
USACE / NAVFAC / AFCEC / NASA UFGS-26 29 01.00 10 (November 2008)

Preparing Activity: USACE

Superseding
UFGS-26 29 01.00 10 (April 2006)

UNIFIED FACILITIES GUIDE SPECIFICATIONS

References are in agreement with UMRL dated July 2022

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DIVISION 26 - ELECTRICAL

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ELECTRIC MOTORS, 3-PHASE VERTICAL INDUCTION TYPE 11/08

NOTE: This guide specification covers the requirements for procurement of 3-phase vertical induction motors for driving storm-water pumps for local flood-control pumping stations. 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 section covers motors with special features of construction which are considered necessary to provide maximum insurance against failures where the motors are to be operated only for short periods of time, at infrequent intervals, and at locations where the average relative humidity of the air is high. Where operating characteristics or features of motor construction differ from this specification but are considered desirable, this specification may be modified accordingly. The designer must also consider unusual service

conditions such as direct exposure to the sun,
vermin infestation, or high altitude.

In adapting this specification to any project, the
form and phraseology will be changed as necessary to
properly specify the work contemplated. When
deviations from this specification are considered
necessary, prior approval from HQ USACE will be
obtained.

1.1 REFERENCES

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

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

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

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

AMERICAN 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

ASTM INTERNATIONAL (ASTM)

ASTM A123/A123M (2017) Standard Specification for Zinc
(Hot-Dip Galvanized) Coatings on Iron and
Steel Products

ASTM A153/A153M (2016a) Standard Specification for Zinc
Coating (Hot-Dip) on Iron and Steel
Hardware

ASTM B344 (2020) Standard Specification for Drawn or
Rolled Nickel-Chromium and
Nickel-Chromium-Iron Alloys for Electrical

Heating Elements

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)

NEMA MG 1

(2016) Motors and Generators - Revision
1: 2018; Includes 2021 Updates to Parts
0, 1, 7, 12, 30, and 31

1.2 SUMMARY

The work under this section includes providing all labor, equipment, and material and performing all operations required to design, manufacture, assemble, test, and package and deliver the vertical induction motors for driving pumps specified under Section 35 45 01 VERTICAL PUMPS, AXIAL-FLOW AND MIXED-FLOW IMPELLER TYPE.

- a. Supply motors complete with all accessories, spare parts, tools, and manufacturer's data and instructions as specified herein.
- b. Submit [6] [_____] copies of complete instructions for the proper installation, inspection, and maintenance of the machines provided for this particular service. Submit to the Contracting Officer not later than the date the equipment is shipped from the manufacturer's plant. Include a cross-sectional drawing indicating the major component parts of the motor and the procedure for disassembly.
- c. Submit [6] [_____] copies of a complete list of renewal parts with prices for each different rating of motor. Include the list along with the instruction manual.

1.3 SUBMITTALS

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

For Army projects, fill in the empty brackets following the "G" classification, with a code of up to three characters to indicate the approving authority. Codes for Army projects using the Resident Management System (RMS) are: "AE" for Architect-Engineer; "DO" for District Office (Engineering Division or other organization in the District Office); "AO" for Area Office; "RO" for Resident Office; and "PO" for Project Office. Codes following the "G" typically are not used for Navy, Air Force, and NASA projects.

The "S" classification indicates submittals required

as proof of compliance for sustainability Guiding Principles Validation or Third Party Certification and as described in Section 01 33 00 SUBMITTAL PROCEDURES.

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

SD-02 Shop Drawings

Motors; G[, [_____]]

SD-03 Product Data

Insulated Windings; G[, [_____]]

Duty Cycle; G[, [_____]]

Motors; G[, [_____]]

Government Study

Spare Parts

SD-06 Test Reports

Starting Capabilities

Factory Tests

SD-07 Certificates

Power Factor and Efficiency

Factory Tests

SD-10 Operation and Maintenance Data

Instructions; G[, [_____]]

1.4 QUALITY ASSURANCE

1.4.1 Corrosion Prevention and Finish Painting

The equipment provided under these specifications will be subjected to severe moisture conditions and must be designed to render it resistant to corrosion from such exposure. The general requirements to be followed to mitigate corrosion are specified below. Any additional special treatment or requirement considered necessary for any individual items is specified under the respective item. However, other corrosion-resisting treatments

that are the equivalent of those specified herein may, with the approval of the Contracting Officer, be used.

1.4.1.1 Fastenings and Fittings

Where practicable, provide corrosion-resistant screws, bolts, nuts, pins, studs, springs, washers, and other similar fittings or treat in an approved manner to render them resistant to corrosion.

1.4.1.2 Corrosion-Resisting Materials

Corrosion-resisting steel, copper, brass, bronze, copper-nickel, and nickel-copper alloys are acceptable corrosion-resisting materials.

1.4.1.3 Corrosion-Resisting Treatments

Perform hot-dip galvanizing in accordance with [ASTM A123/A123M](#) or [ASTM A153/A153M](#) as applicable. Other corrosion-resisting treatments may be used if approved by the Contracting Officer.

1.4.1.4 Frames

Clean motor frames, end bells, covers, conduit boxes, and any other parts, if of steel, and if they will be coated during the process of insulating the windings, of rust, grease, millscale, and dirt, and then treated and rinsed in accordance with manufacturer's standard process. If any of the above-listed parts are not coated during the process of insulating the windings then, in addition to the above, give one coat of primer and then two coats of manufacturer's standard moisture-resistant coating, processed as required.

1.4.1.5 Cores

Thoroughly clean the assembled motor core and then immediately prime by applying a minimum of two coats of a moisture-resisting and oil-resisting insulating compound. Give a minimum of one coat to air gap surfaces.

1.4.1.6 Shafts

Clean exposed surfaces of motor shafts of rust, grease, and dirt and, except for bearing surfaces, give one coat of a zinc molybdate or equivalent primer and two coats of a moisture-proof coating, cure each as required. Shafts of a corrosion-resisting steel may be used in lieu of the above treatment.

1.4.1.7 Finish Painting

NOTE: If severely moist conditions exist, a separate paint system should be specified using Section [09 97 02 PAINTING: HYDRAULIC STRUCTURES](#), system 21, epoxy finish or equivalent. When such painting is specified, care must be taken to specify a paint that will adhere to and not be injurious to the protective painting provided under these specifications.

Finish paint all equipment in accordance with the standard practice or

recommendation of the manufacturer, as approved by the Contracting Officer.

1.4.2 Government Study

NOTE: Item d. may be used only when the pump and
motor are furnished under the same procurement.

Submit [6] [_____] copies of the specified data. Supply to the Government, for completion of its Motor Torque and Accelerating Time Studies (MTATS), the following data:

- a. Complete equivalent circuit data referred to the stator with friction, windage, and stray load losses.
- b. Current, power factor, and torque versus speed (0-100 percent, inclusive, in 1 percent increments up to 95 percent and in 0.1 percent increments above 95 percent) and load (0-125 percent, inclusive, in 25 percent increments) as a function of line voltage (from 80 percent to 110 percent, inclusive, in 5 percent increments), for rated and 90 percent of rated voltage at starter. Only tabulated data will be required.
- c. Load inertia, Wk2 of motor rotating parts, pound-feet.

[d. Load inertia, Wk2 of pump rotating parts (wet), pound-foot2.]

PART 2 PRODUCTS

2.1 NAMEPLATES

Include rated voltage, rated full-load amperes, rated horsepower, service factor, number of phases, RPM at rated load, frequency, code letter, locked-rotor amperes, duty rating, insulation system designation, and maximum ambient design temperature.

2.2 MOTORS

NOTE: For weak source (high thevenin source impedance), the electric utility must be contacted to determine starting restrictions, maximum inrush, or voltage dip limits. This is especially critical for motors over 75kw 100 hp. The designer must then perform a Motor Torque and Accelerating Time Study (MTATS) to evaluate the motor starting torque and voltage dip requirement. The selection of a reduced voltage starter must then be based on the electric utility requirements and the motor pump arrangement.

Supply motors under these specifications that are the vertical shaft type as required by the pump manufacturer, normal or low starting torque, low starting current, squirrel-cage induction type, designed for full voltage starting, of drip-proof construction, and conforming to the applicable requirements of NEMA MG 1, except as hereinafter specified.

- a. Submit [6] [_____] copies of equipment foundation dimensions; outline drawings with weights, nameplate data, and details showing method of mounting and anchoring the motor. Obtain Contracting Officer's approval in writing prior to the commencement of manufacture of motors.
- b. [Six] [_____] copies of complete descriptive specification of each type and size motor provided, with necessary cuts, photographs, and drawings to clearly indicate the construction of the motor, the materials and treatments used to prevent corrosion of parts, bearing construction, and type of insulation used on all windings.
- c. Include all information required for selection of protective and control equipment and for operational setting, such as, but not limited to, normal and maximum operation temperature for windings and bearings, overload trip setting for motor at pump maximum head condition and starting times for starting at rated and 90 percent starter voltage.

2.2.1 Rating

NOTE: NEMA MG 1, Parts 12 and 20, cover medium and large induction motors, respectively. Any motor specified by speed and horsepower will be included in either Part 12 or Part 20. References to both parts are listed in some cases, as either or both parts may apply to a particular project.

Wind each motor for 3-phase, 60-Hz, alternating current, and for the respective operating voltage listed below:

PLANT	PUMP	SERVICE	MOTOR OPERATING VOLTAGE
[_____]	[_____]	[_____]	[_____]
[_____]	[_____]	[_____]	[_____]

Design motor for operation in a 40 degrees C 105 degrees F ambient temperature and all temperature rises must be above this ambient temperature. A rated horsepower of the motor less than 110 percent of the determined maximum load requirement of the pump is not acceptable. Provide motors that have a service factor of 1.0 or apply using a service factor of 1.0 if standard service factor is greater than 1.0. For the temperature rise above the ambient temperature for continuous rated full-load conditions and for the class of insulation used, do not exceed the values given in NEMA MG 1, paragraph 12.42 or paragraph 20.8.

2.2.2 Operating Characteristics

2.2.2.1 Torques

NOTE: The "Operating Characteristics" specified are to limit the locked-rotor current to a value sufficiently low to permit full-voltage starting. Manufacturer's standard is to limit locked-rotor current to 600 percent of design full-load current.

However, if local conditions are such that lower starting current is desirable, the locked-rotor current may be specified not to exceed 500 percent of the design full-load current. When 500 percent is specified, the breakdown torque of 150 percent of full-load torque will be used. The designer will note that these percentages are for design full-load current at rated power factor and will vary based on actual load and supply conditions. Designer should consult local utility for actual requirements for limitations on inrush currents. When inrush current cannot be sufficiently limited by motor design, a reduced voltage starter will be used.

When reduced voltage starting is required, closed transition autotransformer type reduced voltage starters should be used. These starters provide the most flexibility during installation since both input voltage and inrush current may be adjusted. This specification is not meant to limit the selection of a reduced voltage starter to only autotransformer type. The use of a wye-delta type starter may be appropriate in certain situations. The reduced starter cost for use of other than autotransformer type starters must be weighed against the increased cost in motor designs; however each design should be evaluated for the most suitable type starter. All reduced voltage starters will reduce the motor starting torque, so the designer should evaluate the load characteristics to ensure that motor torque will be sufficient under all starting conditions. If reduced-kVA starters are required, EM 1110-2-3105 should be consulted for further guidance and possible pump design considerations.

Provide sufficient starting torque to start the pump to which the motor will be connected under the maximum conditions specified, do not use starting torque less than 60 percent of full-load torque. Breakdown torque less than [200] [150] percent of full-load torque is not permitted.

2.2.2.2 Locked-Rotor Current

NOTE: The locked-rotor current will increase with a power factor or lower than rated load. This information must be taken into account when the designer is specifying the motor. When inrush current is particularly critical, due to system limitations on voltage dip or current, the designer must obtain limits from the local utility and supply this information in this paragraph. The requirements for locked-rotor current (inrush) must be coordinated with power factor and efficiency requirements of for power factor efficiency specified below.

Do not exceed [600] [500] percent of normal full-load running current. [Do not exceed [_____] amps at 90 percent of rated voltage during any point in the starting cycle under worst case starting conditions. For reduced voltage starting, the above criteria applies to supply side of the starter.]

2.2.2.3 Starting Capabilities

NOTE: Frequency of starting must always be considered in motor applications. The starting capabilities to be met by all motors are set forth below. However, the actual motor duty cycle should be specified in paragraph DUTY CYCLE, along with the requirement for the special motor starting nameplate. Undoubtedly, these starting capabilities will be adequate in most cases since the actual load inertia, WK2 of the pumps is much less than the NEMA values, the load torque is low, and the frequency of starting (number of starts per unit of time) is low. When the frequency of starting is several times per hour, or the load torque is high, a thorough study and perhaps a modified motor may be required. To ensure that all requirements of the specifications are met, submittal of the operating data should be required. It is possible that with higher starting frequencies the rotor may have to operate at temperatures higher than typical, so that modifications would be required.

Provide large motors, on the basis of the load torque characteristics and the load inertia Wk2 listed in NEMA MG 1, paragraphs 20.41 and 20.42, that are, as a minimum, capable of making the starts required in NEMA MG 1, paragraph 20.43. Provide smaller motors conforming to the requirements in NEMA MG 1, paragraph 12.50. Submit [6] [_____] copies of certified test reports, when available, of tests previously performed on motors of each type and size specified or calculated data to substantiate the motor's capability to conform to the specified requirements.

2.2.2.4 Duty Cycle

Submit an analysis to verify that the motor, when operated in accordance with the duty cycle specified, will not undergo injurious temperature rise. If the duty cycle cannot be met with a standard NEMA design motor, the motor manufacturer must provide a description of proposed modifications to provide such compliance. Each motor, when operating at rated voltage and frequency and on the basis of the connected pump load inertia Wk2 and the speed-torque characteristics of the load during starting conditions as furnished by the pump manufacturer, must be capable of performing on a continuous basis the following motor duty cycle without injurious temperature rise: [operation at rated load over a period of approximately [_____] [hours] [days]] [a running period at rated load of not less than [_____] [minutes] [hours] and a standstill period of not less than [_____] [minutes] [hours].] Provide a starting information nameplate setting forth the starting capabilities on each motor. Also include the minimum time at standstill and the minimum running time prior to an additional start on the nameplate.

2.2.2.5 Balance

Do not exceed the specified values for balance of each motor when measured in accordance with NEMA MG 1, paragraph 12.06 or paragraph 20.53. Provide motors that meet the provisions of Section 35 45 01 VERTICAL PUMPS, AXIAL-FLOW AND MIXED-FLOW IMPELLER-TYPE paragraph [_____].

2.2.2.6 Noise

NOTE: The Department of Defense (DOD) considers hazardous noise exposure of personnel as equivalent to 85 decibels or greater A-weighted sound pressure level (dBA) for 8 hours in any one 24-hour period. On the assumption that pumping plant operating personnel may be exposed to noise levels approaching or exceeding that defined by the DOD as hazardous, the motor noise limit should be specified not to exceed 85 dBA. The additional cost of providing motors meeting this requirement should be investigated and weighed against an alternate of providing a room to isolate these personnel from the noise exposure.

Operate all motors at a noise level less than 85 decibels A-weighted mean sound pressure level (dBA). Determine noise in accordance with [_____]. The specified noise limit applies for a reference distance of one meter for free-field conditions.

2.2.2.7 Power Factor and Efficiency

NOTE: List power factor and efficiency for each size. Motor efficiencies are not standardized and vary with manufacturer. Efficiency and its associated power factor are primarily a function of load, horsepower rating, and speed. Some general guidelines are as follows:

Operation below - rated low	Decreased efficiency, lower power factor
Higher horsepower - higher power factor	Increased efficiency
Higher speeds - higher power factor	Increased efficiency

For motors above 75 kW 100 hp, efficiency and power factor may not be a consideration since most motors of this size have a rated efficiency of around 90 percent and a power factor of greater than 0.8. When this is the case, delete power factor efficiency requirements from paragraph MOTORS, and the certification requirement in paragraph SUBMITTALS. The designer should consult manufacturer's literature and individual applications for efficiencies and power factor to specify. The designer should also weigh the cost of a more efficient motor vs a larger motor with

increased efficiency due to size. Generic motor data are available which may be used if manufacturer's data are not available.

The power factor and efficiency at full load, 3/4 full load, and 1/2 full load must not be less than [____], [____], [____] and [____], [____], [____], respectively. Motors will be rejected if factory tests specified in paragraph FACTORY TESTS do not demonstrate that these values will be met or exceeded. Submit certification of guaranteed value of power factor and efficiency for full load, 3/4 full load, and 1/2 full load.

2.2.3 Frames and Brackets

Provide cast iron, cast steel, or welded steel frames and end brackets. Build the mounting ring, unless otherwise approved, integral with the frame or lower end bracket and arranged for direct mounting on the pump, or station floor, or as required by the installation conditions. Treat against corrosion as specified in paragraph GENERAL REQUIREMENTS.

2.2.3.1 Stator Frame

Provide rigid stator frame that is sufficiently strong to support the weight of the upper bearing bracket load, the weight of the stator core and windings, and to sustain the operating torques without perceptible distortion. Support the stator frame, if not direct mounted on the pump, on a motor base or drive pedestal which in turn will be supported on sole plates or other suitable structure installed in the concrete foundation constructed as part of the pumping station structure. Provide the motor base or drive pedestal with bolts and dowels for fastening to the sole plates or supporting structure for preserving the alignment.

2.2.3.2 Supporting Bracket

Provide upper bracket supporting the thrust bearing and upper guide bearings of sufficient strength and rigidity to support the weight of the entire rotating element of the motor, together with the pump impeller and shaft, and the hydraulic thrust of the pump impeller.

2.2.3.3 Overspeed Alternate

NOTE: NEMA MG 1 paragraphs 12.48 and 20.44 specify that overspeeds are for emergencies lasting no longer than one minute. Using this option will insure additional costs due to requirements well beyond standard limits.

Design each motor to withstand indefinitely, without injury, the maximum overspeed to which the motor will be subjected when the pump to which it is connected is acting as a hydraulic turbine under the maximum head with the pump discharge pipe open.

2.2.3.4 Antireverse Device Alternate

Install a self-actuated backstop device or antireversing ratchet, to prevent reverse rotation of the pump due to loss of power or failure of the electric prime mover, as an integral part of the motor. Submit the

design of the device to the Contracting Officer for approval. Provide sufficient capacity to prevent reverse rotation with a back-flow through the pump due to a [_____] foot differential head. If the device requires a lubrication system, provide an oil reservoir independent of the one used for the thrust bearing and complete with visible oil level gauge and 120-volt a.c. rated high and low level contacts. Terminate all electrical leads in the accessory terminal box specified in paragraph MOTOR TERMINALS AND BOXES. Provide lubricant for the antireverse device containing a corrosion inhibitor whose type and grade is shown on a special nameplate attached to the frame adjacent to the lubricating filling device.

2.2.3.5 Eyebolts

Provide eyebolts, lugs, or other approved means for assembling, dismantling, and removing the motor, if required, from above using an overhead crane. Provide all lifting devices required for use in conjunction with the crane with the motor.

2.2.4 Cores

Build up the cores for the stators and rotors of separately punched thin laminations of low-hysteresis loss, nonaging, annealed, electrical silicon steel, assembled under heavy pressure, and clamped in such a manner as to insure that the assembled core is tight at the top of the teeth of the laminated core. Properly insulate laminations from each other. Only use laminations free from burrs, and take care to remove all burrs or projecting laminations from the slots of the assembled cores. Key, dovetail, or otherwise secure cores to the shaft or frame in an approved manner. Treat against corrosion as specified in paragraph GENERAL REQUIREMENTS.

2.2.5 Insulated Windings

NOTE: If motor temperature rise is of particular concern, the designer may specify Class F insulation with a Class B temperature rise instead of Class F insulation with 110 percent continuous overload factor. Use final sentence of item f. only when the pump and motor are furnished under the same procurement.

Furnish motors that have a nonhygroscopic, sealed, fungus-resisting insulation of a type designed and constructed to withstand severe moisture conditions, and insofar as practicable, to operate after long periods of idleness without previous drying out. Provide sealed windings and connections defined in NEMA MG 1 paragraph 1.27.2. Submit a detailed description of and specification for the manufacturing process, submit the materials and the insulating varnish or compound used in insulating the windings to the Contracting Officer for approval before manufacture of the motors is commenced. If, in the opinion of the Contracting Officer, the insulation proposed is not of the quality specified and if the methods of manufacture are not considered to be in accordance with best modern practice, the motors will not be accepted. Submit [6] [_____] copies of motor design curves and [6] [_____] copies of motor speed-torque curves, as specified. Completely assemble insulated windings, unless otherwise approved, in the motor core before impregnating with the insulating compound. Furnish 100 percent solid resin compound.

- a. Impregnate the windings with the insulating compound by vacuum impregnation method followed by baking. Repeat the procedure as often as necessary to fill in and seal over the interstices of the winding, but in no case must the number of dips and bakes be less than two dips and bakes when the vacuum method of impregnation is used. Provide completed stator that is capable of passing the submerged or sprayed water test, as applicable, required by NEMA MG 1 paragraph 20.49.
- b. Random wound coils may be used on motors supplied in NEMA frame size 445 TP and smaller. The components of the insulation system and the conductor insulation of the coils must be Class F insulation with a 110 percent continuous overload factor as defined in NEMA MG 1 paragraph 1.66. After winding, encapsulate the completely wound stator with an insulating resin as defined in NEMA MG 1 paragraph 1.27.1.
- c. Use form wound coils on motors supplied in NEMA frames larger than 445 TP. Provide components of the insulation system and coil insulation of the rectangular conductors conforming to Class F insulation with a 110 percent continuous overload factor as defined in NEMA MG 1, paragraph 1.66. The completed stator windings and connections must be of the sealed type as defined in NEMA MG 1 paragraph 1.27.2.
- d. Process insulation to ground on the coil. Slot tubes or cells are not acceptable. Provide insulation of adequate thickness and breakdown strength throughout the length of the coil. Use mica in the slot portion of adequate thickness to withstand the dielectric tests specified in paragraph FACTORY TESTS. Provide uniform form wound coils such that the stator windings on motors of equal ratings are alike, in shape and size, and are interchangeable.
- e. Submit motor design (characteristic) curves or tabulated data (test or calculated), indicating the speed, power factor, efficiency, current, and kilowatt input, all plotted or tabulated against torque or percent load as abscissa. Give the base value whether ANSI or IEEE standard system is used. Also provide the maximum allowable reverse rotation speed for the motor.
- f. Submit [pump and] motor speed-torque curves for the pump starting operation. Plot the motor speed-torque curves for the following values of voltage at the motor terminals: The output of the [closed transition auto-transformer-type reduced voltage] [_____] starter supplied at rated and 90 percent of rated motor voltage [and connected on its 65 percent and 80 percent taps]. [Plot the pump torque curve for starting and accelerating against maximum head. Furnish computations to demonstrate that the motor furnished will carry the pump load under all the foregoing conditions.]
- g. Fully brace coils of all windings so that vibration is virtually eliminated during repeated starts as required by the duty cycle specified as well as during normal operation. If a tied system is used, no tie is dependent upon the integrity of any other tie within the system.

2.2.6 Thermal Protection

For motors rated 500 hp or greater, provide resistance temperature detectors (two per phase) in accordance with NEMA MG 1, paragraph 20.63.

Provide detectors that have a copper resistance element having a resistance of 10 ohms at 25 degrees C 76 degrees F. Terminate leads on the terminal blocks specified in paragraph MOTOR TERMINALS AND BOXES. For motors rated less than 500 hp, embed positive-temperature-coefficient thermistors (one per phase) in the windings. Provide thermistors with all necessary additional equipment, as required, that open a normally closed contact when the critical temperature is reached. Terminate all outgoing wiring on the terminal blocks specified in paragraph MOTOR TERMINALS AND BOXES.

2.2.7 Winding Heaters

NOTE: The inclusion or omission of "Winding Space Heaters" will depend upon the decision reached after giving due consideration to the problem of prevention of moisture condensation on the station equipment. If winding space heaters are not required, this paragraph, including all subparagraphs, must be deleted.

Wrap heaters around the winding end turns. Designate for operation on 120 volts, 1-phase, 60 Hz, alternating current and of sufficient capacity or wattage that, when energized, they will hold the temperature of the motor windings approximately 10 degrees C above the ambient temperature. Design for continuous operation and to withstand at least 10 percent overvoltage continuously. Maintain uniform rate of heat dissipation throughout the effective length of the heater. Install heaters around the winding end turns consisting of the required turns of heating cable wrapped around the end turns and secured in place before the winding is impregnated.

2.2.7.1 Heating Element

Provide heating element conforming to the requirements of ASTM B344 for an 80 percent nickel and 20 percent chromium alloy.

2.2.7.2 Sheath

Provide sheath consisting of a corrosion-resisting, nonoxidizing metal and a wall thickness not less than 0.625 mm 0.025 inch.

2.2.7.3 Insulation

Provide insulation consisting of a granular mineral refractory material, highly resistant to heat, and has a minimum specific resistance of 1,000 megohms per inch cubed at 535 degrees C 1,000 degrees F. Provide insulation for the heating cable (winding wraparound type) type heaters that is suitable for a conductor temperature of 180 degrees C 356 degrees F.

2.2.7.4 Terminals

Provide watertight terminals of the heater, including the leads, and provide with leads suitable for making connections to the drip-proof terminal box provided in paragraph MOTOR TERMINALS AND BOXES. [Furnish terminal box that is readily accessible through the crating so that winding heaters can be energized while motors are in storage.]

2.2.8 Shafts

NOTE: Hollow shaft pumps must be used whenever possible, since they are more readily adjusted. Pumps requiring large motors (above 746 kW 1,000 hp) are limited by the available motors. The exact motor capabilities and sources of supply must be investigated when using hollow shafts with motors above 746 kW 1,000 hp. Solid shafts must be used only when the available motor designs require their use.

Make shafts of high grade steel, finished all over, and of ample size to drive the pumps under maximum load conditions. Provide [hollow] [solid] shafts as required by the pump manufacturer. See paragraph GENERAL REQUIREMENTS for treatment against corrosion.

2.2.9 Bearings

2.2.9.1 Loading

Bearings must be capable of withstanding all stresses incidental to the normal operation of the unit [and the maximum speed of the pumping unit when operating in the reverse direction].

2.2.9.2 Thrust Bearings

NOTE: If the thrust requirements exceed the standard published ratings of commercially available anti-friction thrust bearings, plate-type bearings should be used. Should this condition exist, a specification for plate-type bearings may be obtained from CDR USACE (DAEN-CWE-E) WASH DC 20314.

Thrust bearings must be of the antifriction type of either the ball or roller type. Do not use tandem or series bearing assemblies. Provide antifriction bearings conforming to the requirements of ABMA 9 and ABMA 11.

2.2.9.3 Guide Bearings

Guide bearings must be of the sleeve or antifriction type of either the ball or roller type or a combination of sleeve and antifriction bearings.

2.2.9.4 Lubrication

Provide either oil or grease lubricated bearings and use lubricant containing a corrosion inhibitor. Show type and grade of lubricant used on a special nameplate attached to the frame of the motor adjacent to the bearing lubricant filling device. In addition to the quantity of lubricant required to fill the system initially, provide spare lubricant in sufficient quantity to purge and refill the system.

2.2.9.5 Housings

Design and assemble bearing housings that will permit ready removal of the

bearings, prevent escape of lubricant and entrance of foreign matter, and protected by the lubricant when the motor is idle. Except for prelubricated antifriction bearings of an approved type, provide suitable means to apply and drain the lubricant. Provide oil-lubricated bearing housings with oil-level indicator gauges that will be readily visible.

2.2.9.6 Cooling

Provide self-cooling bearings unless otherwise specifically approved by the Contracting Officer. If the use of cooling is approved, employ means that, unless otherwise approved by the Contracting Officer, require no auxiliary pumping equipment; and provide suitable means to indicate the bearing temperature, actuate an alarm when the bearing temperature is above normal, and actuate a device to shut down the motor when the maximum safe operating temperature of the bearing is reached. Provide copper cooling coils of copper tubing and design for the operating pressure used to circulate the cooling water. Cooling water temperature will be [_____] degrees C.

2.2.9.7 Rating

Rate antifriction bearings on the basis of a minimum life factor of 8,800 hours, based on the life expectancy of 90 percent of the group, unless otherwise approved by the Contracting Officer.

2.2.9.8 Shaft Currents

Insulate bearings or otherwise protect against the damaging effects of shaft currents.

2.3 SURGE PROTECTION

2.3.1 Surge Capacitors

NOTE: To obtain the most reliable protection for 2,300- and 4,000-volt motors, surge capacitors and arresters, mounted at the motor terminals, should be specified. In addition, it is recommended that station-type arresters be installed on the line side of the supply transformers. For 480-volt systems, surge protection is not generally warranted if the station system is connected to the utility line through a transformer which has adequate surge protection on the high side. Each 480-volt installation should be investigated, however, to determine whether surge protection is required, especially where excessive switching voltages may occur or where the lightning incidence rate is high.

Provide a three-pole capacitor unit, equipped with built-in discharge resistors and using a non-polychlorinated biphenyl (PCB) insulating medium, in the main terminal box. Rate each pole [0.5 microfarad and [2,400] [4,160] volts line-to-line] [1.0 microfarad and 650 volts line-to-line]. Provide removable bus links for motor testing. Treat these links to resist corrosion, design to maintain a positive contact, and have low contact resistance.

2.3.2 Surge Arresters

NOTE: Arrester maximum continuous operating voltage (MCOV) rating must be 3,000 volts line-to-ground for 2,400-volt systems and for effectively grounded 4,160-volt systems, 4,500 volts line-to-ground operating voltage for ungrounded or resistance-grounded 4,160-volt systems, or other ratings as required. An effectively grounded system is defined as one in which X_0/X_1 is positive and less than 3 and R_0/X_1 must be positive and less than 1 for all system conditions at the point of application of the surge arrester.

Provide surge arresters of the station type with porcelain tops in the main terminal box. Provide metal-oxide arresters rated [3,000] [4,500] [_____] volts maximum continuous operating voltage (MCOV) line-to-ground. Provide removable bus links for motor testing. Treat these links to resist corrosion, design to maintain a positive contact, and have low contact resistance.

2.3.3 Space Heater

If recommended by the surge protection manufacturer, provide a space heater of adequate capacity and rated 120 volts. Provide space heaters that have a maximum watt density of 20 watts per square inch.

2.4 MOTOR TERMINALS AND BOXES

2.4.1 Stator Terminal Box

Supply drip-proof cast iron or steel conduit terminal boxes, treated as specified for frames in paragraph GENERAL REQUIREMENTS, for housing the stator lead connections [surge capacitors] [and surge arresters] and that have adequate space to facilitate the installation and maintenance of cables and equipment. Furnish boxes that have a [bolted] [hinged securable] cover providing unrestricted access, are mounted on the motor frame, and have an auxiliary floor supporting structure, when required, supplied by the motor manufacturer. Enter conduit from the bottom. Design boxes to permit removal of motor supply leads when the motor is removed. [Provide a "HIGH VOLTAGE - [_____] VOLTS" warning sign on the cover of the box.] [When looking down on the motor/pump assembly, locate the terminal box between degrees and degrees clockwise from the discharge elbow of the pump.]

2.4.2 Stator Terminals

Apply a treatment equal to that of the motor winding to insulated terminal leads. Bring leads out of the stator frame and provide with terminal lugs for connection to the motor supply wiring.

2.4.3 Grounding

Provide a ground bus and means for external connection to the station grounding system in the stator terminal box when surge protection is provided.

2.4.4 Accessory Leads and Boxes

Bring terminal leads for motor winding space heaters, [surge protection equipment space heater], [resistance temperature detectors] [thermistors] and any other auxiliary equipment into conveniently located terminal boxes provided with terminal blocks for extension by others. Provide drip-proof terminal boxes and treat as specified for frames in paragraph GENERAL REQUIREMENTS. Provide auxiliary wiring consisting of stranded copper conductors with 600-volt flame-retardant insulation, except temperature detector leads may be in accordance with the manufacturer's standard practice. Properly identify all wiring and terminals.

2.5 WRENCHES, TOOLS, AND SPECIAL EQUIPMENT

Provide all nonstandard and special equipment required for dismantling, reassembly, and general maintenance of the motor units. Provide one complete set of lifting attachments such as detachable eyebolts or special slings for handling various parts with a hoist.

2.6 FACTORY TESTS

NOTE: The designer should carefully consider whether to allow the Contracting Officer to waive these tests. Decision should be based on expertise in the field within the Division or District.

Give a complete test of one motor of each rating type, selected at random by the Contracting Officer. Give the remainder of the motors check test.

- a. Submit [6] [_____] copies of test reports recording all data obtained during the tests specified to the Contracting Officer for each motor used. Include performance curves indicating the results of subparagraph COMPLETE TEST below.
- b. Submit [6] [_____] certified copies of the results of a "Complete Test" for duplicate equipment. It will be accepted in lieu of the "Complete Test" as specified in subparagraph COMPLETE TEST below for equipment of the respective rating and type.
- c. No substitute will be accepted for the "Check Test." Give the base value whether ANSI or IEEE standard system is used. All complete tests must be [witnessed by the Contracting Officer] [waived in writing].

2.6.1 Complete Test

Include the following:

2.6.1.1 Excitation Test

Including a plot of volts as abscissa versus amperes and watts as ordinates.

2.6.1.2 Impedance Test

Including a plot of volts as abscissa versus amperes and watts as ordinates.

2.6.1.3 Performance Test

Including a plot of torque or percent load as abscissa versus efficiency, power factor, amperes, watts, and RPM or percent slip as ordinates.

2.6.1.4 Speed-Torque Test

Prony brake or other equivalent method. Including a plot of torque in foot-pounds as abscissa versus speed in RPM as ordinate.

2.6.1.5 Temperature Test

Made on completion of paragraph c above. (If screens are provided over openings, test will be made with screens removed and by thermometer).

2.6.1.6 Insulation Resistance-Temperature Test

Take following heat run, readings being taken at approximately 10 degrees C intervals. Determine temperature by the resistance method. Plot test result values on semilogarithmic graphs, the insulation resistance values as logarithmic ordinates and the temperature values as uniform abscissas. For comparison purposes, plot a curve indicating the safe operating value of insulation resistance on the same sheet with the insulation resistance-temperature test curve.

2.6.1.7 Cold and Hot Resistance Measurement

2.6.1.8 Dielectric Test

2.6.1.9 Sound Level Test

In accordance with [_____].

2.6.1.10 Vibration Measurement

In accordance with NEMA MG 1 paragraph 20.54.

2.6.1.11 Conformance Tests

In accordance with NEMA MG 1 paragraph 20.47.

2.6.2 Check Test

Include the following:

2.6.2.1 Routine Test

Test in accordance with NEMA MG 1 paragraph 12.51 or NEMA MG 1 paragraph 20.47.

2.6.2.2 Cold Resistance Measurement

2.6.2.3 Insulation Resistance and Winding Temperature

Insulation resistance and winding temperature at time the insulation resistance was measured.

2.6.2.4 Conformance Test

In accordance with NEMA MG 1 paragraph 20.47.

2.6.2.5 Vibration

Vibration measurement in accordance with NEMA MG 1 paragraph 12.07 or NEMA MG 1 paragraph 20.54.

2.6.3 Form Wound Coil Test

Test all form wound coils, either before or after they are placed in the slots, for short circuits between turns of the individual coils by applying a high frequency voltage of not less than 75 percent of the voltage for which the machine is insulated, or by applying a surge test voltage of equivalent value to the terminals of each coil. Equivalent surge voltage must be a wave whose peak value is equal to 1.06 times the voltage for which the motor is insulated.

2.6.4 Winding Space Heater Test

NOTE: Include this test only where winding space
heaters are specified.

Test each winding space heater unit at the factory for successful operation and dielectric strength.

PART 3 EXECUTION

NOT USED

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