**************************************************************************

**USACE / NAVFAC / AFCEC / NASA** **UFGS-35 45 02.00 10 (February 2016)**

**Preparing Activity: USACE** **Superseding**
**UFGS-22 11 23.00 10 (July 2007)**

**UNIFIED FACILITIES GUIDE SPECIFICATIONS**

**References are in agreement with UMRL dated July 2019**

**************************************************************************

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DIVISION 35 - WATERWAY AND MARINE CONSTRUCTION

SECTION 35 45 02.00 10

SUBMERSIBLE PUMP, AXIAL-FLOW AND MIXED-FLOW TYPE

**02/16**

ATTACHMENTS:



-- End of Section Table of Contents --

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**************************************************************************

SECTION 35 45 02.00 10

SUBMERSIBLE PUMP, AXIAL-FLOW AND MIXED-FLOW TYPE
**02/16**

**************************************************************************
**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 item(s) or insert appropriate information.**

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

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

PART 1 GENERAL

**************************************************************************
**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.**
**************************************************************************

## 1.1 SUMMARY

**************************************************************************
**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.**

**Coordinate the bar spacing in the trash rack with**

**the structural designer and with pump manufacturers.**

**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.**

**************************************************************************

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.

## 1.2 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.

## 1.3 REFERENCES

**************************************************************************

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

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

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

**************************************************************************

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

AMERICAN BEARING MANUFACTURERS ASSOCIATION (ABMA)

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

ABMA 11 (2014) Load Ratings and Fatigue Life for Roller 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 | (2018) Standard for Steel Pipe Flanges for Waterworks Service, Sizes 4 in. through 144 in. (100 mm through 3600 mm) |
| AWWA C208 | (2017) Dimensions for Fabricated Steel Water Pipe Fittings |

AMERICAN WELDING SOCIETY (AWS)

| | |
|---|---|
| AWS D1.1/D1.1M | (2015; Errata 1 2015; Errata 2 2016) Structural Welding Code - Steel |

ASME INTERNATIONAL (ASME)

| | |
|---|---|
| ASME B16.5 | (2017) Pipe Flanges and Flanged Fittings NPS 1/2 Through NPS 24 Metric/Inch Standard |
| ASME B31.1 | (2016; Errata 2016) Power Piping |
| ASME B36.10M | (2015; Errata 2016) Welded and Seamless Wrought Steel Pipe |
| ASME B46.1 | (2009) Surface Texture, Surface Roughness, Waviness and Lay |
| ASME BPVC SEC IX | (2017; Errata 2018) BPVC Section IX-Welding, Brazing and Fusing Qualifications |

ASTM INTERNATIONAL (ASTM)

| | |
|---|---|
| ASTM A27/A27M | (2017) Standard Specification for Steel Castings, Carbon, for General Application |
| ASTM A36/A36M | (2014) Standard Specification for Carbon Structural Steel |
| ASTM A48/A48M | (2003; R 2012) Standard Specification for Gray Iron Castings |
| ASTM A108 | (2013) Standard Specification for Steel Bar, Carbon and Alloy, Cold-Finished |
| ASTM A126 | (2004; R 2014) Standard Specification for Gray Iron Castings for Valves, Flanges, and Pipe Fittings |
| ASTM A240/A240M | (2018) Standard Specification for Chromium and Chromium-Nickel Stainless Steel Plate, Sheet, and Strip for Pressure Vessels and |

for General Applications

| | |
|---|---|
| ASTM A242/A242M | (2013; R 2018) Standard Specification for High-Strength Low-Alloy Structural Steel |
| ASTM A276/A276M | (2017) Standard Specification for Stainless Steel Bars and Shapes |
| ASTM A297/A297M | (2017) Standard Specification for Steel Castings, Iron-Chromium and Iron-Chromium-Nickel, Heat Resistant, for General Application |
| ASTM A312/A312M | (2017) Standard Specification for Seamless, Welded, and Heavily Cold Worked Austenitic Stainless Steel Pipes |
| ASTM A516/A516M | (2017) Standard Specification for Pressure Vessel Plates, Carbon Steel, for Moderate- and Lower-Temperature Service |
| ASTM A576 | (2017) Standard Specification for Steel Bars, Carbon, Hot-Wrought, Special Quality |
| ASTM A668/A668M | (2017) Standard Specification for Steel Forgings, Carbon and Alloy, for General Industrial Use |
| ASTM B98/B98M | (2013) Standard Specification for Copper-Silicon Alloy Rod, Bar, and Shapes |
| ASTM B148 | (2014) Standard Specification for Aluminum-Bronze Sand Castings |
| ASTM B584 | (2014) Standard Specification for Copper Alloy Sand Castings for General Applications |
| ASTM D2000 | (2012; R 2017) 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 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 |

HI ANSI/HI 9.8 (2014) Rotodynamic Pumps for Pump Intake Design - A123

HI ANSI/HI 14.6 (2011) Rotodynamic Pumps for Hydraulic Performance Acceptance Tests - A136

INTERNATIONAL ORGANIZATION FOR STANDARDIZATION (ISO)

ISO 1940-1 (2003; R 2008) Mechanical Vibration - Balance Quality Requirements for Rotors in a Constant (Rigid) State - Part 1: Specification and Verification of Balance Tolerances

INTERNATIONAL SOCIETY OF AUTOMATION (ISA)

ISA RP2.1 (1978) Manometer Tables

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)

NEMA MG 1 (2016; SUPP 20162018) 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 2015) Standard for Continuity of Coating Testing for Electrical Conductors

U.S. ARMY CORPS OF ENGINEERS (USACE)

EM 1110-2-3105 (1999; Change 2) Mechanical and Electrical Design of Pumping Stations

U.S. DEPARTMENT OF DEFENSE (DOD)

UFC 3-310-04 (2013; with Change 1, 2016) Seismic Design of Buildings

## 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.**

**The "S" following a submittal item indicates that the submittal is required for the Sustainability eNotebook to fulfill federally mandated sustainable requirements in accordance with Section 01 33 29 SUSTAINABILITY REPORTING. Locate the "S" submittal under the SD number that best describes the submittal item.**

**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.] Submittals with an "S" are for inclusion in the Sustainability eNotebook, 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

Pump Supplier Qualifications

Materials; G[, [_____]]

Equipment; G[, [_____]]

Spare Parts

Installation Instruction Manual; G[, [_____]]

Impeller Balancing

Factory Tests

Pump Field Tests; G[, [_____]]

SD-05 Design Data

Computations; G[, [_____]]

SD-06 Test Reports

Factory Test Report

Intake Model Tests

Field Test Report

Installation and Start-Up Engineer

SD-07 Certificates

Qualified Welders

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. Clearly 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 has overall responsibility to supply the pumping unit (submersible pump/motor, [reducing gear (if needed)], discharge tube, [discharge elbow,] cables, and related [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 must 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) who is knowledgeable and experienced with the installation and start-up procedures for submersible pumps and the associated equipment specified. Submit the installation and start-up engineer's qualifications. When so requested, the installation engineer is responsible for providing complete and correct direction during installation, initial starting, and subsequent operation of equipment until field tests are completed. The installation engineer initiates instructions for actions necessary for proper receipt, inspection, handling, uncrating, assembly, and testing of equipment. The installation engineer must also keep a record of measurements taken during erection and furnish one copy to the Contracting Officer upon request or upon the completion of the installation of assembly or part. The erecting engineer conducts training on 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. Dimension in the metric (SI) with English conversion inch-pound-second system. 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 and lifting connections.

c. Cross-sectional drawings of each different size of 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 is intended for the erecting engineer.

e. Indicate efficiency, kW bhp, and NPSHR with the capacity-head curve.

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

### 1.5.4 Welding

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

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

## 1.6 DELIVERY, STORAGE, AND HANDLING

Inspect each pump for damage or other distress when received at the project site. Store each pump and associated equipment indoors as recommended by the pump manufacturer, protected from construction or weather hazards at the project site. Provide adequate short-term storage for each pump and equipment in a covered, dry, and ventilated location prior to installation. Follow the manufacturer's instructions for extended storage. Supply proper equipment for handling the pump and consider the equipment as special tools if not completely standard.

Follow the manufacturer's recommendations for handling of the pump.

## 1.7 EXTRA MATERIALS

**************************************************************************

**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 or discussions with the end user as suggested by EM 1110-2-3105.**

**************************************************************************

a. Furnish the following spare parts:

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

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 attachments or fixtures, or any similar items. Furnish lifting devices required for use in conjunction with the [overhead] [truck] crane. Provide the tools in a toolbox or toolboxes.

c. Submit copies of manufacturer's complete parts list showing all parts, spare parts, and bulletins for each pump. Clearly show all details, parts, and adequately describe parts or have proper identification marks. Provide he parts lists [on good quality 216 by 279 mm 8-1/2 by 11 inch paper][on optic disk with default letter print size of, 8-1/2 by 11 inch], 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 to page size and inserted into the bound lists]. Photographs or catalog cuts of components may be included for identification.

## 1.8 WARRANTY

**************************************************************************

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

**************************************************************************

Provide a manufacturer's warranty for the submersible pumps and all equipment furnished under this section against defective workmanship, materials, design, and performance for a period of [_____] years from the date the equipment is accepted. If the equipment or any part thereof does not conform to these warranties, and the Government so notifies the manufacturer within a reasonable time after its discovery, the manufacturer must thereupon promptly correct such nonconformity by repair or replacement. Coordinate the down time for the equipment with the

Government, and keep to a minimum duration that is mutually agreed to by the manufacturer and the Government. The manufacturer is liable during the warranty period for the direct cost of removal of the equipment from the installed location, transportation to the manufacturer's factory or service shop for repair and return, and reinstallation on site. The manufacturer must be given the opportunity to perform the removal and reinstallation and to select the means of transportation. The expense of removing adjacent apparatus, installing spare equipment, costs of supplying temporary service, etc., is not included in this warranty provision.

## PART 2 PRODUCTS

### 2.1 SYSTEM REQUIREMENTS

**************************************************************************

**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. 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.**

**************************************************************************

#### 2.1.1 Pumping Unit Description

**************************************************************************

**NOTE: Provide 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.**

**************************************************************************

Each pumping unit includes a pump/motor, discharge tube, [discharge elbow], air vent, [lifting chain], cable, and controls. Each pump must 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]. Use an electrically operated pump/motor 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.

#### 2.1.2 General Design Requirements

a. Provide the pump meeting head, capacity, speed, efficiency, pump sump design, range of operation, cavitation, and vibration requirements as specified.[ Reduction gears or adjustable impeller blades may be utilized to meet the specification performance requirements.]

b. Design the pump for runaway speed as calculated for the system shown and specified. Include water hammer calculations when long discharge lines exist. Calculate the reverse speed assuming a power failure and the discharge valves fail to close.

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

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

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

f. Design the pump for the calculated hydraulic pressure including a water hammer to which the pump parts are exposed.

g. In addition to the specified head, take into account the pump losses when computing the pump system output.

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

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

j. Use associated pumping equipment including, but not limited to, electrical controls, instrumentation, [and pump control center] that is suitable for [indoor] [outdoor] operation.

2.1.3 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. [Discharge the pumping unit into the discharge system indicated. The system loss curve is included as FIGURE 1 at the end of this section to permit determination of total head. Determine losses within the pumping unit.] [The pump discharge system downstream of the pumping unit must be designed by the pump manufacturer; of the type indicated and fitting within limiting dimensions and elevations indicated. Determine all losses for the discharge system and submit the design head loss computations. Provide sufficient hydraulic computations to substantiate pump selection and demonstrate that the selected pump can meet the project design and operating requirements as specified. Determine losses within the pumping unit.] [Discharge the pumping unit into the discharge chamber indicated. The system loss curve(s) furnished includes all losses beyond the pumping unit. Determine Losses within the pumping unit.]

[ b. Accomplish priming of the siphon without the assistance of vacuum equipment.]

2.1.4 Operating Conditions

a. The pump must 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 establishes and states in the operating manual the procedures for starting and stopping the pumps, including setting of valves or any sequential operations.

2.1.5 Performance Requirements

a. When operated in the dry, the maximum level of vibration of the assembled pumping unit cannot 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. Take measurements at pump operating speed during the Factory Test and the field start-up test.

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

2.1.6 Capacities

**************************************************************************

**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, select a pump. 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 cannot be less than [_____] L/s gpm against total design head of [_____] m ft with water surface in the intake sump at elevation [_____] m ft.]

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

[ c. The pump must 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 must 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.]

[ e. Discharge cannot be less than [_____] L/s gpm through the discharge at invert elevation of [_____] m ft with water surface in the intake sump at elevation [_____] m ft.]

[ f. The pumps must continuously pump water without signs of distress, including cavitation, with a water surface in the intake sump at elevation [_____] m ft.]

[ g. The pump must be able to operate at any condition between condition "e" and condition "f".]

2.1.7 Efficiency

**************************************************************************

**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.**

**************************************************************************

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

2.1.8 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.

## 2.2 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. Provide pumps 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 must 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; bearing the manufacturer's name, model designation, serial number, if applicable, and other pertinent information such as horsepower, speed, capacity, type, and direction of rotation. Make the plate of corrosion-resistant metal with raised or depressed lettering and a contrasting background.

c. Equip the pumping unit with suitably located instruction plates, including any warnings and cautions, describing any special and important procedures to be followed in starting, operating, and servicing the equipment. make plates of corrosion-resistant metal with raised or depressed lettering and a contrasting background.

## 2.3 METALWORK FABRICATION

The materials of construction must 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]] |

### 2.3.1 Designated Materials

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

| MATERIALS | SPECIFICATION | GRADE, CLASS |
|---|---|---|
| Aluminum-Bronze | ASTM B148 | Alloy No. C95500 Castings |
| Cast Iron | ASTM A48/A48M | Class Nos. 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 A297/A297M | Grade CA-15, CAGNN and CF-8M |
| Dimensions for Steel Water Piping Fittings | AWWA C208 | |

| MATERIALS | SPECIFICATION | GRADE, CLASS |
| --- | --- | --- |
| 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 A240/A240M | UNS S30400 |
| Quality Steel | ASTM A36/A36M | |
| Surface Texture | ASME B46.1 | |

### 2.3.2 Bolted Connections

#### 2.3.2.1 Bolts, Nuts, and Washers

Bolts, nuts, and washers must conform to requirements herein specified and paragraphs SUBMERSIBLE PUMP, DISCHARGE TUBE [AND DISCHARGE ELBOW], and 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.

#### 2.3.2.2 Materials Not Specifically Described

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

### 2.3.3 Flame Cutting of Material

Flame cutting of material, other than steel, is subject to Contracting Officer approval. Accurately perform shearing, and neatly finish all portions of work. Steel may be cut by mechanically guided or hand-guided torches, provided an accurate profile with a smooth surface free from cracks and notches is secured. Prepare surfaces and edges to be welded in accordance with Section 3 of AWS D1.1/D1.1M. Chipping and grinding are not required except where specified and as necessary to remove slag and sharp edges of technically guided or hand-guided cuts not exposed to view. Chip, grind, or machine visible or exposed hand-guided cuts to metal free of voids, discontinuities, and foreign materials.

#### 2.3.4 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, carefully check joining of plates in the presence of a Government inspector for misalignment of adjoining parts.

## 2.4 SUBMERSIBLE PUMP

### 2.4.1 Design and Manufacture

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**NOTE: Under paragraph PUMP SUPPLIER QUALIFICATIONS 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 avoid making it restrictive and yet to ensure that only qualified manufacturers would respond.**

**************************************************************************

The submersible pump may be either of cast or fabricated construction. The level of manufacture skill must be consistent with the standards referenced in the specifications. All work performed in the manufacturing of the pumps must be in a skillful and workmanlike manner in accordance with the best modern shop practice and manufacturing of finished products similar in nature to those specified herein. The Government reserves the right to observe and witness the manufacturing of the pumps and to inspect the pumps for compliance with contract requirements during factory assembly.

### 2.4.2 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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#### 2.4.2.1 Pump Speed

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

#### 2.4.2.2 Runaway Speed

Design the pump to sustain full runaway speed without damage at maximum head difference across the pump. Based on the system design as indicated, the manufacturer must compute the maximum reverse runaway speed, and design the pump and motor to sustain that reverse rotation without damage.

### 2.4.3 Pump Construction

#### 2.4.3.1 General

The major pump components must be of materials as described in Table 1. Design the entire support assembly in accordance with UFC 3-310-04 and Sections 13 48 00 [SEISMIC] BRACING FOR MISCELLANEOUS EQUIPMENT and 23 05 48.19 [SEISMIC] BRACING FOR HVAC. All the exposed nuts and bolts must be stainless steel. Machine and fit all mating surfaces where watertight sealing is required with nitrile rubber O-rings. The fitting must 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.

#### 2.4.3.2 Pump Lifting Handle And Lifting Lugs

Design the lifting handle to bear the entire weight of the pumping unit at a conservative factor of safety. Provide lifting lugs where the weight of the separate part requires a lug.

#### 2.4.3.3 Pump and Motor Bearing Arrangement

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

#### 2.4.3.4 Mechanical Seals

provide a mechanical rotating shaft seal system between the impeller and motor to ensure the motor housing is sealed properly. The mechanical seals must be in tandem, lapped and face type seals running in lubricant reservoirs for cooling and lubrication. The mechanical seals must 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 can be exposed to the mixed media. Contain all other components in the lubricant housing. All seal faces must be solid material capable of being relapped. The seals must require neither maintenance nor adjustment, but be easy to check and replace. Shaft seals without positively driven rotating members are not considered acceptable or equal.

#### 2.4.3.5 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.

#### 2.4.3.6 Impeller

The impeller design and manufacture must be the manufacturer's standard. The impeller surface must be smooth, without holes and fabrication offsets. The attachments to shaft must be with keys or other fasteners that are made of stainless steel, and 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 must be those shown on assembly drawings and may be checked in the field or at the factory at the Contracting Officer's option. Balance the impeller at the design operating speed. The standard balance quality grade is G6.3 in accordance with ISO 1940-1. Balance in accordance with the procedure in HI 9.6.4, except that a two-plane balance is required. Submit the results of impeller balancing.

#### 2.4.3.7 Shaft

The shaft must 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. Design the shaft for all torque conditions during normal operation and for runaway speed during reverse flow.

#### 2.4.3.8 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 is for rugged, reliable, and long-lived materials.**

**************************************************************************

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

2.4.4 Motor

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

2.4.4.1 Torque

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

2.4.4.2 Support

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

2.4.5 Cable

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

b. Power and instrumentation cables must 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.

2.4.6 Pump Control and Monitoring

Provide a self-contained pump control and monitoring system. Provide pump controls and control panels in accordance with [Section [_____]] [_____]. Provide independent local indication of the alarm and separate contacts for the remote indication of each alarm and local reset. Sensors must alarm and shut down the pump at an abnormal operating condition. provide separate red alarm indicator lamps and green pump running lamps and label in the enclosure specified in [Section [_____]] [_____]. Provide the following sensors:

[2.4.6.1 Thermal Sensor

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

]2.4.6.2 Temperature Sensor

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

Temperature sensors to monitor the main and support bearings.

2.4.6.3 Float Switch Sensor

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

2.4.6.4 Detectors

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

[2.4.7 Gear Reducer

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

]2.4.8 Air Vent

Provide an air vent, located as indicated, and a combination air and vacuum valve type. The valve must be a minimum 862 kPa 125 lb class and sized for the design flow rate. Provide an isolation valve at the valve's inlet. Materials of construction must 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 must 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.

2.5 DISCHARGE TUBE [AND DISCHARGE ELBOW]

2.5.1 General

a. Design, manufacture, and install the discharge tube [and discharge elbow] in accordance with the pump manufacturer's instructions. For purposes of performance and this specification it is treated as part of the pumping unit. Provide the discharge tube of such size to accommodate the dimensions of the pump supplied in accordance with the manufacturer's requirements. Furnish the discharge tube with lifting points to aid in the handling and installation of the tube. Permanently install it in the pump sump as indicated.

b. Design such that the pumps are automatically and firmly connected to the discharge tube when lowered into place and in accordance with the pump manufacturer's instructions. Provide a locking device that prohibits rotational movement of the pump within the tube.

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

[ d. Install a sole plate as indicated. Design the entire support assembly to the requirements of UFC 3-310-04 and Sections 13 48 00 [SEISMIC] BRACING FOR MISCELLANEOUS EQUIPMENT and 23 05 48.19 [SEISMIC] BRACING FOR HVAC.]

2.5.2 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 must be male/female rabbet type or doweled with not less than four tapered dowels equally spaced around the flange. Machine flanges and drill bolt holes 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 must not be less than 40 mm 1-1/2 inch thick after machining. Flange machining must not vary more than 10 percent of the greatest flange thickness. Construct fabricated flanges, as a minimum, to the dimensions of AWWA C207, Class B. Connect flanges 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. Machine mating flanges parallel to a tolerance of 0.05 mm 0.002 inch. finish the machine mating flange surface to 125 microns or better.

2.5.3 Nuts and Bolts

Use hexagonal type nuts and bolts; with bolts, including assembly, anchor, harness, and dowels of 300 stainless steel. Provide bronze nuts and 300 series stainless steel washers.

[2.5.4 Bolted Lid

Provide a watertight lid, hinged and bolted to the top of the discharge tube.

][2.5.5 Harnessed Coupling

Provide a flexible mechanical coupling or split-sleeve type coupling that either conforms to ASTM F1476, Type II, Class 3, stainless steel (as manufactured by Teekay or Straub Couplings), ASTM F1476, Type 1 (as manufactured by Victaulic), or Dresser Couplings style 38, or approved equal, to connect the pump discharge elbow to the [transition section] [wall thimble] [discharge piping]. Finish the middle ring without pipe stop to facilitate the installation and removal of the coupling. Install a minimum of four harness bolts (sized by the pump manufacturer) at each coupling.

]2.5.6 Wall Thimble

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**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.**

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

2.5.7 Discharge Piping

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**NOTE: Include applicable discharge pipe description.**

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

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

### 2.5.8 Flap Gate

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

### 2.5.9 Dissimilar Metals

When dissimilar metals are used in intimate contact, apply suitable protection against galvanic corrosion. Protect the anodic member by proper electrical insulation of the joint.

## 2.6 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 Research and Development Center (ERDC). 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 consider having the contractor perform a model intake test, or the contractor may consult ERDC 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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### 2.6.1 General

The intake sump design will be provided by the Government. Supply a pump that will meet the performance requirements without undue modifications to the sump as indicated on the drawings. Any such modifications are at no cost to the Government and must receive prior approval.

### [2.6.2 Formed Suction Intake (FSI)

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

]2.7 INTAKE TESTING

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**NOTE: Delete this paragraph if a model test of the intake to the pumping system(s) is not required.**
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Provide complete performance model testing of the pump intake systems. Use the model testing to confirm the configuration of the intake systems, including the proposed intake conduit, hydraulic losses to the pump, the position of the pump in the intake bay, and to confirm the selection of the pump. The Contracting Officer will witness the final tests confirming the geometry for the intake conduit. Furnish the Contracting Officer with not less than 14 days written notice of the time and location for the final tests.

2.7.1 Qualifications

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

2.7.2 Intake Model Setup and Objectives

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

2.7.3 Intake Model Tests

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

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

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

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

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

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

   swirl angle = (1/(tan))(pi*d*n)÷ u

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

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

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

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

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

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

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

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

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

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

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

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

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

Recommendations from the Model Test

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

## 2.8 SHOP ASSEMBLY

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

## 2.9 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 ANSI/HI 14.6

### 2.9.1 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 the usable range of the head-capacity curve cannot be repeated within 3 percent. When this occurs, rerun the test. Compliance with specifications will be determined from curves required by paragraph TEST RESULTS. Test procedures, except as herein specified, must be in accordance with applicable provisions of HI ANSI/HI 14.6, with an acceptance grade of 1U. Use water for testing at approximately the same temperature for all tests run and record it during test runs.

#### 2.9.1.1 Performance of the Pump

Determine performance of the pump by a series of test points sufficient in number to develop a constant speed curve over the range of total heads corresponding to the requirements of paragraph CAPACITIES. The test range must include additional testing at total heads of 0.6 m 2 ft higher than that specified. The lowest total head for testing must be, as a minimum, the total head determined from the referenced paragraph. If the test setup permits testing at lower total heads, extend the range of total heads 0.6 m 2 ft lower. Testing must be inclusive for the speed involved. Perform tests using the heads and suction water elevation specified in paragraph CAPACITIES. Test results with this sump elevation must meet all specified conditions of capacity, head, and bkW bhp. Head differentials between adjacent test points cannot exceed 0.9 m 3 ft, but in no case fewer 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 must be made to clearly define the head-capacity characteristics.

2.9.1.2 Test Results

Plot test results to show the total head, static heads, bkW bhp, and efficiency as ordinates. Plot the results against pump discharge in L/s gpm as the abscissa. Plot curves 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. Establish that the performance requirements of these specifications and the warranties under this contract have been fulfilled. Perform the performance test with the pump and motor assembled as an operating unit to simulate field installation unless otherwise approved in writing by the Contracting Officer. Readings must include one point each within 2 percent of the rated total head, minimum expected head, and maximum expected head. Conduct the test in accordance with accepted practices at full speed; and, unless otherwise specified, conform to HI ANSI/HI 14.6 procedure and instruments.

[2.9.2 Cavitation Test

Use the testing procedures provided in HI ANSI/HI 14.6 to determine the net positive suction head required (NPSHR) by the pump. Select the test arrangement and procedure, from the choices provided in HI ANSI/HI 14.6, that best suits the test facility. NPSHR must, 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 must be 0.6 m 2 ft less than the corresponding net positive suction head available (NPSHA). Use the temperature of the water at the time the tests are run in determining the NPSHR. Use the water elevations specified in paragraph CAPACITIES to determine the NPSHA for pumps.

]2.9.3 Instrumentation and Procedures

Describe each instrument 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, include a sketch of the instrument or instrument arrangement. Include a fully detailed narrative description of each proposed method of instrumentation, procedures to be used, and a sample set of computation. State the lowest equivalent static head that is obtainable with the testing when operating along the head-capacity curve of the proposed pump.

#### 2.9.3.1 Head Measurements

Make head measurements using either a direct reading water column, mercury-air, mercury-water, a Meriam fluid manometer, or a pressure transducer. Measure vacuums with either a mercury-air manometer, a mercury-water manometer, or a pressure transducer. Dampen fluctuations sufficiently to permit column 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. Use manometers as indicated by ISA RP2.1. When pressure transducers are used, check their accuracy with a manometer.

#### 2.9.3.2 Pump Capacity

Determine capacity by a calibrated venturi flowmeter or a long-radius ASME flow nozzle. Do not use orifice plates. Connect venturi or nozzle taps to column gauges equipped with dampening devices that permit the differential head to be determined to either the closest 3 mm one-hundredth (0.01) of 1 foot or water or 2.5 mm one-tenth (0.1) of 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.

#### 2.9.3.3 Rotational Speed of Pump

Measure rotational speed of the pump in accordance with measurement of speed in HI ANSI/HI 14.6, except do not use revolution counters. The device used must permit the speed to be determined to 1 rpm.

#### 2.9.3.4 Power Input

Measure power input to the pump in accordance with power measurements in HI ANSI/HI 14.6. use a method to permit kW bhp to be determined to the closest 0.5 bkW 0.5 bhp.

### 2.9.4 Witness Test

Perform factory tests in the presence of the Contracting Officer. When 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. If the tests 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. Provide copies of all data taken during the testing and plotted preliminary curves to the Contracting Officer with the factory test report.

### 2.9.5 Factory Test Report

Submit, within 30 days of receipt of approval of the witnessed factory test,[bound] [digital] copies of a report covering test setup and performance tests. Include the specified information in the factory test report and, as a minimum, the following:

a. Statement of the purpose of the test, name of the project, contract number, and design conditions. Highlight and explain instances where guaranteed values differ from specified values.

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 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. Label all photographic evidence with the contract number, location, date/time, and test activity. Voice annotate digital recordings 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 must 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 must be a step-by-step explanation of operations required, and 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 must 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, completely clean the sump area of any accumulated construction debris. This final cleaning of the sump area will be witnessed by a representative of the Government. Correct any damage to the pumping units or related equipment during initial start-up due to foreign objects left in the sump areas.

## 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, , and inspection of manufacturing quality 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 must 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 been successfully tested. This thorough electrical checkout procedure must follow a detailed step-by-step approved test plan. Also check the motor and other pumping unit elements undergoing tests at this time. Field test the plan prior to field testing.

### 3.3.1 Dry Test

Test each pumping unit in the dry in accordance with the pump manufacturer's instructions to determine whether it has been properly installed. Conduct such test when, and as, directed by Contracting Officer. Operate the pump at full rated speed. If tests reveal a design or installation deficiency or a manufacturing error in pumping unit components, promptly correct the problem.

### 3.3.2 Wet Test

Test each unit under load for a period of at least [_____] hours or as directed by the Contracting Officer. Conduct the tests to be witnessed by the Government. During the tests, observe, measure, and record the operation of the pumping units [noise (in accordance with HI 9.1-9.5),] motor-bearing temperatures, voltage, and current for each pump. Measured parameters must be within the pump manufacturer's published limits. make vibration measurements at the top of the discharge tube [and flange of the discharge elbow] for each pump. Vibration limits must not exceed those recommended by HI 9.6.4.

### 3.3.3 Field Test Report

Prepare and submit the field test report and a manual of Operating and Maintenance Instructions for the completed system. Submit the Instructions containing complete information on operation, lubrication, adjustment, routine and special maintenance disassembly, repair, reassembly, and trouble diagnostics of pump and auxiliary equipment. [Print the operation and maintenance manual and both parts lists on good quality ANSI size A 216 by 280 mm 8-1/2 by 11-inch paper, bound separately between flexible, durable covers.] [Provide the operation and maintenance manual and both parts lists on optical disc, formatted to print on ANSI size A 216 by 280 mm 8-1/2 by 11-inch paper.]Drawings incorporated in manual or parts lists, may be reduced to page size provided they are clear and legible[, or may be folded into the manual to page size]. Photographs or catalog cuts of components may be included for identification.

## 3.4 PAINTING

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

-- End of Section --