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USACE / NAVFAC / AFCESA / NASA **UFGS-22 10 00.00 10 (July 2007)**

Preparing Activity: USACE **Superseding**
UFGS-22 10 00.00 10 (April 2006)

UNIFIED FACILITIES GUIDE SPECIFICATIONS

References are in agreement with UMRL dated January 2013
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DIVISION 22 - PLUMBING

SECTION 22 10 00.00 10

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

07/07

-- End of Section Table of Contents --

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SECTION 22 10 00.00 10

VERTICAL PUMPS, AXIAL-FLOW AND MIXED-FLOW IMPELLER-TYPE
07/07

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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 items(s) or insert appropriate information.

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

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

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Go to http://wbdg.org/ccb/NAVGRAPH/graphtoc.pdf.
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PART 1 GENERAL

****
NOTE: Figure 1, System Loss Curve (To be provided by the Designer). The Specifier should insert Figure 2 and Figure 3 at the end of this section. (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- or oil-lubricated bearings and packing glands, and permits the manufacturer to use his standard castings for the suction bell and the bowls.

The locating of vanes in the water passage above the diffuser bowl should be avoided; however, on pumps with long columns where the use of intermediate bearings is necessary, spiders or external supports for the bearing housing may be permitted. A shaft-enclosing tube, by itself, may not furnish the needed support.

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 in.). 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 in.). Alternate 2 can also be used for pumps smaller than 1200 mm (48 in.) 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 22 00.00 10 MEASUREMENT AND PAYMENT 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 22 00.00 10.
****

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 Erection Engineer(s)

1.1.2.1 Payment

Payment will be made for costs associated with the services of erection engineer(s) for the period of time that erecting engineers are in service of Government within 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 nonwork 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, 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 site of work, except for travel time; or direct engineers to remain at site of work, in which case they will be paid as provided by contract.

1.1.2.2 Measurement

Services of 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 Erecting Engineer(s)

1.1.3.1 Payment

Payment will be made for costs associated with the travel and transportation expenses of the erecting engineer(s). No payment will be made for daily commuting expenses or subsistence or other personal expenses while enroute 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 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 will be made at the applicable mileage rate of [_____] cents per km mile, provided that such payment shall 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

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 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.

ACOUSTICAL SOCIETY OF AMERICA (ASA)

ASA S2.19 (1999; R 2004) Mechanical Vibration - Balance Quality Requirements of Rigid Rotors, Part 1: Determination of Permissible Residual Unbalance, Including Marine Applications

AMERICAN PETROLEUM INSTITUTE (API)

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

AMERICAN WATER WORKS ASSOCIATION (AWWA)

AWWA C200 (2012) Steel Water Pipe - 6 In. (150 mm) and Larger

AWWA C203 (2008) Coal-Tar Protective Coatings and Linings for Steel Water Pipelines - Enamel and Tape - Hot-Applied

AWWA C207 (2007) Standard for Steel Pipe Flanges for Waterworks Service-Sizes 100 mm through 3600 mm 4 in. through 144 in.

AWWA C208 (2012) Standard for Dimensions for Fabricated Steel Water Pipe Fittings

AMERICAN WELDING SOCIETY (AWS)

AWS D1.1/D1.1M (2012; Errata 2011) Structural Welding Code - Steel

ASME INTERNATIONAL (ASME)

ASME B16.5 (2009) Pipe Flanges and Flanged Fittings:

NPS 1/2 Through NPS 24 Metric/Inch Standard

ASME B46.1	(2009) Surface Texture, Surface Roughness, Waviness and Lay

ASTM INTERNATIONAL (ASTM)

ASTM A108	(2007) Standard Specification for Steel Bar, Carbon and Alloy, Cold-Finished
ASTM A217/A217M	(2011) Standard Specification for Steel Castings, Martensitic Stainless and Alloy, for Pressure-Containing Parts, Suitable for High-Temperature Service
ASTM A269	(2010) Standard Specification for Seamless and Welded Austenitic Stainless Steel Tubing for General Service
ASTM A27/A27M	(2010) Standard Specification for Steel Castings, Carbon, for General Application
ASTM A276	(2010) Standard Specification for Stainless Steel Bars and Shapes
ASTM A285/A285M	(2012) Standard Specification for Pressure Vessel Plates, Carbon Steel, Low- and Intermediate-Tensile Strength
ASTM A312/A312M	(2012) Standard Specification for Seamless, Welded, and Heavily Cold Worked Austenitic Stainless Steel Pipes
ASTM A351/A351M	(2012a) Standard Specification for Castings, Austenitic, for Pressure-Containing Parts
ASTM A352/A352M	(2006; R 2012) Standard Specification for Steel Castings, Ferritic and Martensitic, for Pressure-Containing Parts, Suitable for Low-Temperature Service
ASTM A36/A36M	(2008) Standard Specification for Carbon Structural Steel
ASTM A48/A48M	(2003; R 2008) Standard Specification for Gray Iron Castings
ASTM A516/A516M	(2010) Standard Specification for Pressure Vessel Plates, Carbon Steel, for Moderate- and Lower-Temperature Service
ASTM A576	(1990b; R 2012) Standard Specification for Steel Bars, Carbon, Hot-Wrought, Special Quality
ASTM A609/A609M	(2012) Standard Specification for Castings, Carbon, Low-Alloy, and Martensitic Stainless Steel, Ultrasonic

Examination Thereof

ASTM A668/A668M	(2004; R 2009) Standard Specification for Steel Forgings, Carbon and Alloy, for General Industrial Use
ASTM B148	(1997; R 2009) Standard Specification for Aluminum-Bronze Sand Castings
ASTM B584	(2012a) Standard Specification for Copper Alloy Sand Castings for General Applications
ASTM D2000	(2012) Standard Classification System for Rubber Products in Automotive Applications
ASTM E165/E165M	(2012) Standard Practice for Liquid Penetrant Examinationfor General Industry
ASTM E709	(2008) Standard Guide for Magnetic Particle Examination
ASTM F1476	(2007) Standard Specification for Performance of Gasketed Mechanical Couplings for Use in Piping Applications

HYDRAULIC INSTITUTE (HI)

HI 2.4	(2008) Rotodynamic (Vertical) Operations
HI 2.6	(2000) Vertical Pump Tests
HI 9.1-9.5	(2000) Pumps - General Guidelines for Types, Applications, Definitions, Sound Measurements and Documentation

ISA - INTERNATIONAL SOCIETY OF AUTOMATION (ISA)

ISA RP2.1	(1978) Manometer Tables

U.S. DEPARTMENT OF DEFENSE (DOD)

UFC 3-310-04	(2012) Seismic Design for Buildings

1.3 SYSTEM DESCRIPTION

Design, furnish, and install [_____] [identical] vertical axial-flow or mixed-flow, single [or two-]stage impeller-type pumps.

1.3.1 Design Requirements

****

NOTE: 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 trashrack. Trash-racks will have [_____] mm inch clear openings. Pumps shall be designed to operate in the dry.

b. Pumps shall be driven by 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 [33 45 00.00 10 SPEED REDUCERS FOR STORM WATER PUMPS]].

c. Design pump so that no major modifications, alterations, or additions will be required to the pumping station or suction bays to accommodate it. However, requests for changes in setting of pump, supports, and accessories, which would involve only minor modifications, will be considered. Design pump so that pump parts will fit within the limiting horizontal and vertical dimensions shown and so installation and maintenance can be accomplished by [interior; overhead traveling crane,] [truck crane using hatch in roof.] Pumps, [or pump parts assembled at pumping station] shall be capable of being lowered through floor openings shown with minimum of 25 mm 1 inch clearance around each side.

[d. Pump shall 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. Losses within pump shall be determined by Contractor.]

[d. Pump discharge system downstream of pump [discharge elbow] [diffuser] shall be designed by pump manufacturer. It shall be of type shown and shall fit within limiting dimensions and elevations shown. Determine all losses for discharge system and submit for approval.]

[d. Pump shall discharge into discharge chamber shown. System loss curve(s) furnished includes all losses beyond the discharge elbow. Losses within the pump shall be determined by the Contractor.]

[e. Priming of siphon will be accomplished [with] [without] assistance of vacuum equipment.]

1.3.2 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.

****

The pump shall:

[a. Discharge not less than [[_____] m^3/s cfs][[_____] L/s gal/min] against total head corresponding to [pool-to-pool][a static][bowl] head of [_____] m feet with water surface in sump at Elevation [_____] m feet.]

[b. Discharge not less than [[_____] m^3/s cfs][[_____] L/s gal/min] against total head corresponding to [pool-to-pool][static][bowl] head of [_____] m feet with water surface in sump at Elevation [_____] m feet.]

[c. Discharge not less than [[_____] m^3/s cfs][[_____] L/s gal/min] against total head corresponding to [pool-to-pool][static][bowl] head of [_____] m feet with water surface in sump at Elevation [_____] m feet.]

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

[Operation of pump at condition "a" may be at the rotative speed, which is the same as or different from that required to meet condition(s) "b", "c", and "d".]

1.4 SUBMITTALS

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

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

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

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

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

SD-02 Shop Drawings

Detail Drawings[; G][; G, [_____]]

SD-03 Product Data

Materials
Spare Parts
Total Head[; G][; G, [_____]]
Shipping Bills
Installation and Erection Instructions Manual
Field Tests

SD-04 Samples

Materials[; G][; G, [_____]]

SD-05 Design Data

Dynamic Analysis[; G][; G, [_____]]

SD-06 Test Reports

Witness Test[; G][; G, [_____]].
Factory Test[; G][; G, [_____]]

SD-10 Operation and Maintenance Data

Operation and Maintenance Instructions Manual

1.5 QUALITY ASSURANCE

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

1.5.1 Freeze Protection

All parts of the pump shall have drain holes to eliminate trapped water that could freeze. These drain provisions shall be self-draining without any requirement to enter the sump.

1.5.2 Detail Drawings

****
NOTE: Select appropriate alternate paragraph "d". The first paragraph (Alternate 1) may be used for pump with discharge diameters up to and including 1350 mm (54 inch). The second paragraph (Alternate 2) 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. Dimensions shall be in English [or metric with English conversion].[Drawings requiring changes as a result of model test should be submitted within 45 days after approval of model test.]

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

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

c. Cross-sectional drawings of pump showing each component. Show major or complicated sections of 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. Alternate 1) 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. Alternate 2) Detail and assembly drawings of entire pump. Include all dimensions required to manufacture pump.]

e. Drawings covering erection and installation, which Contractor intends to furnish to erecting engineer.

1.6 DELIVERY, STORAGE, AND HANDLING

1.6.1 General

Furnish 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, in duplicate, mailed promptly to 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.

1.6.2 Processing for Storage

Prepare pumps (and spare parts) for storage indoors. Indoor storage consists of a permanent building that has leak-proof roof, full walls to contain stored equipment, and a concrete floor or temporary trailers. A temporary structure may also be built at job site for equipment storage that will contain features of the permanent building above except that provision for ventilation will be provided and floor may be crushed rock. A vapor barrier will be provided below the crushed rock. Crushed rock will be of sufficient thickness so that settlement of equipment will not occur. Equipment stored on crushed rock will have cribbing under each support location so that equipment does not come in contact with crushed rock. A plastic barrier will be placed between equipment and wood cribbing. Submit a list of equipment and materials requiring humidity-controlled storage to Contracting Officer no later than 30 days prior to shipment of pumping units. Long term storage (greater than 6 months) requirements shall be in accordance with pump manufacturers recommendations.

1.7 PROJECT/SITE CONDITIONS

1.7.1 Datum

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

1.7.2 [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 [sump bay] [sump] [immediately inside trashrack] 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] [_____]. Pump manufacturer shall determine total head. Submit computations of total head and losses. Total head includes losses from the water surface on suction side of pump to discharge water surface.]

[Bowl head is the difference in meters feet between the water surface elevation in [sump bay] [sump] [immediately inside of trashrack] and elevation of diffuser exit plus head of water occurring at the diffuser exit. Pump manufacturer shall determine total head. Total head includes losses beyond the pump diffuser plus velocity head loss.]

1.8 MAINTENANCE

1.8.1 Special Tools

****
NOTE: Add applicable sections for drive units used.
****

Furnish one set of all "special tools" required to completely assemble, disassemble, or maintain pump. "Special tools" refer to oversized or specially dimensioned tools, special attachment or fixtures, or any similar items. If required, provide a device for temporarily supporting pump shaft and impeller during assembly, disassembly, and reassembly of [motor] [gear reducer] when thrust bearing is not in place. Lifting devices required for use in conjunction with [overhead] [truck] crane shall be furnished. Provide portable steel cabinet large enough to accommodate all "special tools" furnished 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 [33 45 00.00 10 SPEED REDUCERS FOR STORM WATER PUMPS]. Mount 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 cabinet with a padlock. Furnish padlock complete with three keys. Pack "special tools" in wooden boxes if size and weight do not permit storage in tool cabinet. Provide slings if box and tools are heavier than 34 kg 75 pounds.

[1.8.2 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 furnishing 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.
****

Furnish the following spare parts:

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

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

c. Fifty percent of each size and length of bolt, nut and washer used on one main 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 main pump impeller.] [One complete main pump impeller bowl assembly 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 shall be duplicates of the original parts furnished and shall be interchangeable therewith. Spare parts shall be packed in crates as specified in paragraph PROCESSING FOR STORAGE, subparagraph GENERAL. If the crates and parts are heavier than 34 kg 75 pounds, slings should be provided.

g. [Ten] [_____] Copies of manufacturer's complete parts list showing all parts and spare parts and bulletins for pump. Clearly show all details and parts, and adequately describe parts or have proper identification marks.

]PART 2 PRODUCTS

2.1 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 13, 05 50 14 and 05 50 15 as appropriate.

****

If not specified, materials and fabrication shall conform to the requirements of Section [05 50 13 MISCELLANEOUS METAL FABRICATIONS] [05 50 14STRUCTURAL METAL FABRICATIONS] and Section 05 50 15 CIVIL WORKS FABRICATIONS. Material selection not specified shall be guided by HI 9.1-9.5 for corrosion, erosion, and abrasion resistance. Submit two 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 list designating materials to be used for each item at time of submittal of drawings. Furnish, within 60 days of notice of award, names of manufacturers of machinery and other equipment which Contractor contemplates incorporating 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 shall be at risk of subsequent rejection.

a. The pump shall be identified by means of a separate name-plate permanently affixed in a conspicuous location. The plate shall bear the manufacturer's name, model designation, serial number if applicable, and other pertinent information such as wattage horsepower, speed, capacity, type, direction of rotation, etc. The plate shall be made of corrosion-resisting metal with raised or depressed lettering and contrasting background.

b. The pump shall be equipped 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. Plates shall be made of corrosion-resisting metal with raised or depressed lettering and contrasting background.

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

2.2 METALWORK FABRICATION

2.2.1 Designated Materials

Designated materials shall 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
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

MATERIALS	SPECIFICATION	GRADE, CLASS
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	Grades S30400 and S41000
Steel Forging	ASTM A668/A668M	Class F
Steel Pipe 150 mm 6 inch and Larger	AWWA C200	
Steel Plates, Pressure Vessel	ASTM A516/A516M	Grade 55
Steel Plate, Structural Quality	ASTM A285/A285M	Grade B
Structural Steel	ASTM A36/A36M	
Surface Texture (Surface Roughness, Waviness, and Lay)	ASME B46.1	

2.2.2 Bolted Connections

2.2.2.1 Bolts, Nuts, and Washers

Bolts, nuts, and washers shall conform to requirements of paragraph MATERIALS AND METALWORK FABRICATION, subparagraph DESIGNATED MATERIALS, and paragraph VERTICAL PUMPS, subparagraph PUMP COLUMN AND DISCHARGE ELBOW, subparagraph NUTS AND BOLTS 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.

2.2.2.2 Materials Not Specifically Described

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

2.2.3 Metalwork

2.2.3.1 Flame Cutting of Material

Flame cutting of material other than steel shall be subject to approval of Contracting Officer. Shearing shall be accurately done, and all portions of work neatly finished. 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. Surfaces and edges to be welded shall be prepared in accordance with AWS D1.1/D1.1M. Chipping and/or grinding will not be required 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 shall be chipped, ground, or machined to metal free of voids, discontinuities, and foreign materials.

2.2.3.2 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 shall occur on the outer surface, leaving inner surface properly aligned. When welding has been completed and welds have been cleaned, but prior to stress relieving, joining of plates shall be carefully checked in the presence of Government inspector for misalignment of adjoining parts. Localized misalignment between inside or wetted surfaces of an adjoining flange-connected section of pump or formed suction intake shall not exceed amount shown in Column 4 of Table 1 for the respective radius or normal distance from the theoretical flow centerline. Misalignments greater than allowable amount shall be corrected 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. No metal shall be removed until Contractor has assured himself and Contractor Officer that no excessive stresses will occur in 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, pipe shall be rejected for use. Proposed procedure for all corrective work, other than minor grinding, shall be approved by Contracting Officer prior to start of corrective work. Corrective work shall be finished by grinding corrected surface to a smooth taper. Length of the taper along each flow line element shall be 10 times the depth of the offset error at flow line. Wetted surface irregularities that might have existed in an approved model shall not be reason for accepting comparable surface irregularities in 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

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)
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

2.2.3.3 Stress-Relieving Procedure

After all fabrication welding is completed, and prior to any machining, stress-relieve bell by heat treatment. Submit proposed stress-relieving procedure for approval by Contracting Officer.

2.2.4 Examination of Castings

All castings shall be cleaned and carefully examined for surface defects. All defects shall be further examined by nondestructive means. Examination personnel shall be qualified/certified in accordance with applicable ASTM requirements. The examination procedure and qualification of the examiner shall be submitted for approval. Examination tests shall be made in the presence of the Contracting Officer. Choose the examination procedure best suited for the application.

2.2.4.1 Examination Procedures

a. Ultrasonic - Inspection shall conform to the applicable provisions of ASTM A609/A609M.

b. Magnetic Particle - Inspection shall conform to the applicable provisions of ASTM E709.

c. Liquid Penetrant - Inspection shall conform to the applicable provisions of ASTM E165/E165M.

2.2.4.2 Acceptance and Repair Criteria

Acceptance and repair criteria shall be in accordance with Section [05 50 13 MISCELLANEOUS METAL FABRICATIONS] [05 50 14 STRUCTURAL METAL FABRICATIONS].

2.3 VERTICAL PUMPS

2.3.1 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 optimum efficiency point.
****

[Rotative speed of pump shall 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 TESTS (Alternate 2).]

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

2.3.2 Reverse [Rotation] [Flow]

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

[Pump shall withstand, with no damage, full rotative speed caused by subjecting pump to reverse flow. Head used to determine this reverse rotative speed is calculated from specified highest discharge side water elevation and lowest pump intake side water elevation.[Pump and its connected electric motor shall 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.][Drive systems containing reduction gears or engines shall be furnished with a non-reverse device.]]

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

2.3.3 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 2.6. 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 shall 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 2.6, shall include losses from the suction bell to the discharge elbow outlet and shall not be less than [_____] percent at the head-capacity condition(s) specified in paragraph CAPACITIES.]

2.3.4 Suction Bell

****

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

DISCHARGE DIAMETER mm (in.)	MINIMUM THICKNESS mm (in.)
Up to and including 750 (30)	10 (3/8)
Above 750 (30) and up to and including 1200 (48)	13 (1/2)

DISCHARGE DIAMETER mm (in.)	MINIMUM THICKNESS mm (in.)
Above 1200 (48) and up to and including 2100 (84)	**16 (5/8)**

If a formed suction inlet (FSI) is specified, this paragraph should be deleted.
****

Make suction bell of [either cast iron, cast steel, or welded steel plate,] [stainless steel plate]. Provide flanged connection for mating with 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 pump. [Steel plate, if used,][Stainless steel plate] shall have thickness of not less than [_____] mm inch. Suction bell shall be [made in one piece][split vertically with bolted flanges joining the two pieces together. Alignment shall be maintained by use of dowels]. Suction bell shall be supported entirely by pump casing. Supports from sump floor will not be acceptable, [except those that are part of a formed suction intake].[Umbrellas, if used, should be supported by suction bowl. Construct umbrella in two pieces if a single piece umbrella could not be removed using pump opening in operating floor. Provide bolted flanges on each half of umbrella and provide for easily removable bolted connection to suction bowl. Provide sufficient lifting lugs on umbrella to aid in handling.]

2.3.5 Impeller Bowl

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

DISCHARGE DIAMETER mm (in.)	MINIMUM THICKNESS mm (in.)
Up to and including 750 (30)	**13 (1/2)**
Above 750 (30) and up to and including 1200 (48)	**16 (5/8)**
Above 1200 (48) and up to and including 2100 (84)	**19 (3/4)**

****

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

2.3.6 Diffuser Bowl

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

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

2.3.7 Pump Column and Discharge Elbow

2.3.7.1 Column and Discharge Elbow

****
NOTE: Use 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 shall be used in pumps having 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 mm (in.)	TOLERANCE ON ACTUAL O.D. mm (in.)
Less than or equal to 400 (16	Plus/minus 1.5 (0.06)
400 (16) to 600 (24)	Plus/minus 2.0 (0.08)
600 (24) to 1050 (42)	Plus/minus 2.5 (0.10)
Greater than 1050 (42)	Plus 3.0 (0.12)/Minus 1.5 (0.06)

****

Make column and discharge elbow of [either cast iron, cast steel, or welded steel plate] [stainless steel plate]. [Steel plate, if used,][Stainless steel plate] shall have thickness of not less than [_____] mm inch after machining is completed. Elbow shall be of [short radius type][long radius type][mitered type].[Turning vanes shall not be used.][Turning vanes, if used, shall be spaced apart at least twice the space of clear space of trashrack.] Column and discharge elbow shall be designed to withstand internal pressures and external loadings associated with various conditions of pump operation. Provide flanges for mating individual segments together and for mating pump column to diffuser bowl. Flanges shall have rabbeted fits or four equally spaced dowels installed in flanges for initial alignment purposes and to maintain concentric alignment. The elbow shall terminate in a plain-end circular section. Diameter tolerance of plain end shall be [_____] mm inch. Diameter of discharge end of elbow shall be as shown and shall allow standard diameter flexible couplings to be used. Adjustable thrust rods and thrust lugs shall be used to transfer the load by bridging the coupling.

2.3.7.2 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 in.) in discharge diameter and supported from different floors.

****

[Pump column and discharge elbow shall be designed for suspension from a baseplate assembly specified in paragraph BASE PLATE AND SUPPORTS and located at operating floor level.]

[Design pumping unit for installation as shown. Baseplate for supporting [electric motor] [gear reducer] shall be at elevation of operating floor, EL [_____]. Pump casing shall be supported at intermediate floor, EL [_____]. Furnish [support system] [support system consisting of columns extending from baseplate to intermediate floor]. Support system shall transfer entire load on baseplate to intermediate floor. Design support system to maintain proper alignment of pumping unit and propeller blade setting. Include support system in the dynamic analysis.]

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

2.3.7.4 [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 Waterways Experiment Station.

The use of a Formed Suction Intake (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 WES and is now included in 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 manufacturer's 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 pump house structural design, because 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 mm (in.)	THICKNESS mm (in.)
Up to and including 450 (18)	10 (3/8)
From 450 (18) to and including 900 (36)	13 (1/2)
From 900 (36) to and including 1350 (54)	16 (5/8)

EXIT DIAMETER OF FSI mm (in.)	**THICKNESS mm (in.)**
From 1350 (54) to and including 2100 (84)	**19 (3/4)**

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 shall be as follows:

FSI EXIT DIAMETER mm (in.)	**THICKNESS mm (in.)**
Up to and including 1200 (48)	**13 (1/2)**
From 1200 (48) to and	**19 (3/4)**

****

[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 FSI water passage with pump, sized to fit within limiting elevations and dimensions shown. No bearing shall be located below the impeller when FSI is used.

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

c. Construct FSI of [fabricated steel,][cast iron,][cast steel,][or a combination of these materials embedded in concrete][formed concrete as indicated]. Stiffeners used shall be on 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 [hatch in operating floor] [pump opening in operating floor] [through sump gate and trashrack]. Bolts used to connect flanges shall be stainless steel with bronze nuts. Minimum thickness of fabricated material shall 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.

d. FSI connection to pump impeller bowl flange shall be designed by the pump manufacturer 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.]

2.3.7.5 Flanges

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

INSIDE DIAMETER OF JOINT mm (in.)	**THICKNESS mm (in.)**
Up to and including 600 (24)	**32 (1-1/4)**
From 600 (24) to and including 1050 (42	**38 (1-1/2)**
From 1050 (42) to and including 2100 (84)	**50 (2)**

****

Machine flanges and drill bolt holes concentric with pump shaft vertical centerline, having tolerance of plus or minus one fourth of clearance between bolt and bolt hole. When fabricated from steel plate, flanges shall 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 shall not 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. Flanges on major components of pump casing (suction bell, impeller bowl, diffuser bowl, and column and elbow piping) shall be designed such that blind holes necessitating use of cap screws or stud bolts will not be used. Design flanges for connection to column pipe by at least two continuous fillet welds. One weld shall connect inside diameter of flange to pump column and the other shall connect outside diameter of pump column to flange. Final design of welds rests with manufacturer, and specified welds are the minimum requirement. They shall be parallel machined, when provided on each end of the same component, and mounted parallel to a plane that is normal to pump shaft centerline. Flanges on each end of the same component shall 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 minimum of three jacking bolts to aid in disassembly of pump.

2.3.7.6 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 "PERMATEX" or equal 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 flange. If rabbeted fit is not used, then Contractor shall provide the method used to determine concentricity of connected pieces.

2.3.7.7 Nuts and Bolts

Bolts used in assembling pump and its supporting members, including anchor bolts and dowels, shall be of 300 series stainless steel. Use only bronze nuts and hexagonal bolts and nuts. Washers used shall be 300 series of stainless steel.

2.3.7.8 Galvanic Protection

****

NOTE: Select appropriate alternate paragraph.

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

Alternate 2 should be used for pumps having a discharge diameter greater than 20 in.. This may also be used for pumps with sidecharge diameters of 500 mm (20 in.) 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 (in.)	MINIMUM NUMBER OF ANODES USED	TOTAL WEIGHT OF ANODES USED kg (lbs))
From 500 (20) to and including 900 (36)	2	18 (40)
From 900 (36) to and including 1200 (48)	4	36 (80)
From 1200 (48) to and including 2100 (84)	7	68 (150)

****

[When dissimilar metals are used, dissimilar parts shall be electrically isolated. 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 pump so that continuity is obtained between anode and pump. Verify continuity by checking joint with an ohmmeter. Locate anodes on exterior of pump below normal sump level. Total weight of anodes used per pump shall be [18][36][68] kg [40][80][150] pounds. Pump joints shall be electrically bonded at the joints.]

2.3.7.9 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 conforming to ASTM F1476, Type II, Class 3, stainless steel as manufactured by Teekay or Straub Couplings or Dresser style 38 or approved equal, to connect pump discharge elbow to [transition section] [wall thimble] [discharge piping].

2.3.7.10 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.

****

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

2.3.7.11 Discharge Piping

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

2.3.8 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 ft)) or, when severe corrosion is expected.
****

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

2.3.8.1 Removal and Prior To Finishing

After removal from mold, and prior to finishing of surface imperfections, castings shall be inspected by Contracting Officer. Minor surface imperfections shall be filled or ground down 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 shall be as required in Section [05 50 13 MISCELLANEOUS METAL FABRICATIONS] [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.

2.3.8.2 Balance

****
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-in.) used in this paragraph are determined from Figure 2.1 of ASA S2.19 for grade G6.3. Impellers for pumps having a discharge diameter greater than 600 mm (24 in) shall 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 ASA S2.19.
****

Balance impeller by the two-plane balancing technique. Impeller shall be balanced at [maximum] [rated] operating speed. Check balance at 110 percent of balance speed, and make needed corrections. Amount of allowable unbalance shall be in accordance with grade G6.3 of ASA S2.19. Weights needed to obtain required level of balance shall be securely fastened to inside cavity of impeller hub. In no case will portions of the impeller be removed or weights be added to outside of hub, vanes, or water passages. Submit balancing procedure to Contracting Officer for approval at least four weeks prior to date of balancing. Each finished impeller shall be weighted and weight stamped on the bottom of hub. Weight shall be accurate to 0.5 percent of the total weight of impeller. Weighing and balancing shall be witnessed by Contracting Officer.

2.3.9 Shafting

2.3.9.1 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 unwatered. The shaft lengths are limited in length by the headroom available. Shaft sections are usually less than 3000 mm (10 ft) 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.
****

Impeller shaft shall be stainless steel and intermediate shaft(s) shall be [cold-rolled carbon steel] [same material as impeller shaft]. Design shafting so that [shaft sections shall not exceed [_____] mm feet in length and that] any necessary vertical adjustment of impeller can be made [from operating room floor] without interfering with shaft alignment. Also provide for removal of impeller from below without disassembly of pump above impeller bowl. If 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 shaft material and rated wattage horsepower of [motor] [engine]. The second uses 75 percent of the yield strength of shaft material and [locked rotor torque of motor] [maximum wattage horsepower of engine].

2.3.9.2 Couplings

****

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

****

Pump and [motor] [gear reducer] shafts[and pump shaft sections] shall be coupled together using rigid flanged coupling capable of transmitting the forces and torques involved. Coupling halves shall be bolted together and shall be maintained concentric with each other, by means of a rabbet fit, to within 500 µm 0.002 inch. Shaft coupling nut, if used, shall be retained by fitted bolts, and all tolerances specified for the coupling shall apply. Finish machine the flange and bore in one setup to insure that flange of coupling shall be true to the bore. Flange shall be perpendicular to the bore, and parallel to the opposite end and mating flanges to within 500 µm 0.002 inch. Flange shall be concentric to centerline of shaft to within 0.50 mm 0.002 inch.[Pump shaft sections shall be joined together with [sleeve-type couplings capable of taking rotation in either direction. Threads, except on fasteners, shall not be employed in construction of sleeve-type couplings] [threaded couplings in which the threaded shaft ends are threaded into the coupling].] Couplings, including keys and fasteners, shall be constructed of stainless steel materials. The finished shaft assembly shall be concentric about shaft centerline to within 100 µm 0.004 inch. Shop assemble couplings and pump shaft and inspect for compliance with contract requirements. After inspection, matchmark parts, including fitted bolts, to their mating pieces.

2.3.9.3 Journals

****

NOTE: Select 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.

****

[Provide replaceable stainless steel one-piece journal sleeves at each guide bearing, packing gland and seal locations. Finish sleeves at all bearings and packing gland locations to at least 32 rms and finish sleeve at seal locations to 16 rms. Securely fasten sleeves to shaft to prevent movement. Keys and fasteners, if used, shall be made from corrosion resisting steel; fastening by adhesive or welding is not acceptable. The surface hardness of the sleeves at the bearing and packing gland locations shall 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 shaft at seal journal locations to 16 rms. The Contractor has the option 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 shaft to prevent movement. Keys and fasteners, if used, shall be made from corrosion resisting steel; fastening by adhesive or welding is not acceptable. The surface hardness at the seal locations shall be as recommended by the seal manufacturer.]

2.3.9.4 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.

****

A circumferential line shall be inscribed or etched on shaft above stuffing box and an adjustable pointer shall be provided and mounted opposite this line in order to indicate a change in vertical position of shaft and to permit realignment after [motor] [gear reducer] removal.

2.3.10 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 ft) length or greater should have external supports. The enclosing tube is split when pump size is 1800 mm (72 inch) or larger.

****

Provide shaft enclosure to cover intermediate shaft and coupling. It [shall be placed in tension or]shall be rigid enough to be self-supporting.[External supports or bracing located in pump water passage shall not be used for support of the enclosing tube unless necessary to support intermediate bearings or indicated to be necessary or advantageous by dynamic analysis required in paragraph DYNAMIC ANALYSIS. Consider effect of external supports, including rubber inserts, in the dynamic analysis required in paragraph TEST, INSPECTIONS, AND VERIFICATIONS, subparagraph DYNAMIC ANALYSIS.] Design enclosure to be watertight and for easy assembly and disassembly in the field.[Enclosure shall be split longitudinally to permit easy removal without removing or disassembling pump shaft.] Enclosing tubes constructed with screw type joints and using tension in tube to hold alignment, shall be constructed to prohibit tension tube from unscrewing when packing gland adjustments are made. Provide shaft enclosure for grease-lubricated pumps with a drain having a shut-off valve located outside of the to permit draining enclosure between operation periods. Locate drain at bottom of shaft enclosure. On oil-lubricated pumps, the enclosing tube below lowest bearing and above oil seals shall be fitted with an oil/water drain line to the outside of pump. Drain line shall have a check valve outside of pump to preclude entrance of sump water.

2.3.11 Guide Bearings and Seals

****
NOTE: 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.
****

2.3.11.1 Guide Bearings

Provide pump with sleeve-type bearings designed for [grease] [oil] lubrication. Bearing shall have a bronze lining in contact with shaft journal and shall be replaceable type. Arrange bearing liner for maximum distribution of [grease] [oil] for lubrication of journal surface. Bearings shall have a surface finish of 0.80 µm 32 microinches rms or better to match 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 bearing and journal due to differential water pressure.

2.3.11.2 [Oil][Grease] Lubrication Shaft Seals

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

[Pumps designed for oil lubrication shall have a shaft seal system located below upper pump shaft bearing. Seal system shall consist of a seal containing two lip elements. Element facing bearing shall have a stainless steel garter spring back-up and be constructed of TFE (Teflon). Secondary element shall face impeller and be constructed of TFE. Use bullet-shaped assembly tool or other special tool over end of shaft or grooves in shaft to preclude damage to lip element during assembly. Assembly tools used are considered a special tool and shall be furnished to Government as part of special tools specified in paragraph MAINTENANCE, subparagraph SPECIAL TOOLS. Pumps having two stages shall have seals to protect extra bearings required by two stages of construction.]

[Pumps designed for grease lubrication shall have a shaft seal consisting of lip seals. Seal system shall consist of a lip-type seal located on each end of bearing. Each seal shall contain a lip element having a stainless steel garter spring back-up and be constructed of TFE (Teflon). Lip element shall face bearing. Lowest bearing shall have an additional grease seat with lip facing away from bearing. Use bullet-shaped assembly tool or other special tools over the end of shaft and shaft grooves to preclude damage to lip element during assembly. Assembly tool used is considered a special tool and shall be furnished to Government as part of special tools specified in paragraph MAINTENANCE, subparagraph SPECIAL TOOLS.]

2.3.12 Bearing Heat Sensors

****

NOTE: Bearing heat sensors may be used in pumps having a discharge diameter large than 600 mm (24 inch). 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 shall be used when the unsupported length is 450 mm (18 inch) or less. Schedule 120 should be used for greater unsupported lengths.

****

Fit [impeller shaft bearings] [each bearing] with temperature-sensing elements, inserted in bearings to within 3 mm 1/8 inch of shaft. These temperature-sensing elements shall be provided with temperature readouts mounted [on [engine] [motor] instrument board] [at a central location as shown]. Provide visual and audible alarm system to warn of bearing overheating. Support leads and protect from water and mechanical damage. Terminate leads outside of pump casing in a waterproof connection head, Minco CH 339 or equal, and cap until final connections are made in the field. The connection head shall be rated watertight to 175 kPa 25 psi. Lead protection shall consist of pipes fastened to pump with brackets using bolts and nuts to permit their removal, and shall be constructed with enough unions to be completely disassembled. Leads passing through pump water passage in pump shall either be contained in a guide vane or be protected by [Schedule 80] [Schedule 120] pipe. Protection pipe shall be removable if connected to shaft-enclosing tube. Install bearing heat sensors as shown in Figure 2 at end of the section. Run leads and wiring to a junction box located on baseplate. Provide terminal strip in junction box for connection of wiring to temperature readouts.

2.3.13 Thrust Bearing

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

2.3.14 Packing Gland

Provide grease-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 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.
****

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

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

2.4.1 [Centralized Pressure Lubrication System]

2.4.1.1 [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. It shall positively indicate proper or improper functioning of any individual metering device. Mount pressure pump, individual metering devices, and any required auxiliary operating accessories suitably on baseplate. System shall be furnished complete and ready for operation, including sufficient lubricant to fill each pressure pump lubricant reservoir. Submit complete centralized pressure lubrication system to Contracting Officer for review and approval. Furnish lubricant recommended by pump manufacturer, subject to approval of Contracting Officer.]

2.4.1.2 [Pumping Unit

Provide Electric motor-driven central pumping unit as a complete assembly, consisting of 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 requirements specified. Pump shall be of multiple individual piston, positive displacement type utilizing hardened steel pistons closely fitted to cylinder bores to eliminate the need for packing, and spring-actuated check valves shall not be required for its operation. Pump shall deliver not less than 100 mL 6 cu inches of lubricant per minute against a pressure of not less than 13.8 MPa 2,000 psi measured at the most remote bearing connection. Lubricant reservoir shall be of suitable metallic construction, shall have a capacity of not less than 11 kg 24 pounds of lubricant, shall be provided with suitable means that will ensure positive priming of pump at all times (such as an atmospheric or spring-loaded follower plate), an indicator to show quantity of lubricant in reservoir, and a screened fill connection to permit filling reservoir by transfer pump without exposing lubricant to atmosphere. Provide 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 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. Electric power will be supplied at 115 volts single phase, 60 cycles. Use time clock setting recommended by main pump manufacturer.]

2.4.1.3 [Metering Valves

Provide metering or measuring valve for each bearing and stuffing box. It shall be fully hydraulic in its operation, requiring no internal springs or check valves. Valve size to be determined by the pump manufacturer.]

2.4.1.4 [Piping

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

2.4.2 Lubrication System Accessories

2.4.2.1 Grease Gun

A hand operated, heavy duty lever grease gun for charging lubrication lines and for emergency lubrication shall be provided. Provide grease as recommended by the vertical pump manufacturer.

2.4.2.2 [Service Facilities

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 shall be provided. The pump shall be self-contained and designed for mounting on the grease drum to protect the contents from the entrance of foreign matter. The pump shall deliver not less than 0.45 kg one pound in not more than eight strokes of the pump handle under normal temperature conditions. Furnish necessary hose and quick disconnect coupling for a complete system. The hand-towed dolly shall have a rigid platform with four anti-friction bearing mounted wheels, a towing handle and a provision for securing the lubricant barrel. The type of lubricant shall be as recommended by the vertical pump manufacturer.]

2.5 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 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.

2.6 TESTS, INSPECTIONS, AND VERIFICATIONS

2.6.1 [Critical Speeds][Dynamic Analysis]

****
NOTE: 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.
****

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

[Before 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 [33 45 00.00 10 SPEED REDUCERS FOR STORM WATER PUMPS] are released for manufacture, pump/motor structure shall be analyzed by pump manufacturer 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. Dynamic analysis model shall be constructed 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 pump structure. Analyze 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 provided by motor manufacturer. If motor manufacturer cannot demonstrate to the satisfaction of Contracting Officer (based on impact tests of similar units) that the Reed critical frequency value is accurate, motor manufacturer shall conduct a dynamic analysis using finite element methods as described to determine motor Reed critical frequency for use by pump manufacturer. Submit 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 test motor furnished before shipment to determine actual Reed critical frequency of motor. Include results of impact tests included in motor test data to be submitted. Pump manufacturer shall 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. If any design changes are required, these shall be incorporated at no cost to Government.]

[2.6.1.1 Torsional Analysis

Before pump, gear drive, and engine are released for manufacture, engine supplier shall analyze the system for harmful torsional natural frequencies using mass elastic information provided by pump and gear drive manufacturers. 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.

][2.6.1.2   Lateral Frequency Analysis

Before pump, gear drive, and engine furnished under Section(s) [41 65 10.00 10 [DIESEL] / [NATURAL GAS FUELED] ENGINE PUMP DRIVES][,] [33 45 00.00 10 SPEED REDUCERS FOR STORM WATER PUMPS], respectively, are released for manufacture, pump/gear drive structure shall be analyzed by pump manufacturer 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. The dynamic analysis model shall be constructed using a commercially available program such as Ansys, Cosmos/M, or equivalent that utilizes finite element methods. The model shall incorporate effects of column pipes, cover pipes, shafts, bearings, mass concentrations, and other such features as necessary to accurately model pump structure. Analyze 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 highest and lowest sump water levels. The model shall incorporate Reed critical frequency and mass elastic diagram information provided by gear drive manufacturer. If gear drive manufacturer cannot demonstrate to the satisfaction of 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 shall be conducted by gear drive manufacturer to determine gear drive Reed critical frequency for use by pump manufacturer. Submit 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 gear drive before shipment to determine the actual Reed critical frequency of the drive. Submit results of impact tests. Pump manufacturer shall 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 pump/gear drive structure. If any design changes are required, these shall be incorporated at no cost to Government.

][2.6.2   Lubricating System Tests

Test complete lubricating system for each pumping unit, as deemed necessary by Contracting Officer, to determine that system meets operational requirements specified. At least one valve of each size furnished shall be tested with the lubrication line removed from its bearing and fitted with a pressure relief valve and pressure gage. The pressure relief valve shall be adjusted to discharge it at the operating pressure specified and the system shall be operated through one or more cycles as required to obtain an accurate measurement of the quantity of lubricant delivered, which shall be within plus or minus 20 percent of the theoretical delivery of the respective valve. Any component parts that are damaged as the result of these tests or that fail to meet the requirements of the specification shall be replaced, reinstalled, and retested at the Contractor's expense.

]2.6.3 Factory Test

****
NOTE: Each different size pump should be given performance tests.

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.
****

2.6.3.1 General

****
NOTE: Select appropriate alternate paragraph.

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

[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.] Cavitation testing shall be performed in accordance with HI 2.6 if no published NPSHR curves are available.]

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

2.6.3.2 Test Setup

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

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

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

Alternate 2) [The model pump shall be homologous to the proposed prototype pump, and mounted with the shaft in the vertical position.[The sump where the pump suction occurs shall be equipped 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 shall be as indicated on Figure 3 at the end of this section. The inlet diameter shall be not less than 275 mm 11 inches.[If a formed suction intake (FSI) is specified for the pump, the complete FSI, including the [gate][bulkhead] slot, shall be included in the model test.] The FSI used in the model test shall be geometrically the same as that used for the proposed pump.]

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

[Prototype Pump(s) - Prototype (first pump built) pump(s) if selected, shall be set with shaft in vertical position. 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. Tests shall be completed prior to assembling any pump except the [one] [ones] to be tested. (FSI specified shall be installed on the prototype pump that is tested.)]

2.6.3.3 Instrumentation and Procedures

Each instrument shall be described 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. When necessary for clarity, sketch of instrument or instrument arrangement shall be included. 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 proposed pump. Test procedures, except as specified, shall be in accordance with applicable provisions of HI 2.6.

a. 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, a mercury-water manometer, or a pressure transducer. Fluctuations shall be dampened 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. Manometers shall be used as indicated by ISA RP2.1. When pressure transducers are used, their accuracy shall be checked with a manometer.

b. Capacity - Determine capacity by calibrated venturi flowmeter or long-radius ASME flow nozzle. Do not use orifice plates. Connect venturi or nozzle taps to column gages equipped with dampening devices that will permit 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.

c. Rotational Speed of Pump - Measure rotational speed of pump in accordance with "Method of Rotary Speed Movement" in HI 2.6, except that revolution counters shall not be used. Non-contacting hand-held electronic tachometers are acceptable. Device used shall permit speed to be determined to 1 r/min rpm.

d. Power Input - Measure power input to pump in accordance with "Power Measurements" in HI 2.6. Use a method to permit pump brake wattage horsepower to be determined to the closest 0.5 kW 0.5 horsepower.

****
NOTE: Alternate 2.
****

e. Cavitation Tests - The instruments to be used for these tests shall be selected by the Contractor and shall be of the type suited for cavitation testing. However, in no case shall the instruments used yield results less accurate than those obtained with the performance test.

2.6.3.4 Pump Test

Test shall demonstrate that proposed pump complies with specified performance. Pump shall be capable of operation without instability over entire range of heads specified in paragraph CAPACITIES. Instability is defined, for this specification, as when one or more of the following conditions occur:

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

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

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

Rerun test if this occurs. Compliance with specifications will be determined from curves required by paragraph TEST RESULTS. Test procedures, except as specified, shall be in accordance with applicable provisions of HI 2.6. Temperature of water used for testing shall be approximately the same for all tests run and shall be recorded during test runs.

2.6.3.5 Test Procedure

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

a. Performance of The Pump - The performance of the pump shall be determined 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 shall 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 shall be, as a minimum, the total head determined from paragraph "CAPACITIES". If the test setup permits testing at lower total heads, the range of total heads shall be extended 600 mm 2 feet lower. Testing shall be inclusive for [each] [the] speed(s) involved with the sump at elevation[s] [_____] [and [_____] NGVD feet]. Tests shall be made using prototype [total] [pool-to-pool] heads. Head differentials between adjacent test points shall not exceed 900 mm 3 feet, but in no case shall less 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 shall be made to clearly define the head-capacity characteristics. When a scale model of the pump is tested, the efficiency of the prototype pump shall be considered to be the efficiency of the model. No other computation or adjustment of model efficiency to prototype conditions will be permitted.

b. Sump Elevations - Tests shall be conducted 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.] [The sump elevations used shall be those specified in paragraph CAPACITIES.] The test results with this sump elevation shall meet all specified conditions of capacity, head, and brake kW horsepower. Submit curves indicating test results.

c. 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.

d. Demonstration - Demonstrate to Government witness that the blade templates fit the tested pump. Demonstration shall be done immediately after testing is completed. Retain all templates for the tested pump, and furnish them to Government upon request of Contracting Officer, to permit Government to verify geometric similarity with the manufacturer's pump. In addition to providing templates, furnish dimensioned drawings of impeller, which contain all dimensions needed to manufacture it. Tested impeller shall be stamped with identification marks. Provide necessary facilities and instruments needed to permit Government to verify that pump[s] [is] [are] in complete geometric similarity with the tested pump.

2.6.3.6 Cavitation Tests

****
NOTE: Alternate 2.
****

a. Model Test - The model test shall 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]. NPSHR shall, as a minimum, be determined 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 these over-capacity conditions shall be used. The other test capacity points shall be equally spaced between the highest and lowest capacities.

b. NPSHR - NPSHR shall be determined on a constant-capacity, constant-speed basis, using arrangement Figure 2.62 or 2.63 as described under paragraph "Net Positive Suction Head Required Test" in HI 2.6. Suction conditions shall be varied to produce cavitation. NPSHR shall 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). A sufficient number of points to accurately locate the departure point shall be obtained.

****
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.
****

c. Value of NPSHR - The value of NPSHR shall be [300] [600] [900] mm [1] [2] [3] feet less than the corresponding available net positive suction head (NPSHA). NPSHA shall be determined 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. The water elevations specified in paragraph CAPACITIES shall be used to determine the NPSHA for the pumps.

d. Plotting Test Results - The test results shall be plotted to the scales determined by the Contracting Officer at the time of the test. Curves showing [static] [pool-to-pool] [total] head, brake kW horsepower, and [pool-to-pool] efficiency as ordinates and NPSH as the abscissa shall be drawn. In addition, curves showing NPSHR versus capacity shall be drawn with NPSH as the ordinate and capacity as the abscissa. NPSHA points shall be shown on the curves.

e. 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, the following method shall be used. No other method will be acceptable. The inaccuracy shall be determined for each parameter, and the calculations shall be furnished to the Contracting Officer for approval. Using the calculated inaccuracy as the radius and the test point as the center, a circle shall be drawn for each test point. Two curves, one a maximum and the other a minimum, shall be drawn and shall pass through or touch each circle. The maximum curve shall touch the top and the minimum curve shall 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, another curve (the mean) shall be drawn. The point at which the mean curve departs from the constant values (point of tangency) shall be considered to be the NPSHR of the pump for the capacity at which the test was run.

2.6.3.7 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 id 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 shall furnish two copies of the curves required in paragraph PUMP TEST [AND CAVITATION TESTS] along with a set of sample calculations with constants and conversion factors. [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. Computations of test results and plotted preliminary curves shall be furnished to the witness.

2.6.3.8 Test Report

****
NOTE: Delete item "o" if water passage is not included in the contract.
****

Submit, within 30 days of receipt of approval of the witness test, to Government [3] [4] [7] bound copies of a report covering completely test setup and performance[and cavitation] tests. Each test report shall include, as a minimum, the following:

a. Statement of the purpose of test, name of project, contract number, and design conditions should be given. Where guaranteed values differ from specified values, they also should be given.

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

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

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

e. 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 24 color photographs of test equipment, test setup and representative test segments, and a VHS videotape, at least 30 minutes in length, covering the same information as photographs. All photographic evidence should be labeled with Contract number, location, date/time, and test activity. Videotape shall be voice annotated 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 should be incorporated in the construction contract.]

2.7 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 3-310-04 SEISMIC DESIGN FOR BUILDINGS.

****

The baseplate shall be proportioned 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. It shall be supported and anchored as shown on the drawings. 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 shall be furnished. A sole plate [as shown on the drawings] shall be provided under the baseplate. The sole plate shall be installed, leveled and grouted in accordance with API RP 686, Chapter 5 -

Mounting Plate Grouting. Jacking bolts shall be provided for leveling the baseplate assembly. An anchor bolt layout shall be provided to aid in placement of anchor bolts. All leveling jacking bolts shall be backed off after grouting so that they do not support any of the load. The pedestal supporting the [motor][right-angle reduction gear] shall contain a 25 mm 1-inch lip to contain water leakage from the shaft packing. A threaded drain to the sump shall be provided.[Seismic requirements shall be in accordance with UFC 3-310-04 and Sections 13 48 00 SEISMIC PROTECTION FOR MISCELLANEOUS EQUIPMENT and 13 48 00.00 10 SEISMIC PROTECTION FOR MECHANICAL EQUIPMENT.]

2.8 FACTORY ASSEMBLY

The pump shall be assembled at the manufacturer's plant[in a vertical position] to assure proper fitting and alignment of all parts. Tolerances shall not exceed those specified or shown on the the Contractor's manufacturing drawings. Rotating elements shall be checked for binding. The suction bell, impeller housing, diffuser, and the discharge elbow shall 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. All parts disassembled for shipment shall be matchmarked.

PART 3 EXECUTION

3.1 INSTALLATION

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

   (1) Description shall be complete, orderly, step-by-step explanation of operations required, and shall 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) Description shall be complemented and supplemented by drawings, sketches, photos, and similar materials to whatever extent necessary or desirable, and the overall result shall be a description that may be comprehended by an engineer or mechanic without extensive experience in erecting or installing pumps of this type.

b. The erection engineer(s), familiar with the equipment to be installed, shall supervise the handling, installation, start-up and testing of the equipment as required by paragraph ERECTION ENGINEER(S).

c. Submit [10] [_____] copies of Operation and Maintenance Instructions Manual containing complete information on operation, lubrication, adjustment, routine and special maintenance, disassembly, repair, reassembly, and trouble diagnostics of pump and auxiliary units. Operation and maintenance manual and both parts lists shall be printed on good quality ANSI size A 216 by 280 mm 8-1/2 by 11-inch paper, bound separately between flexible, durable covers. 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.

3.2 FIELD TESTS

****
NOTE: Select appropriate bracketed statement.
****

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. Included therein shall be 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

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NOTE: A four hour operating field test is preferred. It allows adequate time to make all required observations and test measurements. Vibration measurements should be specified when the designer feels certain that water will not be available to do wet testing or as a preliminary check of the installation.
****

Pumping unit, consisting of pump [and motor] [and gear reducer] [right-angle gear reducer, and diesel engine] shall be tested in the dry to determine whether it has been properly erected and connected. Such test shall be made when, and as, directed by Contracting Officer. After pumping unit has been completely assembled, including all rotating elements and lubrication system, operate at full rated speed for [three 15-minute periods] [a period of 2 hours], to assure proper alignment and satisfactory operation.

a. [Take vibration measurements of the assembled pumping units in both the axial and radial direction at the pump operating speed. Vibration shall be measured as displacement in mils and shall not exceed the maximum displacement (mils-peak-to-peak) shown in the "good" range of General Machinery Vibration Severity Chart. This chart may be obtained from Entek IRD, 1700 Edison Drive, Cincinnati, Ohio 45150.]

b. Vibration measurements shall be taken in accordance with HI 2.4. Vibration limits shall not exceed those recommended by HI Figure 2.41. 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.

c. [Pumping unit shall be operated at full-rated speed until the temperature rate of rise has stabilized for all bearings. Bearings' temperature shall be considered 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].

d. Dry test run shall be repeated 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, test shall be terminated until the cause of overheating is determined and corrections made. Then dry test run shall be repeated.] Should tests reveal that there is a design deficiency or a manufacturing error in pumping unit components, the problem shall be promptly corrected by and at the expense of Contractor.

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.
****

Each pump unit shall be given a test 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 the operation of the pumps will be observed and measurements of[sound,] vibration and bearing temperatures shall be taken and recorded. Without additional costs to the Government, make all changes and correct any errors for which the Contractor is responsible. The Contracting Officer may waive or postpone the test if sufficient water is not available. Appropriate changes will then be made to the contract.

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://wbdg.org/ccb/NAVGRAPH/graphtoc.pdf for download.

-- End of Section --