

DIVISION 16 – ELECTRICAL
SECTION 16220 – MOTORS

PART 1 – GENERAL

1.01 SECTION INCLUDES

- A. Electric motors for use on ac power systems up to 600 volts.
- B. Motors that are factory-installed as part of equipment.
- C. Field-installed motors.
- D. Section does not include manufacturer's definite purpose, direct current, synchronous or wound rotor motors.

1.02 REFERENCE, SPECIFICATIONS, CODES, AND STANDARDS

- A. Codes: Comply with applicable requirements of the following codes:
 - a. NEMA - National Electrical Manufacturer's Association.
 - b. ASTM - American Society for Testing Materials
 - c. AFBMA - Antifriction Bearing Manufacturers Association
 - d. ANSI - American National Standards Institute
 - e. IEEE - Institute of Electrical and Electronics Engineers
 - f. NEC - National Electric Code
 - g. UL - Underwriters' Laboratories, Inc.
- B. All materials and equipment shall be labeled or listed as being approved by the Underwriters Laboratories (UL) whenever applicable. Equipment offered as meeting the intent of the UL requirements may be acceptable subject to the approval of OWNER.
- C. Equipment shall be built and installed in compliance with OSHA.

1.03 SUBMITTALS

- A. Shop drawings and brochures shall be submitted for all items to be furnished and shall include at least the following:
 - 1. Shop drawings, including all equipment and components.
 - 2. Brochures and/or catalogue cuts:
 - a. Preliminary dimension print and frame size.

- b. Approximate motor weight.
 - c. Complete motor nameplate Information.
- B. Installation and Maintenance Manual Information:
 - 1. Submit IO&M Manual to include the following:
 - a. Complete product submittals in electronic Adobe Acrobat (pdf) format.
 - b. Storage and alignment instructions
 - c. Installation instructions with connection diagrams
 - d. Schedule of routine maintenance and required lubrication
 - e. Product description including materials of construction, physical arrangement, dimensions, exploded views, parts lists, and trouble-shooting guides
 - f. Certified assembly drawing
 - g. Certified motor data and performance curves for rated capacity including:
 - i. Nominal efficiency in accordance with IEEE 112 for three phase motors 1 hp and larger.
 - ii. Full load power factor and maximum recommended correction capacitor kVA for motors 5 hp and larger.
 - iii. Complete nameplate data in accordance with NEMA standards and Section 2.02.P below.
 - iv. Performance characteristics:
 - 1) Guaranteed minimum efficiencies at 100%, 75% and 50% of full load.
 - 2) Guaranteed minimum power factor at 100%, 75% and 50% of full load.
 - 3) Locked rotor current.
 - 4) Full load current.
 - 5) Starting torque.
 - 6) Full Load torque.
 - 7) Breakdown torque.
 - h. Warranty & guarantee information
 - i. Test reports as specified.

- j. Cut sheets for all buy-out items.

1.04 QUALITY ASSURANCE

A. Manufacturer's Qualifications

- 1. Have a minimum of ten (10) years experience in manufacture and successful start-up of the specified equipment/design. OWNER may request submission of a list of ten (10) similar projects completed within the last ten (10) years including project names and addresses; contact names, addresses and telephone numbers of owners; and other any other information specified or requested by the OWNER.

B. Items provided under this section shall be listed or labeled by UL or other Nationally Recognized Testing Laboratory (NRTL).

- 1. Terms "NRTL" shall be as defined in OSHA Regulation 1910.7.
- 2. Terms "listed" and "labeled" shall be as defined in National Electrical Code, Article 100.

C. Comply with NEMA MG 1, "Motors and Generators."

D. Comply with UL 1004, "Motors, Electric".

1.05 WARRANTY

A. Guarantee and warranty shall be furnished.

B. Motor components shall have a full 3-year performance warranty.

PART 2 – PRODUCTS

2.01 MANUFACTURERS

- A. US Motors, Baldor, General Electric, or TECO Westinghouse. No other manufacturers will be accepted.

2.02 GENERAL

- A. Specific requirements are detailed in the SUPPLEMENT; any contradictions between the SUPPLEMENT and other requirements of this section shall be resolved by the Arlington County Project Officer.
- B. Requirements below apply to motors covered by this section except as otherwise indicated.
- C. Motors 1/2 hp and Larger: polyphase where three phase electrical service is available.
- D. Motors Smaller Than 1/2 hp: single-phase.

- E. Frequency Rating: 60-hertz.
- F. Voltage Rating: Determined by voltage of circuit to which motor is connected or following motor voltage ratings (utilization voltages):
 - 1. 120 Volts Circuit: 115 volts - motor rating.
 - 2. 208 Volts Circuit: 200 volts - motor rating.
 - 3. 240 Volts Circuit: 230 volts - motor rating.
 - 4. 480 Volts Circuit: 460 volts - motor rating.
- G. Service factors indicated for motors are minimum values and apply at frequency and utilization voltage at which motor is connected. Provide motors which will operate in service factor range when supply voltage is within 10% of motor voltage rating.
- H. Capacity: Sufficient to start and operate connected loads at designated speeds in indicated environment, and with indicated operating sequence, without exceeding nameplate ratings. Provide motors rated for continuous duty at 100% of rated capacity.
- I. Temperature Rise: Based on 104°F (40°C) ambient except as otherwise indicated.
- J. Enclosure: Totally enclosed fan cooled (TEFC) unless otherwise indicated in other sections and as required by NEC:
 - 1. Weather proof motors designed for outdoors and in wet areas.
 - 2. Explosion proof motors approved for specific hazard classifications covered by NEC.
 - 3. Chemical resistant motors designed for severe duty applications, including high humidity, corrosive, dirty or salty atmospheres.
 - 4. Wash down motors designed to prevent ingress of high pressure direct water spray.
- K. Copper Windings.
- L. Premium Efficiency (higher than minimum in NEMA MG1 tables).
- M. Service Conditions.
 - 1. Unless otherwise specified, motors conforming to this Specification shall be suitable for operation in accordance with their rating under the following service conditions:
 - a. Ambient temperature in a range of -40°F to 104°F (-40°C to 40°C).

- b. Maximum altitude of 3,300 feet above sea level.
- c. Indoor or outdoor installations in hostile duty applications.
- d. Motors shall be suitable for continuous operation on a three-phase, 60-hertz system rated 460 volts.

N. Design Requirements:

- 1. Motors shall be capable of withstanding all normal forces that may be imposed upon them during the course of normal operation, including starting and normal stops.
- 2. Motors shall be suitable for across-the-line starting and shall be able to start and accelerate the connected load to full load speed with 90% of rated voltage at the motor terminals.
- 3. Motors shall be capable of continuous operation at full load and rated frequency with a voltage variation of $\pm 10\%$.
- 4. Motors shall be capable of continuous operation at full load and rated voltage with a frequency variation of $\pm 5\%$.
- 5. Motor starting current shall not exceed a value equal to 650% of the motor full load current.
- 6. Motor installation is in a hostile environment subject to dust, moisture and/or corrosive atmospheric conditions. All parts shall be given protective treatment.

O. Noise Level:

- 1. Sound pressure levels shall be measured according to IEEE 85 and shall not exceed 85 decibels as measured on the A-Weighted Scale at a distance of one (1) meter from any motor surface under no load, free field conditions.

P. Motor Vibration:

- 1. Motor vibration shall not exceed 0.08 inches/second velocity.

Q. Nameplates:

- 1. Motor nameplates shall be of stainless steel and shall be securely fastened to the motor frame with pins of a like material.
- 2. The following information shall be contained on the motor nameplate as a minimum:
 - a. Rated horsepower.
 - b. Full load speed.

- c. Frequency.
- d. NEMA KVA code and design letter (when applicable).
- e. Rated voltage.
- f. Manufacturer's serial number.
- g. Service factor.
- h. Insulation class.
- i. Maximum ambient temperature.
- j. Full load current at nameplate voltage.
- k. Frame size designation.
- l. Weight

R. Terminal Boxes:

- 1. Terminal boxes shall be of fabricated steel or cast iron construction to be compatible with the motor enclosure specified and when possible, shall be diagonally split and capable of rotation in 90° increments. Boxes not suitable for rotation must be capable of top entry.
- 2. The area in which the main terminal box is connected with the motor frame shall be fully gasketed in order to prevent entrance of foreign matter into the motor and to provide support for the stator leads where they pass through the motor frame.
- 3. A properly sized grounding terminal shall be mounted in the main terminal box when specified.
- 4. The main terminal box shall be sufficiently oversized to allow stress cone terminations of shielded power cables and to allow mounting of any surge capacitors, lightning arrestors or current transformers as may be specified.

S. Leads:

- 1. Main motor leads shall have EPDM or equal type jackets and shall be permanently tagged for identification.
- 2. The relationship between lead markings and the direction of rotation shall be indicated on a separate motor nameplate.

T. Space Heaters:

- 1. Provide motor space heaters in accordance with the following:
 - a. Motors located outdoors and 5 horsepower and larger.

2. As specified, motors shall be furnished with space heaters to provide sufficient wattage to maintain the internal temperature of the motor at a level approximately 10°C above the ambient temperature while the motor is not in operation.
3. Space heaters shall be of the silicone rubber strip type attached directly to the stator end turns. The leads shall be brought out to an auxiliary terminal box.
4. Space heaters shall be rated for operation on a single phase, 60-hertz, 120-volt AC system.

U. Metering:

1. When specified for metering purposes, one (1) bar or window-type current transformer shall be furnished mounted in the main terminal box.

V. Protective Devices:

1. Stator winding protection shall consist of one or more of the following systems:
 - a. Provide stator winding protection in accordance with the following:
 - 1) Thermostat type for all explosion proof motors and motors operated from variable frequency drives (VFD's) up to 25 horsepower.
 - 2) Thermistor type for non-explosion-proof constant speed motors 50 horsepower and larger up to 200 horsepower and motors operated from VFD's 30 horsepower and larger up to 200 horsepower, unless specified otherwise.
 - 3) RTD type for motors 200 horsepower and larger.
 - b. Six (6) 120 ohm nickel resistance-type temperature detectors (RTD's) embedded in the stator windings, two (2) per phase. Each detector shall have its leads wired to an auxiliary terminal box.
 - c. One (1) positive temperature coefficient (PTC) thermistor temperature sensor embedded in each phase of the stator winding and corresponding solid state electronic control. Thermistor system shall be U.S. Motors' "THERMA-SENTRY".
 - d. Three (3) bi-metallic thermostats of the automatic reset type, with normally closed contacts, mounted one per phase. Each thermostat shall be furnished with leads suitable for connection to the control circuit.

2. Provide bearing protection in accordance with the following:
 - a. Provide bearing protection for motors 200 horsepower and larger.
 - b. Bearing protection shall consist of one of the following:
 - 1) Two (2) 120 ohm nickel resistance-type temperature detectors (RTD's), one (1) per bearing, mounted as closely as possible to the outer surface of each bearing. Each detector shall have its leads wired to a terminal block located in an auxiliary terminal box.
 - 2) Indicating scale.
 - 3) Two (2) dial type thermometers, one (1) per bearing.
 - 4) Two (2) iron or copper constantan thermo-couples, one (1) per bearing.
 3. When specified, surge protection shall be provided in form of surge capacitors and lightning arrestors mounted, one (1) per phase in the main terminal box.
 4. When specified, differential ground protection shall consist of three (3) window-type current transformers, mounted one (1) per phase in the main terminal box. Leads of each phase shall be passed through individual current transformers. Transformers shall be of a ratio specified by the Purchaser at time of order placement.
- W. Ventilating Fans:
1. Ventilating fans shall be corrosion resistant, non-sparking material. All fans shall be suitable for bi-directional rotation.
- X. Conduit Box:
1. Conduit box shall be gasketed between the conduit box halves. A grounding provision shall be provided in the conduit box. The conduit box shall be oversize as compared to NEMA requirements and diagonally split and rotatable in 90 degree increments. The conduit box shall be field convertible to cast iron.
- Y. External Screws And Bolts:
1. External screws and bolts shall be grade five, hex heads and be plated to resist corrosion.
- Z. Motor Shaft:

1. Motor shaft shall be provided with an external recessed slinger at the drive end of the motor to provide additional (minimum IP-54) protection from moisture and foreign material.

AA. Rotor And Stator Air Gap Surfaces:

1. Rotor and stator air gap surfaces shall be coated so as to prevent corrosion.

2.03 POLYPHASE MOTORS

- A. Squirrel-cage induction-type conforming to following requirements except as otherwise indicated.
- B. NEMA Design Letter Designation: "B".
- C. Bearings: Double-shielded, pre-lubricated ball bearings suitable for radial and thrust loading for application.
 1. Re-greaseable with Alemite fittings extended to accessible location for frame 250 and larger.
 2. AFBMA B10 bearing life rated - 130,000 hours for horizontal direct coupled motors and 50,000 hours for horizontal belted and vertical type applications.
 3. Vertical Motors:
 - a. Thrust Bearings:
 - 1) Motors shall be designed and constructed with thrust bearings on top to allow inspection and/or replacement without requiring complete disassembly of motor.
 - 2) Thrust bearings shall be deep-groove ball, angular contact ball or spherical roller type. Bearings mounted back-to-back or in tandem are acceptable and may be furnished when required according to manufacturer's standard design.
 - 3) Deep-groove ball bearings shall be used only on normal thrust design motors and shall be capable of handling thrust loads in either direction.
 - 4) High thrust design motors shall be supplied with angular contact ball bearings whenever possible and in accordance with manufacturer's standard design.
 - 5) Where thrust requirements restrict the use of angular contact bearings, spherical roller bearings shall be furnished.

- a) When required, motors furnished with spherical roller bearings shall also be provided with a system of coils in the oil reservoir for the circulation of cooling water.
 - b) Spherical roller bearings shall be spring loaded to keep the lower bearing race in contact and prevent bearing damage during starting and momentary up-thrust conditions.
- b. Guide Bearings:
 - 1) Guide bearings shall be deep-groove ball type and shall be located at the bottom of the motor.
 - 2) Guide bearings may be stacked when necessary according to manufacturer's standard design to accommodate specified up-thrust conditions.
 - 3) Guide bearings or bearing assemblies shall be provided with sufficient means for preventing the leakage of lubricant or entrance of foreign matter along the shaft.
- c. Lubrication:
 - 1) Thrust bearings shall be oil lubricated and contained in an oil reservoir with oil sight level gauge and oil fill and drain openings with plugs.
 - 2) Deep-groove ball bearings furnished as thrust bearings for normal thrust motors shall be grease lubricated. When furnished as guide bearings for high thrust units, they shall be oil lubricated.
 - 3) Grease lubricated bearings shall be furnished with provisions for in-service positive lubrication. A drain shall be provided to guard against over lubrication.
- 4. All motors 250 frame and above shall have fully regreasable, anti-friction bearings. All motors 140 frame and lower shall be sealed and lubed for life, 180-360 frame shall be double shielded and 400-440 frame bearings will be open.
- 5. All motors 182 frame and above shall have cast iron inner bearing caps.
- 6. All motors shall have a charged lubrication system to inhibit moisture condensation.

7. Standard motors in frames 254-447 shall have extended grease fittings on the opposite drive-end to facilitate re-lubrication. Grease ports shall be located on the periphery of the motor endshield.
8. Motor shall be fitted with a shaft slinger for a minimum of IP-54 protection.
- D. Energy Efficient Motors: Premium efficiency, greater than that stated in NEMA MG 1, Table 12-10 for that type and rating of motor.
- E. Multi-Speed Motors: Separate winding for each speed.
- F. Internal Thermal Overload Protection For Motors: For motors so indicated, protection automatically opens control circuit arranged for external connection. Protection operates when winding temperature exceeds safe value calibrated to temperature rating of motor insulation. Internal thermal overload protection shall not be installed on inverter duty motors.
- G. Motors for Reduced Inrush Starting: Coordinate with indicated reduced inrush controller type and with characteristics of driven equipment load. Provide required wiring leads in motor terminal box to suit control method.
- H. Torque:
 1. Breakdown torque shall be 200% or more of maximum torque load placed on motor shaft.
 2. Provide necessary WK₂ curves for special loads to coordinate with motors.
 3. Supply special motors where load requirements exceed standard design.
- I. Open Drip Proof (ODP) – IP22:
 1. Premium energy efficient.
 2. Protected openings.
 3. Class F insulation.
 4. 1.15 service factor.
 5. Cast iron construction.
- J. Totally Enclosed Fan Cooled (TEFC) and Totally Enclosed Non-Ventilated (TENV) – IP44:
 1. Premium energy efficient.
 2. 1.15 service factor, Class "F" insulation.
 3. Cast iron construction; frame, conduit box, end shields, fan cover, inner caps for 182T frames and larger.

4. Positive lubrication systems.
 5. Removable eyebolt.
 6. Suitable for indoor and outdoor installations.
 7. Diagonally split, neoprene gasketed, rotatable oversized conduit box with NPT threaded lead hole.
 8. Conduit box mounted, UL approved clamp type grounding lug.
 9. Permanently numbered non-wicking leads.
 10. Rust inhibitive non-washing lubricant.
 11. Stainless steel nameplate with data listed in Section 2.02.P and:
 - a. NEMA nominal efficiency (MG 1-12).
 - b. AFBMA bearing numbers.
 - c. Lubrication instructions.
- K. Corrosion Resistant (Mill and Chemical Duty) – IP55:
1. Same features as TEFC, except as noted below.
 2. Neoprene lead seal separator gasket mounted between motor frame and conduit box.
 3. Anti-static corrosion resistant fan.
 4. Zinc plated hex head hardware.
 5. Stainless steel T drains and breather fittings.
 6. Stator and rotor completely epoxy coated for corrosion protection.
 7. Non-metallic V-ring shaft slinger.
 8. Double shielded bearings.
 9. Double-coated epoxy enamel exterior finish.
 10. Stainless steel nameplate.
- L. Explosion Proof:
1. Same features as TEFC.
 2. Approved for NEC hazardous classified location as noted in equipment Specification or as indicated on Contract Drawings.
 3. Automatic explosion proof breather drains.

- M. Wash-down Duty Motor – IP56:
 - 1. Same features as Corrosion Resistant (Mill and Chemical Duty).
 - 2. Sealed to prevent ingress of direct application of a stream of water at 5,000 psig.
- N. Submersible pump and mixer motors – IP68:
 - 1. As specified with equipment Specifications.
 - 2. 1.10 service factor, unless otherwise indicated in equipment Specification sections.

2.04 SINGLE-PHASE MOTORS

- A. One of following types as selected to suit starting torque and other requirements of specific motor application:
 - 1. Permanent Split Capacitor.
 - 2. Split-Phase Start, Capacitor-Run.
 - 3. Capacitor-Start, Capacitor-Run.
- B. Shaded-Pole Motors: Use only for motors smaller than 1/20 hp.
- C. Internal Thermal Overload Protection for Motors: For motors so indicated, protection automatically opens power supply circuit to the motor, or control circuit arranged for external connection. Protection operates when winding temperature exceeds safe value calibrated to temperature rating of motor insulation. Provide device that automatically resets when motor temperature returns to normal range except as otherwise indicated.
- D. Bearings, belt connected motors and other motors with high radial forces on motor shaft shall be ball bearing type. Sealed, pre-lubricated sleeve bearings may be used for other single phase motors.

2.05 SOURCE QUALITY CONTROL

- A. Testing:
 - 1. Perform individual motor test on motors over 1 hp.
 - 2. Test shall be standard NEMA routine production test in accordance with MG 1-12.55.

SUPPLEMENT
AC-MOTOR REQUIREMENTS

Reference Equipment, Equipment Tag No., and/or Work Order No.

_____ Horsepower rating: _____

Voltage rating: _____

Phase: _____

RPM: _____

Frame: _____

Insulation Class: _____

Duty: _____

Temperature range: _____ to _____ °C

Enclosure (mark all that apply):

- | | | |
|---|--|--|
| <input type="checkbox"/> explosive proof | <input type="checkbox"/> weatherproof (IP56) | <input type="checkbox"/> chemical resistant (IP55) |
| <input type="checkbox"/> wash down (IP56) | <input type="checkbox"/> submersible (IP68) | <input type="checkbox"/> ODP (IP22) |
| <input type="checkbox"/> TEFC (IP44) | <input type="checkbox"/> TENV (IP44) | |

Mounting (mark all that apply):

- | | | | |
|---------------------------------------|---------------------------------|-----------------------------------|-------------------------------------|
| <input type="checkbox"/> foot mounted | <input type="checkbox"/> c-face | <input type="checkbox"/> vertical | <input type="checkbox"/> horizontal |
|---------------------------------------|---------------------------------|-----------------------------------|-------------------------------------|

Stator winding protection:

- | | | |
|-------------------------------------|-------------------------------------|------------------------------|
| <input type="checkbox"/> thermostat | <input type="checkbox"/> Thermistor | <input type="checkbox"/> RTD |
|-------------------------------------|-------------------------------------|------------------------------|

Bearing protection:

- | | | | |
|--------------------------------|---|---------------------------------------|--|
| <input type="checkbox"/> RTD's | <input type="checkbox"/> indicating scale | <input type="checkbox"/> thermometers | <input type="checkbox"/> thermocouples |
|--------------------------------|---|---------------------------------------|--|

Drive type system:

- | | | |
|---------------------------------------|---|---|
| <input type="checkbox"/> v-belt drive | <input type="checkbox"/> synchronous belt drive | <input type="checkbox"/> direct coupled |
|---------------------------------------|---|---|

Other specifications:

- | | |
|---|---|
| <input type="checkbox"/> winding space heaters | <input type="checkbox"/> differential ground protection |
| <input type="checkbox"/> surge protection | <input type="checkbox"/> thermal overload protection |
| <input type="checkbox"/> reduced inrush starting (soft start) | <input type="checkbox"/> constant torque |
| <input type="checkbox"/> _____ | |

END OF SECTION