GAS] FUELED ENGINE PUMP DRIVES][,] [35 45 03.00 10 SPEED REDUCERS FOR STORM WATER PUMPS], respectively, are released for manufacturing, the pump/gear drive structure must be analyzed by the Contractor for harmful natural frequencies in the lateral directions. A natural frequency that occurs within 25 percent above or below [normal operating speed] [any operating speeds required for pump operating conditions] is considered to be harmful. Construct the dynamic analysis model using a commercially available program such as Ansys, Cosmos/M, or equivalent that utilizes finite element methods. Incorporate effects of column pipes, cover pipes, shafts, bearings, mass concentrations, and other such features in the model as necessary to accurately model the pump structure. Analyze the structure in the run (wet) condition and consider the effect of water mass in the column and the damping effect of water in the sump at the highest and lowest sump water levels. The model must incorporate Reed critical frequency and mass elastic diagram information provided by the contractor. If the Contractor cannot demonstrate to the satisfaction of the Contracting Officer (based on impact tests of similar units) that the Reed critical frequency value is accurate, a dynamic analysis using finite element methods as described herein must be conducted by the Contractor to determine gear drive Reed critical frequency for use by pump manufacturer. Submit the complete dynamic analysis report including the following information:

a. Computer program used.

b. Schematic diagram of the model depicting nodes and elements.

c. Input data consisting of node coordinates, element types, material properties, element characteristics, element connectivities, and specified displacements.

d. Gear mass elastic and Reed critical information(or dynamic analysis, if required).

e. Analysis results including all significant natural frequencies.

f. Interpretation of results.

Impact-test the gear drive before shipment to determine the actual Reed critical frequency of the drive. Submit results of impact tests. The Contractor must address any discrepancy between calculated and actual gear drive Reed critical frequency values as to whether or not design changes are required to prevent harmful natural frequencies in the pump/gear drive structure. If any design changes are required, incorporate at no cost to the Government.

]][2.9.3 Lubricating System Tests

****

NOTE: Delete these paragraphs if water-lubricated pumps are called for.

****

Test the complete lubricating system for each pumping unit, as deemed necessary by the Contracting Officer, to determine that the system meets the operational requirements specified. Test at least one valve of each size furnished with the lubrication line removed from its bearing and fitted with a pressure relief valve and pressure gage. Adjust the pressure relief valve to discharge it at the operating pressure specified and operate the system through one or more cycles as required to obtain an accurate measurement of the quantity of lubricant delivered. This must be within plus or minus 20 percent of the theoretical delivery of the respective valve. Replace, reinstall, and retest any component parts that are damaged as the result of these tests or that fail to meet the requirements of the specification.

]2.9.4 Factory Test

****

NOTE: Test each different size pump for performance.

Alternate specifications for the "Factory Test" have been provided in this specification. Alternate 1 gives the manufacturer the option of testing either the prototype pump (first pump produced) or a homologous model of the pump. This alternative should be used for all pumps having a diameter up to and including 1200 mm 48 inch. Alternate 2, which requires a homologous model of the pump be tested for performance and NPSHR characteristics, should be used for pumps having a diameter greater than 1200 mm 48 inch. Alternate 2 can also be used for pumps smaller than 1200 mm 48 inch in diameter if the expected annual operating time is greater than 500 hours per year or for the special case when there is no published NPSHR curve available.

The designer should specify performance testing of the assembled pump in the factory to check that the requirements of the specification have been met.

The Performance Test is a required test, whereas the Cavitation, Hydrostatic, Submersible Motor Integrity, and Vibration tests are optional. The designer should be familiar with ANSI/HI 14.6 to determine which tests are needed to balance technical adequacy and cost.

The Cavitation test, or NPSHR test, is costly due to the complexity. The designer should include cavitation testing whenever the cavitation characteristics of the proposed pump have not been determined (by test) by any one of the prospective suppliers. Testing should be conducted on a full-scale (prototype) pump. It should also establish the structural and operating integrity of the complete pumping unit. The prototype pump would be the first pump built. This test may not be necessary if there is sufficient inlet head pressure and the pump has a stated NPSHR that would be

acceptable with a suitable margin (see ANSI/HI 9.6.1). The pump could be tested at the minimum design head pressure to verify that the guaranteed head and power at the specific rate of flow instead of performing the NPSHR test. HI ANSI/HI 14.6 provides guidance for testing in Appendix D.
****

2.9.4.1 General

****
NOTE: Select the appropriate alternate paragraph.

In the second alternate, the inclusion of the discharge water passage is based on the complexity of the passage and should be decided in earlier design documents.
****

Allow government access for witness testing upon request. [Provide means for remote witness test upon Government request.]

[Performance of [the] [each size] pump to be furnished will be accepted on the basis of the factory test. Conduct this test using either a scale model of [pump or first pump produced for this contract.] [each size of pump or one of each size of pump produced for this contract.] [Perform cavitation testing in accordance with HI ANSI/HI 14.6][NPSH testing is not required].

][Determine the performance and cavitation limits of the proposed pump [and the shape of the discharge water passage] by a series of tests made on a scale model of the pump[and discharge water passage]. Complete the model test within [180] [240] days after the date of notice to proceed.

][2.9.4.2 Test Setup

****
NOTE: Select the appropriate alternate paragraph. First paragraph, Alternate 1; second paragraph, Alternate 2.

If an FSI is used that does not use the dimensions/ratios as furnished by the Government, a complete pump should be tested.
****

[Alternate 1) [A model pump, if used, must be homologous to the proposed prototype pump, installed with the shaft in the vertical position, and have an impeller inlet diameter of not less than 275 mm 11 inches. Complete the model test within [150] [180] days after date of notice of award. Include a model of the[[sump] [including sump closure gate] [and discharge water passage]] [[Contractor's standard sump] [and discharge water passage]].[Install a model of the formed suction intake (FSI) specified on the model pump that is tested.]

[Prototype Pump(s) - Set prototype (first pump built) pump(s), if selected, with the shaft in the vertical position. A factory test elbow may be used in lieu of the prototype elbow for testing purposes, providing test results are adjusted to reflect the difference in losses. Complete tests prior to assembling any pump except the [one] [ones] to be tested. (Install the FSI specified on the prototype pump that is tested.)]]]

[Alternate 2) [The model pump must be homologous to the proposed prototype pump, and mounted with the shaft in the vertical position.[Equip the sump where the pump suction occurs with windows strategically located for viewing those areas where separation is likely to occur. Windows may be rings of transparent material approximately 100 to 125 mm 4 to 5 inches wide securely anchored between flanges.] The impeller inlet diameter and the datum for this test specification must be as indicated on Figure 3 at the end of this section. The inlet diameter must be not less than 275 mm 11 inches.[If a formed suction intake (FSI) is specified for the pump, include the complete FSI, including the [gate][bulkhead] slot, in the model test.] The FSI used in the model test must be geometrically the same as that used for the proposed pump.]]

****

NOTE: Delete paragraph below. if Alternate 2, above, is selected.

****

][2.9.4.3 Instrumentation and Procedures

In the test report describe each instrument to be used in the tests in detail, giving all data applicable, such as manufacturer's name, type, model number, certified accuracy, coefficient, ratios, specific gravity of manometer fluid to be used, and smallest scale division. Provide calibration data on each of the instruments used. When necessary for clarity, include a sketch of the instrument or instrument arrangement. Include fully detailed narrative description of each proposed method of instrumentation, procedures to be used, and a sample set of computations. State the lowest equivalent static head that is obtainable with the testing when operating along the head-capacity curve of the proposed pump. Perform test procedures, except as specified, in accordance with applicable provisions of HI ANSI/HI 14.6.

2.9.4.3.1 Head Measurements

Make head measurements using either a direct reading water column, mercury-air, mercury-water, a Meriam fluid manometer, or a pressure transducer. Measure vacuums with either a mercury-air manometer, a mercury-water manometer, or a pressure transducer. Dampen fluctuations sufficiently to permit column gages or a differential pressure transducer to be read to either closest 2 mm 0.01 foot of water or Meriam fluid or 2 mm 0.1 inch of mercury. Use manometers as indicated by ISA RP2.1. When pressure transducers are used, check their accuracy with a manometer.

2.9.4.3.2 Capacity

Determine capacity by a calibrated venturi flowmeter or long-radius ASME flow nozzle. Do not use orifice plates. Connect the venturi or nozzle taps to the column gages equipped with dampening devices that permits differential head to be determined to either the closest 2 mm 0.01 foot of water or Meriam fluid or 2 mm 0.1 inch of mercury. Magnetic flowmeters and flowmeters utilizing ultrasonic flow measurements will be acceptable if calibration of flowmeter has been completed within the last 6 months.

2.9.4.3.3   Rotational Speed of Pump

Measure the rotational speed of the pump in accordance with "Method of Rotary Speed Movement" in HI ANSI/HI 14.6, except that revolution counters cannot be used. Non-contacting hand-held electronic tachometers are acceptable. The device used must permit the speed to be determined to 1 rpm.

2.9.4.3.4   Power Input

Measure power input to the pump in accordance with "Power Measurements" in HI ANSI/HI 14.6. Use a method to permit pump brake wattage horsepower to be determined to the closest 0.5 kW 0.5 horsepower.

2.9.4.3.5   Cavitation Tests

****

NOTE: Alternate 2.

****

Use instruments suited for cavitation testing. However, do not use instruments that yield results less accurate than those obtained with the performance test. {may not be applicable in some situations, for instance very high head.}

2.9.4.3.6   Mechanical Tests

****

NOTE: This mechanical test is highly involved and should only be used in specific circumstances of newly designed or custom pumps.

****

Take vibration measurements of the assembled pumping units per HI ANSI/HI 14.6.

][2.9.4.4   Pump Test

****

NOTE: Tolerance Bands
The designer may use AISI/HI 14.6 to specify different testing tolerance bands based on size and application of specified pumps.

****

Demonstrate that the proposed pump complies with the specified performance. The pump must be capable of operation without instability over the entire range of heads specified in paragraph CAPACITIES. Tolerances must be in accordance with HI requirements. Instability is defined, for this specification, as when one or more of the following conditions occur:

a. the pump has two or more flow rates at the same total head;

b. The head-capacity curve has a dip (region on curve where change in flow rate produces an abnormally low head);

c. When any point in the usable range of head-capacity curve cannot be repeated within 3 percent.

Rerun the test if this occurs. Compliance with specifications will be determined from curves required by paragraph TEST RESULTS. Test procedures, except as specified, must be in accordance with applicable provisions of HI ANSI/HI 14.6. The acceptance grade is 1U as described in HI ANSI/HI 14.6. [Pumps are acceptable is they achieve the guarantee point requirements stated in paragraph CAPACITIES.] Use water at approximately the same temperature for all tests run and record the temperature during test runs.

][2.9.4.5 Motor, Cables, and Controller Test

Test the pump motor per NETA ATS. For induction motors use NETA ATS 7.15.1. For Synchronous motors use NETA ATS 7.15.2.

][2.9.4.6 Test Procedure

****
NOTE: The suction water elevation is that level indicated in paragraph CAPACITIES.
****

2.9.4.6.1 Performance of The Pump

Determine the performance of the pump by a series of test points sufficient in number to develop a constant-speed curve over the range of total heads corresponding to the [static] [pool-to-pool] [bowl] heads in paragraph CAPACITIES. The performance/test range must include additional testing at total heads 600 mm 2 feet higher than the total head determined in paragraph CAPACITIES. The lowest total head for testing must be, as a minimum, the total head determined from paragraph CAPACITIES. If the test setup permits testing at lower total heads, extend the range of total heads 600 mm 2 feet lower. Testing must be inclusive for [each] [the] speed(s) involved with the sump at elevation[s] [_____] [and [_____] NGVD feet]. Conduct tests using prototype [total] [pool-to-pool] heads. Head differentials between adjacent test points cannot exceed 900 mm 3 feet, but in no case may fewer than 10 points be plotted in the pumping range. If the plot of the data indicates a possibility of instability or dip in the head-versus-capacity curve, a sufficient number of additional points on either side of instability must be made to clearly define the head-capacity characteristics. When a scale model of the pump is tested, consider the efficiency of the prototype pump to be the efficiency of the model. No other computation or adjustment of model efficiency to prototype conditions will be permitted.

2.9.4.6.2 Sump Elevations

Conduct tests at two different sump elevations (approximately a 1500 mm 5 foot differential) to determine the effect of test sump geometry on the performance of the pump. Should the test results indicate that the performance is not the same in all respects for both sump conditions, take whatever corrective action is necessary to produce congruent results.[One of the two sump elevations used may be at the specified elevation.] [Use the sump elevations specified in paragraph CAPACITIES.] The test results with this sump elevation must meet all specified conditions of capacity, head, and brake kW horsepower. {Submit} curves indicating test results.

2.9.4.6.3 Tests Results

Plot results of tests to show total head, [[static] [pool-to-pool] [bowl] heads], brake kW horsepower and efficiency as ordinates; all plotted against pump discharge as the abscissa. Plot curves showing prototype performance to a scale that will permit reading head directly to [60] [150] mm [0.2] [0.5] foot, capacity to [190] [380] [760] [1900] L/min [50] [100] [200] [500] gpm, [0.14] [0.28] [1.4] m^3/s [5] [10] [50] cfs, efficiency to 1 percent, and power input to [3.7] [7.5] [18.6] [37.2] kW [5] [10] [25] [50] horsepower.

2.9.4.6.4 Demonstration

Demonstrate to the Contracting Officer that the blade templates fit the tested pump. Perform the demonstration immediately after testing is completed. Retain all templates for the tested pump, and provide them to the Government upon request of the Contracting Officer, to permit the Government to verify geometric similarity with the Contractor's pump. In addition to providing templates, submit dimensioned drawings of the impeller that contain all dimensions needed to manufacture it. Stamp the tested impeller with identification marks. Provide necessary facilities and instruments needed to permit the Government to verify that pump[s] [is] [are] in complete geometric similarity with the tested pump.

][2.9.4.7 Cavitation Tests

****

NOTE: Alternate 2.

****

2.9.4.7.1 Model Test

The model test must include the determination of net positive suction head required (NPSHR) at five or more points on [the constant speed curve][each constant speed curve when more than one speed is involved]. Determine NPSHR, as a minimum, for five or more capacities corresponding to prototype capacities over the total range of specified operating conditions. If the pump has a capacity greater than that specified for the lowest and/or highest operating condition, then use these over-capacity conditions. Equally space the other test capacity points between the highest and lowest capacities.

2.9.4.7.2 NPSHR

Determine NPSHR on a constant-capacity, constant-speed basis, using arrangement Figure F.3 or F.4 as described under paragraph NET POSITIVE SUCTION HEAD REQUIRED TEST in HI ANSI/HI 14.6. Vary suction conditions to produce cavitation. NPSHR must be the maximum value at which any one or all of the plotted curves, head, kW horsepower, and efficiency depart from the constant values (point of tangency). Obtain a sufficient number of points to accurately locate the departure point.

2.9.4.7.3 Value of NPSHR

****

NOTE: The amount head margin used to determine adequacy of NPSHR is determined during the design of the pumping station as indicated in Engineering Manual EM 1110-2-3105.

****

The value of NPSHR must be [300] [600] [900] mm [1] [2] [3] feet less than the corresponding available net positive suction head available (NPSHA). Determine NPSHA using the temperature of the water in the model at the time the tests are run and the datum shown on Figure 3 at the end of this section. Use the water elevations specified in paragraph CAPACITIES to determine the NPSHA for the pumps.

2.9.4.7.4 Plotting Test Results

Plot the test results to the scales determined by the Contracting Officer at the time of the test. Draw curves showing [static] [pool-to-pool] [total] head, brake kW horsepower, and [pool-to-pool] efficiency as ordinates and NPSH as the abscissa. In addition, draw curves showing NPSHR versus capacity with NPSH as the ordinate and capacity as the abscissa. Show NPSHA points on the curves.

2.9.4.7.5 Curves

Should it be considered necessary by the Contractor to take into account measurement inaccuracies when drawing the curve needed to determine NPSHR in accordance with paragraph NPSHR, use the following method. No other method is acceptable. Determine the inaccuracy for each parameter, and submit the calculations to the Contracting Officer for approval. Using the calculated inaccuracy as the radius and the test point as the center, draw a circle for each test point. Draw two curves, one a maximum and the other a minimum, and pass through or touch each circle. The maximum curve must touch the top and the minimum curve must touch the bottom of as many circles as is practicable while maintaining smooth curves. Should the plot indicate that a test point is obviously erroneous, it may be ignored by mutual consent or the test may be rerun. Halfway between the maximum and minimum curves, draw another curve (the mean). The point at which the mean curve departs from the constant values (point of tangency) is considered to be the NPSHR of the pump for the capacity at which the test was run.

][2.9.5 Intake Tests

****

NOTE: Delete this paragraph if a model test of the intake to the pumping system(s) is not required.

****

Provide complete performance model testing of the pump intake systems. Use the model testing to confirm the configuration of the intake systems, including the proposed intake conduit, hydraulic losses to the pump, the position of the pump in the intake bay, and to confirm the selection of the pump. The Contracting Officer will witness the final tests confirming the geometry for the intake conduit. Notify the Contracting Officer with not less than 14 days written notice of the time and location for the final tests.

2.9.5.1 Qualifications

Perform the modeling work in a hydraulic laboratory located within the United States where this type of work has been performed for a period of at least ten years. The individual in responsible charge of the modeling work must be a registered professional engineer in the U.S. state where the model testing will be performed with at least ten years' experience in pump and intake modeling work for similar projects. The engineer must seal and sign all reports and data documents generated as a part of the test work prior to submitting them.

2.9.5.2 Intake Model Setup and Objectives

The model intake setup must be of the intake system, custom designed for this installation and suitable for operation at atmospheric pressure for observation of the intake basin performance. The intake model must be suitable for use with a model pump. Use clean and clear water for the test to allow proper observation. The temperature of the water during any test cannot exceed 30 degrees C 85 degrees F.[For the FSI, provide a setup to determine flow patterns in the suction basin approaching the intake, along with losses to the pump. Provide further tests to identify flow patterns in the intake itself and approach patterns at the entrance to the pump.] In the intake model, include all items in the intake path, including, but not limited to: models of the trash rack, stoplog slots, access ladders, and the stilling wells in the intake bays.

2.9.5.3 Intake Model Tests

The objective of the modeling work is to define the performance of the proposed pumping unit and to confirm the geometry to be used for the pump intake. The model must have a model-to-prototype Froude number ratio of 1, based upon the pump impeller diameter. Arrange the model in the same relative orientation as the prototype structure and include the bay configuration and screening system. Perform all testing with the same model.[

Intake Tests: For the formed suction intake geometry shown on the drawings, use the model setup to determine flow characteristics in the suction basin intake bay and at the entrance to the FSI at all specified operating conditions. In addition, use the model to determine the effect of the intake system on pump operating characteristics. Use a siphon generated by a separate pump to examine flow characteristics in the intake bay using Froude relationships to model intake operation in the first set of tests. Use second test to develop information on the effect of the intake on pump operation. Use these values to forecast the performance of the pump-intake conduit combination.]

[Alternate Intake Geometry: If an intake geometry differing from that indicated is proposed, or other modifications such as baffling, test the proposed intake and/or modifications to demonstrate its suitability for use in the project and compliance with Appendix I in EM 1110-2-3105. For that reason, design the laboratory setup specifically to monitor free and sub-surface vortices, swirl and pre-rotation approaching the pump impeller, flow separation at hydraulic surfaces in the intake conduit and at the hydraulic surfaces approaching the pump impeller, and axial velocity distribution at the entrance to the impeller.]

a. The intake conduit and pump inlet must contain several clear windows and similar appurtenances and adequate lighting at all critical areas to allow visual determination of the presence of vortices, turbulence, and other defects. Make provisions to insert dye at intervals in the intake conduit and at the entrance to the impeller during operation of the test. Reynolds and Weber numbers for all model runs must be greater than 30,000 and 120, respectively. The Contractor must develop scale factors for velocity, flow, and time for use in evaluation of model results. Scale factors are subject to review by the Contracting Officer. In addition to model runs at all specified operating conditions, conduct no fewer than five runs at 1.5 times Froude-scaled flows after final geometrics for the intake conduit and intake bays have been established, keeping the submergences at the geometrically scaled values. Track and document circulation contributing to development of vortices.

b. Determine vortex formation in the model every 15 seconds extending over a period of 10 minutes. Classify vortices in accordance with the strength classification system in HI ANSI/HI 9.8 for both surface and subsurface vortices, using dye wand injection to assist in classification. The Contractor must provide both photographic and video documentation of vortex formation. Direct particular attention to subsurface vortex formation at the intake conduit entrance and on intake conduit surfaces leading to the impeller entrance.

c. Provide a swirl meter or other satisfactory device to determine liquid rotation (swirl) at the entrance to the impeller. Obtain swirl readings at intervals of 20 seconds for a period of not less than 10 minutes after the model has achieved steady-state operation at any specified operating condition. Swirl angle is defined by the relationship:

swirl angle = (1/(tan))(pi*d*n)÷ u

Where:
u = average axial velocity at the swirl meter.
d = diameter of the conduit at the swirl meter.
n = revolutions/second at the swirl meter.

d. Headloss Measurements: Measure headloss from the upstream model boundary to just upstream of the pump inlet for each documentation test and include a minimum of the following conditions:

Pump No.	Avg On/Off El. (m) (feet)	Individual Pump Q (cubic m per second) (fps)	Total Pump Q (cubic m per second) (fps)

****

NOTE: Provide an expected order of pump operations and expected intake elevations at start-up for each pump.

****

e. Also record the head loss from just upstream of the FSI to the throat of one model pump for a minimum of 10 flow rates after the model Euler number is determined to be constant and at least one point (near the middle of the data) must be within 2 percent of the scaled rated flow of the pump. Measure head loss with a differential manometer or differential stilling basin. Install a minimum of four pressure taps around the pump throat measurement point and joined to form an average pressure reading. Calculate a dimensionless head loss coefficient for the formed inlet that includes the entrance loss into the formed inlet.

f. Determine the velocity profile in the channel cross section approaching the intake and performing the velocity traverses on perpendicular axes at the intake throat, just upstream from the impeller. Velocity measurement instruments must be capable of an accuracy of plus or minus 2 percent.

g. Use the following as criteria for acceptance of the proposed design:

(1) Free surface and sub-surface vortices entering the pump intake must be less severe than Type 1, as defined in HI ANSI/HI 9.8, unless dye core vortices appear for less than 10 percent of the time or only for pump operating conditions that are expected to be infrequent, such as the listed maximum or minimum operating conditions.

(2) Swirl angles, both maximum and average, indicated by swirl meter readings, must be less than 5 degrees. Swirl angles as great as 7 degrees will be accepted if occurring less than 10 percent of the time or for operating conditions that are expected to be infrequent, such as the listed maximum or minimum operating conditions.

(3) Velocities at points of equal radii at the throat of the intake conduit must be within 10 percent of each other.

(4) Determine NPSHR on the basis of a one percent reduction of efficiency.

(5) Time-varying velocity fluctuation (turbulence) levels as defined by a standard deviation over average velocity at a point within the pump throat must be less than 10 percent.

h. Unless otherwise specified, conform accuracy of all measurements to the levels established in HI ANSI/HI 14.6.

2.9.5.4 Recommendations from the Model Test

If the results of the intake model testing indicate that any features of the design are deficient, report this to the Contracting Officer in writing immediately. If the intake modeler has recommendation for improving the flows in the pumps, provide them in the Intake Model Test Report. Flag these as important information that requires the Contracting Officer's immediate attention. Note all recommendations considered major changes. provide any minor recommended changes to the intake as variations in the shop drawings.

]2.10 PUMP DRAINAGE

Provide drain holes for all parts of the pump to eliminate trapped water. These drain provisions must be self-draining without any requirement to enter the sump.

2.11 WITNESS TEST

****

NOTE: The time to review test data should be 2 weeks. Longer times may be used when the District has staffing difficulties or special arrangements are required to have data reviewed by others. The shortest period is preferred since this may permit

the pump tested to remain in place during the review period. If the pump/test instruments are not moved, then the possibility of changes to the test results for the witness test are less likely to occur. The cost of the tests would be less also.
****

When the Contractor is satisfied that the tested pump performs in accordance with the requirements of the specifications and the guaranteed values, notify the Contracting Officer that the witness tests are ready to be run and provide copies of the curves required in paragraph PUMP TESTING [and paragraphs under CAVITATION TESTS] along with a set of sample calculations with constants and conversion factors. Also, provide instrument calibration data in this report. [Two] [Three] [Four] weeks will be required to review this data before the Contracting Officer will be available to visit the Contractor's laboratory for witnessing the test. Should the results of the witness test reveal that the tested pump does not perform in accordance with the requirements of the specification and the guaranteed values, make such changes as are required to make it acceptable before again notifying the Contracting Officer that the witness tests are ready to be run. Immediately upon completion of each witness test, submit copies of all data taken during the test to the Contracting Officer witnessing the test. Furnish computations of test results and plotted preliminary curves to the witness.

2.12 CERTIFIED TEST REPORT

****
NOTE: The certified test report is appropriate when testing required under the contract was of the general requirements outlined in HI 14.6 and pumps are of a common conventional type.
****

Submit Contractor's pump manufacturer certified completed test report stating the specified pumps meet HI ANSI/HI 14.6 after testing is complete.

[2.13 TEST REPORT

****
NOTE: This section is not necessary if Contractor's pump fabricator is required to provide a certified test report.

Require this more detailed report when more custom and specific testing was outlined in the specifications.

If used, delete item "o" if water passage is not included in the contract.

****

Submit, in accordance with HI ANSI/HI 14.6, and within 30 days of receipt of approval of the witness test, to Government [3] [4] [7] [hard bound] [digital] copies of a report covering completely the test setup and performance[and cavitation] tests. Include, as a minimum, the following in each test report:

a. Provide a statement of the purpose of the test, the name of the project, contract number, and design conditions. Also provide where guaranteed values differ from specified values.

b. A resume of preliminary studies, if such studies were made.

c. A description of the test pump and motor, including serial numbers, if available. Information required under "b" may be included here.

d. A description of the test procedure used, including dates, test personnel, any retest events, and witness test data.

e. A list of all test instruments with model numbers and serial numbers.

f. Sample computations (complete).

g. A discussion of test results.

h. Conclusions.

i. Photographic evidence in the form of either multiple color photographs of test equipment, test setup, and representative test segments, and a digital recording on optical disc, at least 30 minutes in length, covering the same information as photographs. Label all photographic evidence with the Contract number, location, date/time, and test activity. Voice annotate the digital recording with the same information.

j. Copies of instrument calibration.

k. Copies of all recorded test data.

l. Curves required by paragraph TESTS RESULTS.

m. Curves showing the performance of the test pump.

n. Drawings of the test setup showing all pertinent dimensions and elevations and a detailed dimensioned cross section of the pump.

[o. Drawings including cross sections of water passages that must be incorporated in the construction contract.

] p. The name and credentials of the Contractor's Erecting Engineer(s) who was(were) responsible for the pump testing.

]PART 3 EXECUTION

3.1 INSTALLATION

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NOTE: Designers should be come familiar with API RP 686 so details can be specified appropriatly.
****

Install the [soleplate and] baseplate in accordance with API RP 686. Provide [leveling nuts][jacking bolts] for leveling the baseplate assembly. Provide an anchor bolt layout to aid in placement of anchor bolts.[Back off all leveling jacking bolts after grouting so that they do not support any of the load.] The pedestal supporting the [motor][right-angle reduction gear] must contain a 25 mm 1-inch lip to contain water leakage from the shaft packing. Provide a threaded drain to the sump.

3.1.1 Equipment

a. Install the equipment specified under this section and related drive machinery specified under other sections of this specification in accordance with the approved Installation and Erection Instructions Manual; no later than time of pump delivery, submit a typed or printed, and bound, [digital] manual describing procedures to be followed by the erecting engineer in erecting, assembling, installing, and dry-and wet-testing the pump. To the extent necessary or desirable, coordinate and consolidate description of the pump with similar descriptions specified for the [gear reducer and diesel engine] [motor] [gear reducer].

    (1) The description must be a complete, orderly, step-by-step explanation of operations required, and also include such things as alignment procedures, bolt torque values, permissible blade/bowl clearances; permissible bowl out-of-roundness; permissible shaft misalignment; recommended instrument setups; recommended gages and instruments; bearing clearances; and similar details.

    (2) Complement and supplement the description with drawings, sketches, photos, and similar materials to whatever extent necessary or desirable, resulting in a description that may be comprehended by an engineer or mechanic without extensive experience in erecting or installing pumps of this type.

b. The Contractor's erection engineer(s), familiar with the equipment to be installed, must supervise the handling, installation, start-up and testing of the equipment as required by paragraph QUALITY ASSURANCE.

c. Submit [digital] copies of Operation and Maintenance Instructions Manual containing complete information on operation, lubrication, adjustment, routine and special maintenance, disassembly, repair, reassembly, and trouble diagnostics for the pump and auxiliary units. [Print the operation and maintenance manual and both parts lists on good quality ANSI size A 216 by 280 mm 8-1/2 by 11-inch paper, bound separately between flexible, durable covers.] [Provide the operation and maintenance manual and both parts lists on optical disc, formatted to print on ANSI size A 216 by 280 mm 8-1/2 by 11-inch paper.] Drawings incorporated in manual or parts lists, may be reduced to page size provided they are clear and legible[, or may be folded into the manual to page size]. Photographs or catalog cuts of components may be included for identification. [Submit operation and maintenance data in accordance with Section 01 78 23 OPERATION AND MAINTENANCE DATA.]

3.1.2 Pipes and Joints

Install pipes and joints in accordance with AWWA M11.

3.2 FIELD TESTS

****

NOTE: Select appropriate bracketed statement.

Different projects will have different site conditions to perform these field tests. It's likely that many projects will be accepted outside of flood conditions with very little water available for a long term test run. Edit these testing requirements carefully and account for the anticipated field conditions.

****

After the pumping unit is installed and prior to start-up, completely clean the sump area of any accumulated construction debris. Once final cleaning of the sump area is completed, the area will be area reviewed by a representative of the Government. Correct any damage to the pumping units or related equipment during initial start-up due to foreign objects left in the sump areas.

Prior to proceeding with construction of the [test setup but not later than [60] [90] days after date of notice to proceed, submit a description of the test setup and test procedure proposed. Include dimensioned drawings and cross-sectional views of the setup and pump, respectively, with location of instruments and points of their connection shown.] [model, but not later than 90 days after the date of notice to proceed, submit a description of the proposed model and test procedure. Include dimensioned drawings and cross-sectional views of the model pump showing with the location of all instruments and the point of their connection to the model.]

3.2.1 Dry Tests

****

NOTE: Specify an operating field test duration which is reasonable. This could be as little as 15-30 minutes, or as much as a few hours. All three tests below give you confidence that your pump will operate as designed in its installed location. Whenever possible a combination of both field tests should be performed, even if it it limited.

• Factory Test (shop or model)
PRO - captures the actual design points while pumping
CON - pump not captured in final installed location (in situ per ISO), but rather on a pump stand that is perfectly level and rigidly supported

• Field Dry Test
PRO - isolates the pump assembly in the installed location (in situ)
CON - could face limited test time due to cooling issues with the lack of pump medium (bearings, keel coolers, etc.) thus have higher bearing temps; no hydrodynamic load

• Field Wet Test
PRO - hydrodynamic load present; pump medium available for cooling
CON - not likely pumping at design points, so possible to have some cavitation; could have less test time due to limited water in the intake canal.

Dry tests cannot be conducted on pumps that are lubricated with product water.
****

Test each pumping unit, consisting of a pump [and motor] [and gear reducer] [right-angle gear reducer, and diesel engine] in the dry to determine whether it has been properly erected and connected. [Conduct such test when, and as, directed by Contracting Officer.] [After each pumping unit has been completely assembled, including all rotating elements and the lubrication system, operate at the full rated speed for [15 minutes][30 minutes][a period of 1 hour][three 15 minute periods][a period of 2 hours], to assure proper alignment and satisfactory operation.] Submit field test results.

[a. Take vibration measurements in accordance with HI 9.6.4. Vibration limits cannot exceed those recommended by HI Figure 9.6.4.2.5.1b. If it is not possible to operate the pump at its best efficiency point, vibration limits may be adjusted in accordance with the requirements of the stated standard.

][b. Operate each pumping unit at full-rated speed until the temperature rate of rise has stabilized for all bearings. Consider the bearings' temperature stabilized when the rate of rise does not exceed 0.5 degree Celsius in five minutes 1 degree Fahrenheit in five minutes [[_____] degree(s) [_____] in [_____] minutes].

][c. Repeat the dry test run if it is necessary to interrupt the test before all bearing temperatures have become stable. [If after a run of reasonable duration][If after a test run of [_____] hours] the temperature rate of rise for any bearing has not stabilized, terminate the test until the cause of overheating is determined and corrections are made. Then repeat the dry test run. Should tests reveal that there is a design deficiency or a manufacturing error in the pumping unit components, promptly correct the problem.

][d. Perform testing in accordance with ISO 20816-3]

3.2.2 Wet Tests

****
NOTE: The longest period should be used if water for testing will be available. The estimated water available and the number of pumps requiring tests should be considered when specifying length of tests. Sound testing, if required would only establish a base line for future reference. Consult HI 9.1-9.9.
****

Test each pump unit under load, at or near normal operating conditions, for at least [_____] hours or as directed by the Contracting Officer; the test will be witnessed by the Government. Provide all supplies and equipment required to conduct the test. During the test observe, measure and record the operation of the pumps during the test for[sound,] vibration and bearing temperatures in accordance with [HI 9.6.4][ISO 10816-3]. Submit field test results. Without additional costs to the Government, make all changes and correct any errors. The Contracting Officer may waive or postpone the test if sufficient water is not available.

SYSTEM LOSS CURVE

(DESIGNER TO PROVIDE THIS

FIGURE WHEN CONTRACT

IS PREPARED)

FIGURE 1

BEARING RTD INSTALLATION

FIGURE 2

AXIAL FLOW PUMP
AND
MIXED FLOW PUMP

FIGURE 3

NOTE: Figures 2 and 3 exist as a PDF file located at

http://www.wbdg.org/ffc/dod/unified-facilities-guide-specifications-ufgs/forms-graphics-
for download.

-- End of Section --