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USACE / NAVFAC / AFCEC / NASA **UFGS-22 11 23.00 10 (July 2007)**

Preparing Activity: USACE **Superseding UFGS-22 11 23.00 10 (April 2006)**

UNIFIED FACILITIES GUIDE SPECIFICATIONS

References are in agreement with UMRL dated October 2015

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SECTION TABLE OF CONTENTS

DIVISION 22 - PLUMBING

SECTION 22 11 23.00 10

SUBMERSIBLE PUMP, AXIAL-FLOW AND MIXED-FLOW TYPE

07/07

-- End of Section Table of Contents --

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SECTION 22 11 23.00 10

SUBMERSIBLE PUMP, AXIAL-FLOW AND MIXED-FLOW TYPE
07/07

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NOTE: This guide specification covers the requirement for submersible axial-flow and mixed-flow pumps for a turbid water pumping station. 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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PART 1 GENERAL

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NOTE: This guide specification is for use in construction contracts. It may be used in supply contracts, but should be changed as appropriate. Differences between the technical paragraphs written for Contractor-supplied pumps versus Corps supply specification should be minimal.

This pump specification will be used with the design criteria in EM 1110-2-3102, "General Principles of Pumping Station Design and Layout", and EM 1110-2-3105, "Mechanical and Electrical Design of Pumping Stations", and the references listed in those publications. To the extent possible the

Hydraulic Institute (HI) Standards, 2000, has been referenced as the primary reference standard, and the minimum for manufacturers' compliance, for the manufacture, material, design, test, and performance specifications. The vibration analysis often required of pumps is eliminated and a vibration limit specified.

The pumps described are so short coupled that their resonant frequencies are far above the source frequencies. Furthermore, thousands of these pumps are operating worldwide. The pumps are of the pre-engineered (catalog) type, used at flood control and storm water projects. Over specifying can prove costly and even double the cost of an otherwise inexpensive pump. In general, the two most important attributes to a successful specification will be to obtain a qualified, experienced manufacturer and to properly specify the pumping conditions so that the correct pump is obtained.

The United States now recognizes European Common Market (ECE) products as equal to American manufacture; however, the American Standards quoted are minimal. Foreign manufacturer's contacted stated that the use of American Standards was not a problem.

This guide specification is performance based to comply with memorandum to USACE commands, dated 16 February 1995, stating a preference to use performance-based standards. In the case of pre-engineered pumps that requirement is appropriate and agrees with the way engineering firms presently specify these pumps. It further facilitates the engineer's ability to use the technical expertise available from the pump manufacturers.

Model testing is not included as an alternative for these pumps. Manufacturers assemble and performance test the pumps at the factory. The pumps are shipped assembled.

Witness tests and factory visits have been limited to one visit during the performance test and a pump inspection at the time of the test.

Discharge piping is not covered in this guide specification. Information about discharge piping is contained in EM 1110-2-3105.
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1.1 LUMP SUM PRICE

a. Payment will be made for costs associated with [furnishing] [furnishing and installing] [installing] the submersible pump, axial-flow or mixed-flow type, as specified.

b. Unit of measure: lump sum.

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

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 BEARING MANUFACTURERS ASSOCIATION (ABMA)

ABMA 11	(2014) Load Ratings and Fatigue Life for Roller Bearings
ABMA 9	(2015) Load Ratings and Fatigue Life for Ball Bearings

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	(2013) 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	(2015) Structural Welding Code - Steel

ASME INTERNATIONAL (ASME)

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

ASTM INTERNATIONAL (ASTM)

ASTM A108	(2013) Standard Specification for Steel Bar, Carbon and Alloy, Cold-Finished
ASTM A167	(2011) Standard Specification for Stainless and Heat-Resisting Chromium-Nickel Steel Plate, Sheet, and Strip
ASTM A240/A240M	(2015a) Standard Specification for Chromium and Chromium-Nickel Stainless Steel Plate, Sheet, and Strip for Pressure Vessels and for General Applications
ASTM A242/A242M	(2013) Standard Specification for High-Strength Low-Alloy Structural Steel
ASTM A27/A27M	(2013) Standard Specification for Steel Castings, Carbon, for General Application
ASTM A276/A276M	(2015) Standard Specification for Stainless Steel Bars and Shapes
ASTM A297/A297M	(2014) Standard Specification for Steel Castings, Iron-Chromium and Iron-Chromium-Nickel, Heat Resistant, for General Application
ASTM A312/A312M	(2015) Standard Specification for Seamless, Welded, and Heavily Cold Worked Austenitic Stainless Steel Pipes
ASTM A36/A36M	(2014) Standard Specification for Carbon Structural Steel
ASTM A48/A48M	(2003; R 2012) 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 A668/A668M	(2015) Standard Specification for Steel Forgings, Carbon and Alloy, for General

Industrial Use

ASTM B148	(2014) Standard Specification for Aluminum-Bronze Sand Castings
ASTM B584	(2014) Standard Specification for Copper Alloy Sand Castings for General Applications
ASTM D2000	(2012) Standard Classification System for Rubber Products in Automotive Applications
ASTM F1476	(2007; R 2013) Standard Specification for Performance of Gasketed Mechanical Couplings for Use in Piping Applications

HYDRAULIC INSTITUTE (HI)

HI 1.3	(2013) Rotodynamic (Centrifugal) Pump Applications
HI 2.3	(2013) Rotodynamic (Vertical) Applications
HI 2.6	(2000) Vertical Pump Tests
HI 9.1-9.5	(2000) Pumps - General Guidelines for Types, Applications, Definitions, Sound Measurements and Documentation
HI 9.6.4	(2009) Rotodynamic Pumps for Vibration Analysis and Allowable Values

INTERNATIONAL SOCIETY OF AUTOMATION (ISA)

ISA RP2.1	(1978) Manometer Tables

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)

NEMA MG 1	(2014) Motors and Generators
NEMA WC 70	(2009) Power Cable Rated 2000 V or Less for the Distribution of Electrical Energy--S95-658
NEMA WC 72	(1999; R 2004) Standard for Continuity of Coating Testing for Electrical Conductors

U.S. DEPARTMENT OF DEFENSE (DOD)

UFC 3-310-04	(2013) Seismic Design for Buildings

1.3 SYSTEM DESCRIPTION

****

NOTE: The designer should include in this section those factors of the project design that relate to the specification of the pump. These are factors that will be data inputs to the manufacturer, and are examined during the pump selection procedure and

needed for accurate response to the specification. The specifications as written are for water of normal chemistry and abrasive quality. The Contractor must be informed in the specification of any unusual project conditions.

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1.3.1 General Project Requirements

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NOTES: Insert the name of the Pumping Station.

The other elements of the pumping unit designed for this project should be stated; e.g., electric submersible motor, reduction gear (if needed), and controls.

The planetary gear reduction unit, on rare occasion, may be required in the larger volume propeller pumps such that a smaller, high-speed motor can be used. The design of the gear is an integral part of the design of the pumping unit.

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Design, furnish, and install [_____] identical pumping units for the [_____] Pumping Station shown. Water pumped will not exceed [_____] degrees C F, will be relatively turbid, and may contain sand, silt, and trash capable of passing the trashrack, having 41 mm 1-5/8 inch clear openings.

1.3.2 Pumping Unit Description

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NOTE: An important project design requirement centers on providing a pumping plant design that will accommodate the available pumps and their structural and hydraulic requirements. Pumps are designed to be contained in a discharge tube and able to be lifted from the discharge tube for maintenance and repair.

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In general, each pumping unit includes a pump/motor, discharge tube, [discharge elbow], air vent, [lifting chain], cable, and controls. Each pump shall be of the vertical, axial or mixed-flow submersible type for [storm water] [flood control] [attached to the same shaft with a submersible electric motor] [direct coupled through a reducing gear to a submersible motor]. The pump/motor shall be electrically operated and installed in a discharge tube. Except as otherwise stated or noted, the terms pump and pump/motor both refer to a pump/motor integral unit.

1.3.3 General Design Requirements

a. The pump shall meet head, capacity, speed, efficiency, pump sump design, range of operation, cavitation, and vibration requirements as specified.[The Contractor may utilize reduction gears or adjustable impeller blades to meet the specification performance requirements.]

b. Design the pump for runaway speed as calculated by the Contractor for the system shown and specified. Waterhammer calculations shall be included when long discharge lines exist. The reverse speed shall be calculated assuming power failure and discharge valves fail to close.

c. The pump shall, as a minimum, meet the applicable design, materials, and manufacture requirements of HI 1.3, HI 2.3, HI 9.1-9.5 and these specifications.

d. The pumping unit design and performance shall have been demonstrated by previous successful operation of pumps of the required type and of equal design complexity by the manufacturer.

e. The pump shall operate in a discharge tube. The discharge tube shall fit within the dimensions shown so that installation and maintenance can be carried out by an [overhead bridge] [jib] [mobile] crane. The weight of the pump/motor integral unit shall not exceed [_____] kg lb.

f. The pump shall be designed for the calculated hydraulic pressure including waterhammer to which the pump parts are exposed.

g. The pump losses, as calculated by the Contractor, are in addition to the specified head and shall be allowed for when computing the pump system output.

h. The pump shall have a continuously rising head characteristic with decreasing capacity over the required range of operation specified. The pump shall not have an unstable operating characteristic over the required range of operation.

i. The pump shall meet all requirements for net positive suction head required (NPSHR) and operate without surging.

j. Associated pumping equipment including, but not limited to, electrical controls, instrumentation, [and pump control center] shall be suitable for [indoor] [outdoor] operation.

1.3.4 Design of Discharge System

****

NOTE: A number of installation designs are possible depending on the project site conditions. The designer normally designs the discharge system but has the option to allow the Contractor to design as much of the discharge system as desired. The calculations shall be in accordance with EM 1110-2-3105, with the hydraulic definitions as stated in the HI standards. It is the designer's responsibility to develop FIGURE 1.

****

a. [The pumping unit shall discharge into the discharge system shown. The system loss curve is included as FIGURE 1 at the end of this section to permit determination of total head. Losses within the pumping unit shall be determined by the Contractor.] [The pump discharge system downstream of the pumping unit shall be designed by the pump manufacturer. It shall be of the type shown and shall fit within limiting dimensions and elevations shown. Determine all losses for the discharge system and submit the design head loss computations to the Contracting Officer for approval and sufficient hydraulic computations to substantiate pump selection and demonstrate that the selected pump can meet the project design and operating requirements as specified. Losses within the pumping unit shall be determined by the Contractor.] [The pumping unit shall discharge into the discharge chamber shown. The system loss curve(s) furnished includes all losses beyond the pumping unit. Losses within the pumping unit shall be determined by the Contractor.]

[b. Priming of the siphon will be accomplished without the assistance of vacuum equipment.]

1.3.5 Operating Conditions

a. The pump shall be capable of operating in the dry (for the purpose of maintenance and operating checks) for short periods of time as stated in the manufacturer's operating instruction.

b. The pump manufacturer shall establish and state in the operating manual the procedures for starting and stopping the pumps, including setting of valves or any sequential operations.

1.3.6 Performance Requirements

a. When operated in the dry, the maximum level of vibration of the assembled pumping unit shall not be greater than the value of the lower limit of the good range of the "General Machinery Vibration Severity Chart". This chart can be obtained from Entek IRD, 1700 Edison Drive, Cincinnati, Ohio 45150. Measurements shall be taken at pump operating speed during the Factory Test and the field start-up test.

b. The pump shall be capable of operating without instability over the required range of head.

1.3.7 Capacities

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NOTES: The Corps policy and procedures for plant design and pump selection are explained in detail in EM 1110-2-3102 and EM 1110-2-3105. Using the data from hydrology and hydraulic studies, the designer will establish the performance requirements of the pumps. Using the manufacturers' catalogs that tabulate the characteristics of their pre-engineered units, a pump will be selected. The designer should then locate other pumps with the described characteristic and establish contact with manufacturers.

Any pump selected results from careful analysis of the relationships of speed, net positive suction head (NPSH) (cavitation), head-capacity, range of plant operation, sump design requirement, and to a lesser extent, efficiency. During the selection process the manufacturer's input to the design is obtained and integrated into the selection.

The specification will then state specific values to be attained so that a pump with the desired performance can be obtained. It is necessary to state the requirements so that more than one

manufacturer can respond. All manufacturers must meet the previous experience and manufacturing standards requirements.

Compliance with the performance requirements will be established using procedures stated in the HI Standards and at the time when the pump is assembled and tested at the factory. Efficiency, heads, and other hydraulic values for purpose of specification should conform to HI definitions, even though Corps manuals are used for the purpose of design criteria.

Each pump installation will be uniquely different and may require a slightly different head-capacity specification to establish that the correct pump will be obtained. During the pump selection procedure, the designer will establish certain capacities that must be met over a range of heads. The designer may state more than one operating point on the performance curve or utilize different points on the curve such as rated head, design head best efficiency point (BEP), maximum head, and minimum head. The heads defined are as stated in EM 1110-2-3105.

****

[a. Discharge shall not be less than [_____] L/s gpm against total design head [_____] m ft with water surface in the sump at elevation [_____] m ft.]

[b. Discharge shall not be less than [_____] L/s gpm against total rated head [_____] m ft with water surface in the sump at elevation [_____] m ft.]

[c. The pump shall deliver a minimum capacity of [_____] L/s gpm at a total minimum head of [_____] m ft, plus pump losses with water surface in the sump at elevation [_____] m ft.]

[d. The pump shall deliver a minimum capacity of [_____] L/s gpm at a total maximum head of [_____] m ft, plus pump losses with water surface in the sump at elevation [_____] m ft.]

1.3.8 Efficiency

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NOTES: The selection of pumps for flood and storm water projects will not usually depend on the economics of efficiency. However, a low efficiency can usually be correlated with poor pump hydraulics resulting in a shortened pump life. Therefore, an efficiency relating to the values from the manufacturer's catalog curves should be specified.

In the last bracketed option, specify the point at which the efficiency percentage should be reached.

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The pump shall have an efficiency of not less than [_____] percent at [_____].

1.3.9 Equipment

Submit, within 60 days of Notice of Award, a list of equipment as specified, the names of the manufacturers, performance capacities, and other relevant information for the machinery and other equipment contemplated to be incorporated into the work.

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.

An "S" following a submittal item indicates that the submittal is required for the Sustainability Notebook to fulfill federally mandated sustainable requirements in accordance with Section 01 33 29 SUSTAINABILITY REPORTING.

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

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Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for [Contractor Quality Control approval.][information only. When used, a designation following the "G" designation identifies the office that will review the submittal for the Government.] Submittals with an "S" are for inclusion in the Sustainability Notebook, in conformance to Section 01 33 29 SUSTAINABILITY REPORTING. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-02 Shop Drawings

Detail Drawings; G[, [_____]]

SD-03 Product Data

Materials
Equipment; G[, [_____]]
Spare Parts
Installation Instruction Manual; G[, [_____]]
Factory Tests
Pump Field Tests; G[, [_____]]

SD-05 Design Data

Computations; G[, [_____]]

SD-06 Test Reports

Factory Test Report
Field Test Report
Installation and Start-Up Engineer

SD-10 Operation and Maintenance Data

Operating and Maintenance Instructions; G[, [_____]]

1.5 QUALITY ASSURANCE

1.5.1 Pump Supplier Qualifications

****

NOTE: Submersible pumps are designed as a single machine even though specifications may not always recognize that unity. It is important that the design specifications state that a single manufacturer is to design and supply all parts of the pump unit including pump, motor, discharge tube, reduction gear, and cables. That manufacturer should also have demonstrated capability in sump design for pumps of the larger size.

****

The pump manufacturer shall have overall responsibility to supply the pumping unit (submersible pump/motor, [reducing gear (if needed)], discharge tube, [discharge elbow,] cables, [instrumentation and accessories]) that meet the requirements of this specification. Thus, during start-up, installation, and performance evaluation, the pump manufacturer is the sole responsible party. The pump manufacturer shall supply a list of installations at which pumps of his manufacture, and ones similar to those specified, have been operating for at least 2 years. The components and materials of the pumping unit may occur at different facilities, and be the product of other manufacturers.

1.5.2 Installation and Start-up Engineer

Furnish a competent installation engineer (including those from Contractor's suppliers) fluent in the English language who is knowledgeable and experienced with the installation and start-up procedures for submersible pumps and the associated equipment specified. When so requested, the installation engineer shall be responsible for providing complete and correct direction during installation, initial starting, and subsequent operation of equipment until field tests are completed. The installation engineer shall initiate instructions for actions necessary for proper receipt, inspection, handling, uncrating, assembly, and testing of equipment. The installation engineer shall also keep a record of measurements taken during erection and shall furnish one copy to the Contracting Officer on request or on the completion of the installation of assembly or part. The erecting engineer shall instruct the Contracting Officer or others as designated in the operation and maintenance features of the pump units. Submit the installation report.

1.5.3 Detail Drawings

Submit drawings of sufficient size to be easily read, within [90] [_____] days of Notice of Award. Submit information in the English language. Dimensions shall be in metric with English conversion. Furnish the following:

a. Outline drawings of the pump showing dimensions and weight of the pump/motor.

b. Drawings showing details and dimensions of pump mounting design and layout including any embedded items.

c. Cross-sectional drawings of the pump, showing each component, and major or complicated sections of the pump in detail. On each drawing indicate an itemized list of components showing type, grade, class of material used, and make and model of the standard component used. Include detail and assembly drawings of entire pumping unit assembly.

d. Provide drawings covering the installation that the Contractor intends to furnish to the erecting engineer.

e. The capacity-head curve should indicate efficiency, kW bhp, and NPSHR.

f. Motor characteristic curves or tabulated data (test or calculated) should indicate the speed, power factor, efficiency, current, and kilowatt input, all plotted or tabulated against percent load as abscissas.

1.6 DELIVERY, STORAGE, AND HANDLING

The pump will be inspected for damage or other distress when received at the project site. Store the pump and associated equipment indoors as recommended by the pump manufacturer, protected from construction or weather hazards at the project site. The pump and equipment shall have adequate short-term storage in a covered, dry, and ventilated location prior to installation. The manufacturer's instructions shall be followed for extended storage. Proper equipment for handling the pump shall be supplied and shall be considered as special tools if not completely standard. Follow the manufacturers recommendations for handling of the pump.

1.7 EXTRA MATERIALS

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NOTE: The spare parts noted herein are from other Corps documents. For any specific project, it would

be appropriate to discuss an adequate spare parts list during the designer's plant visitations as suggested by EM 1110-2-3105.
****

a. Furnish the following spare parts:

(1) One complete set of bearings and seals.
(2) Replacement wearing rings and O-rings.
(3) [One impeller].

b. Furnish one set of all special tools required to completely assemble, disassemble, or maintain the pumps. Special tools refers to oversized or specially dimensioned tools, special attachment or fixtures, or any similar items. Lifting devices required for use in conjunction with the [overhead] [truck] crane shall be furnished.

c. Submit [10] [_____] copies of manufacturers complete parts list showing all parts, spare parts, and bulletins for pump. Clearly show all details, parts, and adequately describe parts or have proper identification marks. The parts lists shall be printed on good quality 216 by 279 mm 8-1/2 by 11 inch paper, bound separately of the Operation and maintenance manual with a flexible, durable cover. Drawings incorporated in the parts lists may be reduced to page size provided they are clear and legible, or they may be folded into the bound lists to page size. Photographs or catalog cuts of components may be included for identification.

PART 2 PRODUCTS

2.1 MATERIALS

****
NOTE: The designer usually establishes communication with pump manufacturers concerning materials and design details appropriate for a specific site. The designer should utilize HI Standards, AWWA Standard 101-88, and paragraph DESIGNATED MATERIALS for guidance. Also, Sections 05 50 13 and 05 50 15 (referenced below) need to be included and edited.
****

Submit a list designating materials to be used for each pump part along with the submittal of the drawings. If deviation from specified materials is desired, submit complete specifications for the proposed deviating materials after award of the contract.

a. The pumps shall be designed and manufactured by a firm that is regularly engaged in the manufacture of the type of pump described in these specifications. Provide materials and fabrication conforming to the requirements specified herein and to Section 05 50 13 MISCELLANEOUS METAL FABRICATIONS and Section 05 50 15 CIVIL WORKS FABRICATIONS and to additional specified requirements. Classifications and grade of material incorporated in the work shall be in accordance with designated specifications. Submit deviations from the specified materials in accordance with paragraph SUBMITTALS.

b. Identify the pumping unit by means of a separate nameplate 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 horsepower, speed, capacity, type, and direction of rotation. The plate shall be made of corrosion-resistant metal with raised or depressed lettering and a contrasting background.

c. The pumping unit 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-resistant metal with raised or depressed lettering and a contrasting background.

2.2 METALWORK FABRICATION

The materials of construction shall comply with the following:

TABLE 1 - MATERIALS OF CONSTRUCTION	
PART	MATERIAL
Discharge Bowl	Cast iron, cast steel or [stainless steel] [steel] plate
Suction Bell	Cast iron, cast steel or [stainless steel] [steel] plate
Pump Bowl	Cast iron, cast steel or [stainless steel] [steel] plate
Impeller	Stainless steel or aluminum bronze
Shaft	Cold-rolled carbon steel or stainless steel
Wearing Ring	Manufacturer's standard
Bolts, Key, etc.	Stainless steel
O-rings	Nitrile rubber
Mechanical seals	Tungsten carbide
Discharge tube	[Steel plate] [Stainless steel]
[Discharge elbow	[Steel plate] [Stainless steel]]

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. 30A, 30B, and 30C

MATERIALS	SPECIFICATION	GRADE, CLASS
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 A297/A297M	Grade CA-15, CAGNN and CF-8M
Dimensions for Steel Water Piping Fittings	AWWA C208	
Hot-Rolled Stainless	ASTM A576	Graded G10200, G10450, and G11410
Ring Flanges	AWWA C207	Class B
Rubber Products in Automotive Applications	ASTM D2000	
Seamless and Welded Austenitic Stainless Steel Pipe	ASTM A312/A312M	
Stainless Bars and Shapes	ASTM A276/A276M	Grades S30400 and S41000
Steel Forging	ASTM A668/A668M	Class F
Steel Pipe 150 mm 6 inch and Larger	AWWA C200	
Steel Plates, Pressure Vessel	ASTM A516/A516M	Grade 55
Steel Plate	ASTM A242/A242M	
Stainless Steel Plate	ASTM A167	UNS S30400
	ASTM A240/A240M	
Quality Steel	ASTM A36/A36M	
Surface Texture	ASME B46.1	

2.2.2 Bolted Connections

2.2.2.1 Bolts, Nuts, and Washers

Bolts, nuts, and washers shall conform to requirements herein specified and the paragraphs SUBMERSIBLE PUMP, DISCHARGE TUBE [AND DISCHARGE ELBOW], and the 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 the latest ASTM specification or to other listed commercial specifications covering class or kinds of materials to be used.

2.2.3 Flame Cutting of Material

Flame cutting of material, other than steel, shall be subject to the approval of the 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 Section 3 of 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 technically 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.

2.2.4 Alignment of Wetted Surfaces

Exercise care to ensure that the correct alignment of wetted surfaces being joined by a flanged joint is being obtained. Where plates of the water passage change thickness, provide a transition on the outer surface, leaving the 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 a Government Inspector for misalignment of adjoining parts.

2.3 SUBMERSIBLE PUMP

2.3.1 Design and Manufacture

****

NOTE: The Contractor is required to submit names of previous installations where the selected manufacturer has documented the operating performance for pumps of this design. While the general venturi configuration of the pumps built by different suppliers is similar, the details (e.g., number of bearings, wearing ring design, cast versus fabrication, impeller design, and materials) can be different. Based on design details available, there seems to be little justification to prefer one manufacturer's design over another. The pump portion of the specification is a low tech design compared with the motor and housing internal design, 70 to 80 percent of the cost may be contained in the motor. The emphasis on the pump portion should be on rugged, reliable, long-lasting components that are trouble-free.

The design elements described in this section are taken from drawings, manuals, catalogs, and brochures requested from two manufacturers, one domestic and one foreign. Both have over 30 years of experience and thousands of operating pumps

worldwide. A primary concern in the specification was to not make it restrictive and yet to ensure that only qualified manufacturers would respond.
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At the Contractor's option, the submersible pump may be either of cast or fabricated construction. The level of manufacture skill shall be consistent with the standards referenced in the specifications. All work performed in the manufacture of the pumps shall be in a skillful and workmanlike manner in accordance with the best modern shop practice and manufacture of finished products similar in nature to those specified herein. The Government reserves the right to observe and witness the manufacture of the pumps and to inspect the pumps for compliance with contract requirements during factory assembly.

2.3.2   Speed

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NOTE: HI 2000 bases the maximum operating pump speed calculations on a value of suction-specific speed of 8500. EM 1110-2-3105, Appendix B uses 8000. When calculating the maximum specified pump speed use the more conservative value of suction-specific speed for application where pumps will operate continuously or for extended periods of time above or below point of optimum efficiency.
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2.3.2.1   Pump Speed

Rotative speed of the pump shall not be greater than [_____] rpm.

2.3.2.2   Runaway Speed

The pump shall be designed to sustain full runaway speed without damage at maximum head difference across the pump. Based on the system design as shown by the drawings the manufacturer shall compute the maximum reverse runaway speed, and the pump and motor shall be designed to sustain that reverse rotation without damage.

2.3.3   Pump Construction

2.3.3.1   General

The major pump components shall be of materials as described in Table 1. The entire support assembly shall be designed 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. All the exposed nuts and bolts shall be stainless steel. All mating surfaces. where watertight sealing is required, shall be machined and fitted with nitrile rubber O-rings. The fitting shall be such that the sealing is accomplished by metal-metal contact between machined surfaces which results in controlled compression of the O-rings. Sealing compounds, grease, or secondary devices are not acceptable.

2.3.3.2   Pump Lifting Handle And Lifting Lugs

The lifting handle shall be designed to bear the entire weight of the pumping unit at a conservative factor of safety. Lifting lugs shall be provided where the weight of the separate part requires a lug.

2.3.3.3 Pump and Motor Bearing Arrangement

The pump and motor bearings shall be the standard design of the manufacturer for the pump supplied under this specification. The type and number shall be of proven design as used in previous operating units supplied by the manufacturer. The bearings shall be of the grease lubricated and sealed type. The bearings shall have a minimum B-10 bearing life of 50,000 hr. Each bearing shall be of the correct design to resist the radial and thrust loads applied. Enough bearings shall be provided to ensure the pump rotating elements are supported so that the possibility of excessive vibration is eliminated. Ball and roller bearings life and load ratings shall conform to ABMA 9 and ABMA 11.

2.3.3.4 Mechanical Seals

A mechanical rotating shaft seal system shall be provided between the impeller and motor to ensure the motor housing seal. The mechanical seals shall be in tandem, lapped and face type seals running in lubricant reservoirs for cooling and lubrication. The mechanical seals shall contain both stationary and rotating tungsten carbide face rings unless otherwise specified. In order to avoid seal failure from sticking, clogging, and misalignment from elements contained in the mixed media, only the seal faces of the outer seal assembly and its retaining clips shall be exposed to the mixed media. All other components shall be contained in the lubricant housing. All seal faces must be solid material capable of being relapped. The seals shall require neither maintenance nor adjustment, but shall be easy to check and replace. Shaft seals without positively driven rotating members shall not be considered acceptable or equal.

2.3.3.5 Lubricant Housing

Provide an oil housing with oil, as recommended by the pump manufacturer, to lubricate the shaft sealing system and to dissipate the heat generated by the motor and bearings.

2.3.3.6 Impeller

The impeller design and manufacture shall be the manufacturer's standard. The impeller surface shall be smooth, without holes and fabrication offsets. The attachments to shaft shall be with keys or other fasteners which are to be made of stainless steel. The attachment should be of sturdy construction designed to not loosen, but be easily removed for maintenance. The impeller construction may be cast or fabricated. At the time of assembly the impeller clearances shall be those shown on assembly drawings and may be checked in the field or at the factory at the Contracting Officer's option. The impeller shall be balanced at the design operating speed. The standard balance quality grade is G6.3 in accordance with ASA S2.19. Balancing procedure shall be in accordance with HI 9.6.4, except that a two-plane balance shall be required.

2.3.3.7 Shaft

The shaft shall be [one piece integral with the motor] [two piece with gear reduction] of high-strength cold-rolled carbon steel or stainless steel with a factor of safety of five measured against the ultimate strength. The shaft shall be designed for all torque conditions during normal operation and for runaway speed during reverse flow.

2.3.3.8 Bowl Assembly

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NOTE: This portion of the pump is composed of the venturi section and consists of the suction bell, pump bowl, and discharge bowl. The entire unit acts as a venturi to hydraulically guide and stabilize the flow as it passes through the pump. Heads and stresses are low, and its major design consideration would be rugged, reliable, and long-lived materials.
****

The bowl assembly may be of cast or fabricated manufacture. The hydraulic design shall be the manufacturer's standard design as used in previous operating installations. The general manufacture quality relating to flange design, drilling, bolts, alignments, etc., shall be in accordance with industry standard practice.

2.3.4 Motor

The motor shall be submersible and conform to the requirements of NEMA MG 1. The motor shall be sized to avoid overload when operating at any point along the characteristic curve of the pump. The motors shall be 3-phase, 60-Hz, [_____] V, squirrel cage induction type, NEMA Design B Type. The stator windings and stator leads shall be insulated with a moisture-resistant Class F insulation with temperature resistance of 155 degrees C 311 degrees F. The service factor shall be 1.0. The temperature rise above ambient for continuous full load rated conditions and for the class of insulation used shall not exceed the values in NEMA MG 1. The motor shall be rated for continuous duty when submerged and shall also be capable of operation in the dry for short periods of time for testing and maintenance purposes.

2.3.4.1 Torque

Starting torque shall be sufficient to start the pump, but in no case less than 60 percent of full-load torque. Break-down torque shall not be less than 150 percent of full-load torque.

2.3.4.2 Support

Thrust bearing support shall have sufficient strength and rigidity to support the weight of the entire rotating element of the motor, pump impeller and shaft, and the hydraulic thrust.

2.3.5 Cable

a. Power and instrumentation cable shall be specifically designed for use with a submersible pump application and shall conform to the requirements of NEMA WC 70 and NEMA WC 72. Submersible cable shall be suitable for continuous immersion in water at the maximum depth encountered. Cable shall have an ampacity of not less than 125 percent of the motor full load current. The cable length shall be determined by the pump manufacturer for the installation shown [but shall not be less than [_____] m ft].

b. Power and instrumentation cables shall enter the motor through a sealing system that prevents water entry into the unit and provides strain relief. The cable entry may be comprised of rubber bushings, flanked by stainless steel washers, having a close tolerance fit against the cable outside diameter and the entry inside diameter for sealing by compression of the bushing, or the entry may be sealed by other gland compression methods.

2.3.6 Pump Control and Monitoring

A self-contained pump control and monitoring system shall be provided. Pump controls and control panels shall be provided in accordance with [Section [_____]] [_____]. Independent local indication of the alarm and separate contacts for the remote indication of each alarm and local reset shall be provided. Sensors shall alarm and shut down the pump at an abnormal operating condition. Separate red alarm indicator lamps and green pump running lamps shall be provided and labeled in the enclosure specified in [Section [_____]] [_____]. The following sensors shall be provided:

[2.3.6.1 Thermal Sensor

A thermal sensor in the gear reduction unit (if used) to monitor oil temperature.

]2.3.6.2 Temperature Sensor

Temperature sensors in the stator windings to protect the motor against overheating.

Temperature sensors to monitor the main and support bearings.

2.3.6.3 Foat Switch Sensor

Float-switch sensor positioned between the bearings and the stator-end coils to detect if liquid penetrates the stator housing.

2.3.6.4 Detectors

A junction box leakage detector and a water-in-oil detector.

[2.3.7 Gear Reducer

The pump, when required, shall be designed with a planetary gear unit connecting the pump shaft to the motor shaft. Lubrication shall be of the permanent type, and cooling shall be accomplished by the water flowing over the pump/motor unit. A dual independent mechanical rotating shaft seal system shall be provided between the motor, planetary gear system, and the impeller.

]2.3.8 Air Vent

An air vent shall be provided, located as shown on the contract drawings, and shall be a combination air and vacuum valve type. The valve shall be a minimum 862 kPa 125 lb class and sized for the design flow rate. An isolation valve shall be provided at the valve's inlet. Materials of construction shall be cast iron for the valve body; stainless steel for the internal linkage, float, and float stem; and Buna-N for the needle and seat. The valve shall provide a dual function to release air during pump start-up and to permit air to re-enter to break the vacuum during pump shutdown.

2.4 DISCHARGE TUBE [AND DISCHARGE ELBOW]

2.4.1 General

a. The design, manufacture and installation of the discharge tube [and discharge elbow] shall be in accordance with the pump manufacturer's instructions. For purposes of performance and this specification it shall be treated as part of the pumping unit. The discharge tube shall be of such size to accommodate the dimensions of the pump supplied in accordance with the manufacturer's requirements. It shall be permanently installed in the pump sump as shown on the drawings.

b. The design shall be such that the pumps will be automatically and firmly connected to the discharge tube when lowered into place and shall be in accordance with the pump manufacturer's instructions. A locking device shall be provided that prohibits rotational movement of the pump within the tube.

c. The pumps shall be easily removable for inspection or service without need to enter the pump sump. The pumps shall not require any bolts, nuts, or fasteners for connection to the discharge housing. Stiffening, guides, or other features shall be provided at the pump support to ensure concentric positioning of the pump in the discharge tube. Means shall be provided such that an effective seal is obtained between the pump and discharge tube. Power cable penetrations shall be watertight.

[d. A sole plate, as shown on the drawings, shall be installed. The entire support assembly shall be designed to the requirements of 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.]

2.4.2 Flanged Joints

Design flanged joints to be airtight and watertight, without the use of preformed gaskets, except that the use of a gasketing compound will be permitted. Mating flanges shall be male/female rabbet type or doweled with not less than four tapered dowels equally spaced around the flange. Flanges and drill bolt holes shall be machined concentric with the centerline, having a tolerance of plus or minus 1/4 of the clearance between the bolt and the bolt hole. When fabricated from steel plate, flanges shall not be less than 40 mm 1-1/2 inch thick after machining. Flange machining shall not vary more than 10 percent of the greatest flange thickness. Fabricated flanges, as a minimum, shall be constructed to the dimensions of AWWA C207, Class B. Flanges shall be connected to the column tube [and discharge elbow] with two continuous fillet welds, one at the inside diameter of flange-to-pump-tube and the other at the outside diameter of pump-tube-to-flange. Weld design is the pump manufacturer's responsibility. Mating flanges shall be machined parallel to a tolerance of 0.05 mm 0.002 inch. The machine mating flange surface shall be finished to 125 microns or better.

2.4.3 Nuts and Bolts

Nuts and bolts shall be of the hexagonal type. Bolts, including assembly, anchor, harness, and dowels, shall be 300 stainless steel. Nuts shall be bronze; washers shall be 300 series stainless steel.

[2.4.4 Bolted Lid

A watertight lid shall be provided, hinged and bolted to the top of the discharge tube.

][2.4.5 Harnessed Coupling

Provide a flexible mechanical coupling conforming to ASTM F1476, Type II, Class 3, stainless steel as manufactured by Teekay or Straub Coupling or Dresser style 38 coupling or approved equal, to connect pump discharge elbow to [transition section] [wall thimble] [discharge piping]. The middle ring shall be finished without pipe stop to facilitate the installation and removal of coupling.

][2.4.6 Wall Thimble

The wall thimble shall have one plain end to accommodate flexible mechanical coupling and one flanged end to mate with the flap gate. The plain end shall match the discharge elbow in thickness and diameter, and the flanged end shall be drilled to match and shall be capable of supporting, without distortion, the flap gate. A seal ring will be provided on the wall thimble, located so that it is centered in the wall when embedded. The wall thimble shall be fabricated from steel plates.

]2.4.7 Dissimilar Metals

When dissimilar metals are used in intimate contact, suitable protection against galvanic corrosion shall be applied. The anodic member shall be protected by proper electrical insulation of the joint.

2.5 INTAKE DESIGN

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NOTE: Information on intake design is available in EM 1110-2-3105, Hydraulic Institute standards, manufacturers' catalogs, and model tests from the U.S. Army Engineer Waterways Experiment Station (WES). The designer should be aware of net positive suction head available (NPSHA) and NPSHR from pump performance curves and the plant design operation. If the approach inlet conditions to the pumping station are unique or unusual, the designer should consult WES about the need for a model test or to learn about results from previous testing.

Detailed design information about using a formed suction intake is available in EM 1110-2-3105.

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2.5.1 General

The intake sump design is the Contracting Officer's responsibility. It is the responsibility of the Contractor to supply a pump that will meet the performance requirements without undue modifications to the sump as shown on the drawings. Any such modifications shall be at no cost to the Government and must receive prior approval.

[2.5.2 Formed Suction Intake (FSI)

Provide an FSI for each pump to the dimensional requirements and arrangement shown on the drawings. The FSI will be connected to the inlet of the discharge tube. The method of connection shall be a flanged joint as specified in paragraph Flanged Joints. The Contractor can assume the FSI has a K value of 0.15 for head loss calculations. The FSI shall be constructed of [fabricated steel], [cast iron], [or a combination of these materials]. Any stiffeners used shall be on the outside of the FSI to allow smooth flow within. Bolts shall be stainless steel with bronze nuts. The minimum thickness of fabricated material shall be [10 mm 3/8 inch] [12 mm 1/2 inch] [16 mm 5/8 inch] [19 mm 3/4 inch] Grout holes shall be provided in the floor [and sides] of the FSI to permit grouting during installation.

]2.6 SHOP ASSEMBLY

The discharge tube [and discharge elbow] shall be assembled in the manufacturer's plant to ensure the proper fitting and alignment of all parts. Prior to disassembly, all parts shall be match-marked to facilitate the correct assembly in the field.

2.7 FACTORY TESTS

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NOTE: The designer should specify performance testing of the assembled pump in the factory to check that the requirements of the specification have been met. Cavitation testing is recommended but may not always be required. The designer should include cavitation testing whenever the cavitation characteristics of the proposed pump have not been determined (by test) by any one of the prospective suppliers. Testing should be conducted on a full-scale (prototype) pump. It should also establish the structural and operating integrity of the complete pumping unit. The prototype pump would be the first pump built.

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Submit a description of the factory test setup and test procedure proposed. Submit sufficient data and drawings to demonstrate that testing is in compliance with HI 2.6

2.7.1 Performance Test

Test the pump at the manufacturer's shop to demonstrate that the proposed pump operates without instability and complies with specified performance. Instability is defined when any point in usable range of the head-capacity curve cannot be repeated within 3 percent. When this occurs, the test shall be rerun. Compliance with specifications will be determined from curves required by the paragraph TEST RESULTS. Test procedures, except as herein specified, shall be in accordance with applicable provisions of HI 2.6. The temperature of the water used for testing shall be approximately the same for all tests run and shall be recorded during test runs.

2.7.1.1 Performance of the Pump

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 requirements of the paragraph CAPACITIES. The test range shall include additional testing at total heads of 0.6 m 2 ft higher than that specified. The lowest total head for testing shall be, as a minimum, the total head determined from the referenced paragraph. If the test setup permits testing at lower total heads, the range of total heads shall be extended 0.6 m 2 ft lower. Testing shall be inclusive for the speed involved. Tests shall be made using heads and a suction water elevation specified in the paragraph CAPACITIES. Test results with this sump elevation shall meet all specified conditions of capacity, head, and bkW bhp. Head differentials between adjacent test points shall not exceed 0.9 m 3 ft, but in no case shall less than 10 points be plotted in the pumping range. If the plot of data indicates a possibility of instability or a dip in the head-capacity curve, a sufficient number of additional points on each side of the instability shall be made to clearly define the head-capacity characteristics.

2.7.1.2 Test Results

Test results shall be plotted to show the total head, static heads, bkW bhp, and efficiency as ordinates. The results should be plotted against pump discharge in L/s gpm as the abscissa. Curves shall be plotted showing pump performance to a scale that will permit reading the head directly to 0.15 m 0.5 ft, capacity to 30 L/s 500 gpm, efficiency to 1 percent, and power input to 20 bkW 25 bhp. It shall be established that the performance requirements of these specifications and the warranties under this contract have been fulfilled. The performance test shall be made with the pump and motor assembled as an operating unit to simulate field installation unless otherwise approved in writing by the Contracting Officer. Readings shall include one point each within 2 percent of the rated total head, minimum expected head, and maximum expected head. The test shall be conducted in accordance with accepted practices at full speed; and, unless otherwise specified, the procedure and instruments used shall conform to HI 2.6.

[2.7.2 Cavitation Test

The net positive suction head required (NPSHR) by the pump shall be determined by the testing procedures provided in HI 2.6. Select the test arrangement and procedure, from the choices provided in HI 2.6, that best suits the Contractor's test facility. NPSHR shall, as a minimum, be determined for five or more capacities over the total range of the specified operating conditions. Plot the test results and define NPSHR as the point where a 3 percent drop in performance occurs. The value of NPSHR shall be 0.6 m 2 ft less than the corresponding net positive suction head available (NPSHA). NPSHA shall be determined using the temperature of the water at the time the tests are run. The water elevations specified in paragraph CAPACITIES shall be used to determine the NPSHA for pumps.

]2.7.3 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, a sketch of the instrument or instrument arrangement shall be included. A fully detailed narrative description of each proposed method of instrumentation, procedures to be used, and a sample set of computation shall be included. The lowest equivalent static head that is obtainable with the testing when operating along the head-capacity curve of the proposed pump shall be stated.

2.7.3.1 Head Measurements

Head measurements shall be made using either a direct reading water column, mercury-air, mercury-water, a Meriam fluid manometer, or a pressure transducer. Vacuums shall be measured with either a mercury-air manometer, a mercury-water manometer, or a pressure transducer. Fluctuations shall be dampened sufficiently to permit column gauges or a differential pressure transducer to be read to either the closest one one-hundredth (0.01) of 300 mm 1 ft of water or Meriam fluid or one-tenth (0.1) of 25 mm 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.

2.7.3.2 Pump Capacity

Capacity shall be determined by a calibrated venturi flowmeter or a long-radius ASME flow nozzle. Orifice plates shall not be used. Venturi or nozzle taps shall be connected to column gauges equipped with dampening devices that will permit the differential head to be determined to either the closest one-hundredth (0.01) of 300 mm 1 ft or water or one-tenth (0.1) of 25 mm 1 inch of mercury. Magnetic flowmeters and flowmeters utilizing ultrasonic flow measurements will be acceptable if the calibration of the flowmeter has been completed within the last 6 months.

2.7.3.3 Rotational Speed of Pump

Rotational speed of the pump shall be measured in accordance with measurement of speed in HI 2.6, except that revolution counters shall not be used. The device used shall permit the speed to be determined to 1 rpm.

2.7.3.4 Power Input

Power input to the pump shall be measured in accordance with power measurements in HI 2.6. A method to permit kW bhp to be determined to the closest 0.5 bkW 0.5 bhp shall be used.

2.7.4 Witness Test

Factory tests shall be performed in the presence of the Contracting Officer. When the Contractor is satisfied that the pump performs in accordance with the specified requirements, notify the Contracting Officer, two weeks in advance, that the witness tests are ready to be run and furnish two copies of curves required in paragraph TEST RESULTS above. Should the test reveal that the pump does not perform in accordance with the specifications, make necessary changes before again notifying the Contracting officer that witness tests are ready to be run. Copies of all data taken during the testing and plotted preliminary curves shall be given to the Contracting Officer at the conclusion of the test.

2.7.5 Factory Test Report

Submit, within 30 days of receipt of approval of the witnessed factory test, nine bound copies of a report covering test setup and performance tests. The factory test report shall include the specified information.

Each factory test report shall include, as a minimum, the following:

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

b. Resume of preliminary studies, if such studies were made.

c. Description of pump and motor, including serial numbers, if available.

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, or a digital recording, 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 the paragraph TESTS RESULTS.

m. Curves showing the performance of the prototype pump.

n. Drawings of the test set-up showing all pertinent dimensions, elevations and cross section of the pump.

PART 3 EXECUTION

3.1 INSTALLATION

Perform correct installation and assembly of the pumping unit in accordance with the drawings and with the manufacturer's installation instruction manual. Submit, no later than 30 days prior to time of pump delivery, three copies of a typed and bound manual describing procedures to be followed by the installation engineer in assembling, installing, and dry- and/or wet-testing the pump. Coordinate and consolidate the description of the pump with similar descriptions for other specified pump parts. The description shall be of such a nature that it may be comprehended by an engineer or mechanic without extensive experience in erecting or installing pumps of this type. The description shall be a step-by-step explanation of operations required, and shall include, where applicable, such things as alignment procedures, bolt torque values, recommended instrument setups, recommended gauges and instruments, and similar details. Furnish all bolts, shims, tools, and other devices necessary for installing the pumping units. The manufacturer's representative(s) familiar with the equipment being installed shall supervise the handling, installation, start-up, and testing of the equipment as required in the paragraph INSTALLATION AND START-UP ENGINEER.

3.2 CLEANUP PRIOR TO START

After the pumping unit is installed and prior to start-up, complete clean up of the sump area of any accumulated construction debris shall be done. This final cleaning of the sump area will be witnessed by a representative of the Government. Any damage to the pumping units or related equipment during initial start-up due to foreign objects left in the sump areas shall be corrected at the Contractor's expense.

3.3 PUMP FIELD TESTS

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NOTES: Compliance with specification performance has been made a part of the factory tests; therefore, field tests are for the purpose of baseline measurements. Pump integrity, vibration, manufacture, and inspection are witnessed at the factory.

Perform field testing to ensure proper alignment and installation, start-up and shutdown procedures, checking out controls, and establishing baseline measurements. Two field test methods are available, dry or wet testing, depending on availability of water. Wet testing is preferred, but dry testing may be all that is possible when the pumps are prepared for initial start-up.

If a wet test cannot be conducted at the time of initial start-up because of a lack of water, it should be conducted at a later time, if possible, and does not unduly extend the contract period.

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Submit a field test plan prior to field testing. Field testing shall be conducted by an experienced field test engineer and will be witnessed by the Contracting Officer. Before initially energizing the pump/motors, ensure that all pumping plant control, monitoring, and protective circuits have bee successfully tested. This thorough electrical checkout procedure shall have followed a detailed step-by-step approved test plan. The motor and other pumping unit elements undergoing tests should also be checked at this time. Field test plan prior to field testing.

3.3.1 Dry Test

Each pumping unit shall be tested in the dry in accordance with the pump manufacturer's instructions to determine whether it has been properly installed. Such tests shall be made when, and as, directed by the Contracting Officer. The pump shall be operated at full rated speed. Should tests reveal a design or installation deficiency or a manufacturing error in pumping unit components, the problem shall be promptly corrected by and at the expense of the Contractor.

3.3.2 Wet Test

Each unit shall be given an operating test under load for a period of at least [_____] hr or as directed by the Contracting Officer. Conduct the tests to be witnessed by the Government. During the tests, the operation of the pumping units shall be observed and measurement of [noise (in accordance with HI 9.1-9.5),] motor-bearing temperatures, voltage, and current shall be recorded for each pump. Measured parameters shall be within the pump manufacturers published limits. Vibration measurements shall be made at the top of the discharge tube [and flange of the discharge elbow] for each pump. Vibration limits shall not exceed those recommended by HI 9.6.4.

3.3.3 Field Test Report

Prepare and submit five (5) copies of the field test report and a manual of Operating and Maintenance Instructions for the completed system. Submit [10] [_____] copies of the Instructions containing complete information on operation, lubrication, adjustment, routine and special maintenance disassembly, repair, reassembly, and trouble diagnostics of pump and auxiliary equipment. The operation and maintenance manual shall be printed on good quality 216 by 279 mm 8-1/2 by 11 inch paper, bound separately from the parts list, and bound between a flexible, durable cover. Drawings incorporated in manual may be reduced to page size provided they are clear and legible, or they may be folded into the manual to page size. Photographs or catalog cuts of components may be included for identification.

3.4 PAINTING

Paint the pump/motor in accordance with the pump manufacturer's standard coating system. The painting of the discharge tube [and discharge elbow] and appurtenances shall be in accordance with Section 09 97 02 PAINTING: HYDRAULIC STRUCTURES.

-- End of Section --