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UNIFIED FACILITIES GUIDE SPECIFICATIONS

References are in agreement with UMRL dated January 2022
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SECTION TABLE OF CONTENTS

DIVISION 26 - ELECTRICAL

SECTION 26 29 01.00 10

ELECTRIC MOTORS, 3-PHASE VERTICAL INDUCTION TYPE

11/08

PART 1 GENERAL

1.1 REFERENCES
1.2 SUMMARY
1.3 SUBMITTALS
1.4 QUALITY ASSURANCE
1.4.1 Corrosion Prevention and Finish Painting
1.4.1.1 Fastenings and Fittings
1.4.1.2 Corrosion-Resisting Materials
1.4.1.3 Corrosion-Resisting Treatments
1.4.1.4 Frames
1.4.1.5 Cores
1.4.1.6 Shafts
1.4.1.7 Finish Painting
1.4.2 Government Study

PART 2 PRODUCTS

2.1 NAMEPLATES
2.2 MOTORS
2.2.1 Rating
2.2.2 Operating Characteristics
2.2.2.1 Torques
2.2.2.2 Locked-Rotor Current
2.2.2.3 Starting Capabilities
2.2.2.4 Duty Cycle
2.2.2.5 Balance
2.2.2.6 Noise
2.2.2.7 Power Factor and Efficiency
2.2.3 Frames and Brackets
2.2.3.1 Stator Frame
2.2.3.2 Supporting Bracket
2.2.3.3 Overspeed Alternate
2.2.3.4 Antireverse Device Alternate

2.2.3.5 Eyebolts
2.2.4 Cores
2.2.5 Insulated Windings
2.2.6 Thermal Protection
2.2.7 Winding Heaters
2.2.7.1 Heating Element
2.2.7.2 Sheath
2.2.7.3 Insulation
2.2.7.4 Terminals
2.2.8 Shafts
2.2.9 Bearings
2.2.9.1 Loading
2.2.9.2 Thrust Bearings
2.2.9.3 Guide Bearings
2.2.9.4 Lubrication
2.2.9.5 Housings
2.2.9.6 Cooling
2.2.9.7 Rating
2.2.9.8 Shaft Currents
2.3 SURGE PROTECTION
2.3.1 Surge Capacitors
2.3.2 Surge Arresters
2.3.3 Space Heater
2.4 MOTOR TERMINALS AND BOXES
2.4.1 Stator Terminal Box
2.4.2 Stator Terminals
2.4.3 Grounding
2.4.4 Accessory Leads and Boxes
2.5 WRENCHES, TOOLS, AND SPECIAL EQUIPMENT
2.6 FACTORY TESTS
2.6.1 Complete Test
2.6.1.1 Excitation Test
2.6.1.2 Impedance Test
2.6.1.3 Performance Test
2.6.1.4 Speed-Torque Test
2.6.1.5 Temperature Test
2.6.1.6 Insulation Resistance-Temperature Test
2.6.1.7 Cold and Hot Resistance Measurement
2.6.1.8 Dielectric Test
2.6.1.9 Sound Level Test
2.6.1.10 Vibration Measurement
2.6.1.11 Conformance Tests
2.6.2 Check Test
2.6.2.1 Routine Test
2.6.2.2 Cold Resistance Measurement
2.6.2.3 Insulation Resistance and Winding Temperature
2.6.2.4 Conformance Test
2.6.2.5 Vibration
2.6.3 Form Wound Coil Test
2.6.4 Winding Space Heater Test

PART 3 EXECUTION

-- End of Section Table of Contents --

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SECTION 26 29 01.00 10

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

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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.

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

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 (2018) Motors and Generators

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. These motors shall be supplied 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. Instruction manuals shall be submitted to the Contracting Officer not later than the date the equipment is shipped from the manufacturer's plant. The instructions shall 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. This list shall accompany 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 shall 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, all screws, bolts, nuts, pins, studs, springs, washers, and other similar fittings shall be of corrosion-resisting material or shall be treated 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

Hot-dip galvanizing shall be 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

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, shall be cleaned 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, they shall be given one coat of primer and then two coats of manufacturer's standard moisture-resistant coating, processed as required.

1.4.1.5 Cores

The assembled motor core shall be thoroughly cleaned and then immediately primed by applying a minimum of two coats of a moisture-resisting and oil-resisting insulating compound. Air gap surfaces shall be given a minimum of one coat.

1.4.1.6 Shafts

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

1.4.1.7 Finish Painting

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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.

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Finish painting of all equipment shall be in accordance with the standard practice or recommendation of the manufacturer, as approved by the

Contracting Officer.

1.4.2 Government Study

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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-foots.

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

PART 2 PRODUCTS

2.1 NAMEPLATES

Nameplate data shall 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

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NOTE: For weak source (high thevenin source impedance), the electric utility shall be contacted to determine starting restrictions, maximum inrush, or voltage dip limits. This is especially critical for motors over 75kW 100 hp. The designer shall 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 shall then be based on the electric utility requirements and the motor pump arrangement.
****

The motors to be supplied under these specifications shall be of 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 shall conform 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. Contracting Officer's approval shall be obtained 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. Submittal shall 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

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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.

****

Each motor shall be wound for 3-phase, 60-Hz, alternating current, and for the respective operating voltage listed below:

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

The motor shall be designed for operation in a 40 degrees C 105 degrees F ambient temperature and all temperature rises shall be above this ambient temperature. The rated horsepower of the motor shall be not less than 110 percent of the determined maximum load requirement of the pump. Motors shall have a service factor of 1.0 or shall be applied using a service factor of 1.0 if standard service factor is greater than 1.0. The temperature rise above the ambient temperature for continuous rated full-load conditions and for the class of insulation used shall 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

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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.

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Starting torque shall be sufficient to start the pump to which the motor will be connected under the maximum conditions specified, but in no case shall the starting torque be less than 60 percent of full-load torque. Breakdown torque shall be not less than [200] [150] percent of full-load torque.

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 shall 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 shall obtain limits from the local utility and supply this information in this paragraph. The requirements for locked-rotor current (inrush) shall be coordinated with power factor and efficiency requirements of for power factor efficiency

specified below.
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The locked-rotor current shall not exceed [600] [500] percent of normal full-load running current. [The locked-rotor current shall 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 shall apply to supply side of the starter.]

2.2.2.3 Starting Capabilities

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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.
****

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, shall as a minimum be capable of making the starts required in NEMA MG 1, paragraph 20.43. Smaller motors shall conform 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 shall 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, shall 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].] A starting information nameplate setting forth the starting capabilities shall be provided on each motor. This nameplate shall also include the minimum time at standstill and the minimum running time prior to an additional start.

2.2.2.5 Balance

The balance for each motor when measured in accordance with NEMA MG 1, paragraph 12.06 or paragraph 20.53, shall not exceed the values specified. Each motor's characteristics shall be such that the provisions of Section 35 45 01 VERTICAL PUMPS, AXIAL-FLOW AND MIXED-FLOW IMPELLER-TYPE paragraph [_____] are met.

2.2.2.6 Noise

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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.

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All motors shall operate at a noise level less than 85 decibels A-weighted mean sound pressure level (dBA). Noise shall be determined 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

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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 shall be not 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

Frames and end brackets shall be of cast iron, cast steel, or welded steel. The mounting ring, unless otherwise approved, shall be built 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. Treatment against corrosion shall be as specified in paragraph GENERAL REQUIREMENTS.

2.2.3.1 Stator Frame

The stator frame shall be rigid and 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. The stator frame, if not direct mounted on the pump, shall be supported 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. The motor base or drive pedestal shall be provided with bolts and dowels for fastening to the sole plates or supporting structure for preserving the alignment.

2.2.3.2 Supporting Bracket

The upper bracket supporting the thrust bearing and upper guide bearings shall have 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

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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.
****

Each motor shall be designed 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

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, shall be installed as an integral part of the motor. The design of the device shall be submitted to and approved by the Contracting Officer. It shall have 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, 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 shall be provided. All electrical leads shall be terminated in the accessory terminal box specified in paragraph MOTOR TERMINALS AND BOXES. The lubricant for the antireverse device shall contain a corrosion inhibitor whose type and grade shall be shown on a special nameplate attached to the frame adjacent to the lubricating filling device.

2.2.3.5 Eyebolts

Eyebolts, lugs, or other approved means shall be provided for assembling, dismantling, and removing the motor, if required, from above using an overhead crane. All lifting devices required for use in conjunction with the crane shall be provided with the motor.

2.2.4 Cores

The cores for the stators and rotors shall be built up 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. Laminations shall be properly insulated from each other. Only laminations free from burrs shall be used, and care shall be taken to remove all burrs or projecting laminations from the slots of the assembled cores. Cores shall be keyed, dovetailed, or otherwise secured to the shaft or frame in an approved manner. Treatment against corrosion shall be as specified in paragraph GENERAL REQUIREMENTS.

2.2.5 Insulated Windings

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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.

****

All motors shall 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. All windings and connections shall be of the sealed type as defined in NEMA MG 1 paragraph 1.27.2. Submit a detailed description of and specification for the manufacturing process, the materials and the insulating varnish or compound used in insulating the windings shall be submitted 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. Insulated windings, unless otherwise approved, shall be completely assembled in the motor core before impregnating with the insulating compound. The compound shall consist of 100 percent solid resin.

a. Impregnation of the windings with the insulating compound shall be by vacuum impregnation method followed by baking. The procedure shall be repeated as often as necessary to fill in and seal over the interstices of the winding, but in no case shall the number of dips and bakes be less than two dips and bakes when the vacuum method of impregnation is used. The completed stator shall be of a type 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 shall be Class F insulation with a 110 percent continuous overload factor as defined in NEMA MG 1 paragraph 1.66. After winding, the completely wound stator shall be encapsulated with an insulating resin as defined in NEMA MG 1 paragraph 1.27.1.

c. Form wound coils shall be used on motors supplied in NEMA frames larger than 445 TP. The components of the insulation system and the coil insulation of the rectangular conductors shall conform 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 shall be of the sealed type as defined in NEMA MG 1 paragraph 1.27.2.

d. Insulation to ground shall be processed on the coil. Slot tubes or cells are not acceptable. The insulation shall be of adequate thickness and breakdown strength throughout the length of the coil. Mica shall be used in the slot portion and shall be of adequate thickness to withstand the dielectric tests specified in paragraph FACTORY TESTS. Form wound coils shall be of such uniformity that the stator windings on motors of equal ratings shall be alike, in shape and size, and be 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. The base value shall be given whether ANSI or IEEE standard system is used. The maximum allowable reverse rotation speed for the motor shall also be provided.

f. Submit [pump and] motor speed-torque curves for the pump starting operation. The motor speed-torque curves shall be plotted 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]. [The pump torque curve shall be plotted for starting and accelerating against maximum head. Computations shall be furnished to demonstrate that the motor furnished will carry the pump load under all the foregoing conditions.]

g. Coils of all windings shall be fully braced 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 it shall be such that no tie depends upon the integrity of any other tie within the system.

2.2.6 Thermal Protection

For motors rated 500 hp or greater, resistance temperature detectors (two per phase) shall be provided in accordance with NEMA MG 1, paragraph 20.63. Detectors shall have a copper resistance element having a resistance of 10 ohms at 25 degrees C 76 degrees F. Leads shall be terminated on the terminal blocks specified in paragraph MOTOR TERMINALS AND BOXES. For motors rated less than 500 hp, positive-temperature-coefficient thermistors (one per phase) shall be embedded in the windings. The thermistors with all necessary additional equipment, as required, shall open a normally closed contact when the critical temperature is reached. All outgoing wiring shall terminate on the terminal blocks specified in paragraph MOTOR TERMINALS AND BOXES.

2.2.7 Winding Heaters

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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, shall be deleted.

****

Heaters shall be wrapped around the winding end turns. They shall be designated 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. They shall be designed for continuous operation and to withstand at least 10 percent overvoltage continuously. The rate of heat dissipation shall be uniform throughout the effective length of the heater. Heaters installed around the winding end turns shall consist 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

Heating element shall conform to the requirements of ASTM B344 for an 80 percent nickel and 20 percent chromium alloy.

2.2.7.2 Sheath

Sheath shall be of a corrosion-resisting, nonoxidizing metal and shall have a wall thickness not less than 0.625 mm 0.025 inch.

2.2.7.3 Insulation

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

2.2.7.4 Terminals

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

2.2.8 Shafts

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NOTE: Hollow shaft pumps shall 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 shall be investigated when using hollow shafts with motors above 746 kW 1,000 hp. Solid shafts shall be used only when the available motor designs require their use.

****

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

2.2.9 Bearings

2.2.9.1 Loading

Bearings shall 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

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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.

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Thrust bearings shall be of the antifriction type of either the ball or roller type. Tandem or series bearing assemblies shall not be used. Antifriction bearings shall conform to the requirements of ABMA 9 an d ABMA 11.

2.2.9.3 Guide Bearings

Guide bearings shall 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

Bearings shall be either oil or grease lubricated and the lubricant used shall contain a corrosion inhibitor. Type and grade of lubricant used shall be shown on a special nameplate which shall be 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, spare lubricant shall be provided in sufficient quantity to purge and refill the system.

2.2.9.5   Housings

Bearing housings shall be of a design and method of assembly 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, suitable means shall be provided to apply and drain the lubricant. Oil-lubricated bearing housings shall be provided with oil-level indicator gauges that will be readily visible.

2.2.9.6   Cooling

All bearings shall be self-cooling unless otherwise specifically approved by the Contracting Officer. If the use of cooling is approved, the means employed shall, unless otherwise approved by the Contracting Officer, require no auxiliary pumping equipment; and suitable means shall be provided 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. Cooling coils shall be of copper tubing and designed for the operating pressure used to circulate the cooling water. Cooling water temperature will be [_____] degrees C.

2.2.9.7   Rating

Antifriction bearings shall be rated 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

Bearings shall be insulated or otherwise protected against the damaging effects of shaft currents.

2.3   SURGE PROTECTION

2.3.1   Surge Capacitors

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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.
****

A three-pole capacitor unit, equipped with built-in discharge resistors and using a non-polychlorinated biphenyl (PCB) insulating medium, shall be provided in the main terminal box. Each pole shall be rated [0.5 microfarad and [2,400] [4,160] volts line-to-line] [1.0 microfarad and 650 volts line-to-line]. Removable bus links shall be provided for motor testing. These links shall be treated to resist corrosion, shall be designed to maintain a positive contact, and shall have low contact resistance.

2.3.2 Surge Arresters

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NOTE: Arrester maximum continuous operating voltage (MCOV) rating shall 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 X0/X1 is positive and less than 3 and R0/X1 must be positive and less than 1 for all system conditions at the point of application of the surge arrestor.
****

Surge arresters of the station type with porcelain tops shall be provided in the main terminal box. The arresters shall be of the metal-oxide type rated [3,000] [4,500] [_____] volts maximum continuous operating voltage (MCOV) line-to-ground. Removable bus links shall be provided for motor testing. These links shall be treated to resist corrosion, shall be designed to maintain a positive contact, and shall have low contact resistance.

2.3.3 Space Heater

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

2.4 MOTOR TERMINALS AND BOXES

2.4.1 Stator Terminal Box

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

2.4.2 Stator Terminals

Insulated terminal leads shall receive a treatment equal to that of the motor winding. Leads shall be brought out of the stator frame and shall be provided with terminal lugs for connection to the motor supply wiring.

2.4.3 Grounding

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

2.4.4 Accessory Leads and Boxes

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

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

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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.
****

One motor of each rating type, selected at random by the Contracting Officer, shall be given a complete test. The remainder of the motors shall be given a 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. Test reports shall 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." The base value shall be given whether ANSI or IEEE standard system is used. All complete tests shall be [witnessed by the Contracting Officer] [waived in writing].

2.6.1 Complete Test

A complete test of a motor shall 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

Shall be taken following heat run, readings being taken at approximately 10 degrees C intervals. Temperature shall be determined by the resistance method. Test result values shall be plotted on semilogarithmic graphs, the insulation resistance values as logarithmic ordinates and the temperature values as uniform abscissas. For comparison purposes, a curve indicating the safe operating value of insulation resistance shall be plotted 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

A check test of a motor shall 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

All form wound coils, either before or after they are placed in the slots, shall be tested 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 shall 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

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

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Each winding space heater unit shall be tested at the factory for successful operation and dielectric strength.

PART 3 EXECUTION

NOT USED

... -- End of Section --