

SPECIFICATIONS - DETAILED PROVISIONS
Section 16150 - Induction Motors

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**SECTION 16150
INDUCTION MOTORS**

PART 1 - GENERAL

1.01 DESCRIPTION

- A. This section specifies the electrical requirements for squirrel-cage induction motors. Motors shall be supplied by the manufacturer of the driven equipment as specified in this section, and specifically outlined in the equipment sections of these Specifications. The requirements of the individual driven equipment sections are equally applicable to the work specified herein. Where conflict exists, the individual equipment sections shall take precedence.
- B. Contractor shall furnish and install electric motors, accessories, and appurtenances as specified herein and in conformance with the individual specifications of driven equipment, to provide a complete and operable installation, all in accordance with the requirements of the Contract Documents.
- C. The Contractor and equipment manufacturer shall be responsible for providing motors and controls sized in accordance with the requirements specified herein and in the individual equipment sections. Under no circumstances shall the nameplate rating of the motor be exceeded under the maximum design capacity of the equipment supplied. In addition, the motor service factor shall not be used for motor sizing.

1.02 RELATED SECTIONS

- A. The Contract Documents are a single integrated document, and as such all Specification Sections apply. It is the responsibility of the Contractor and its subcontractors to review all sections and ensure a complete and coordinated project.
- B. Related Specification Sections include, but are not limited to, the following:
 - 1. Sections of the Specifications specifying electric motor driven equipment.
 - 2. Section 16010 - General Electrical Requirements
 - 3. Section 16050 - Basic Electrical Materials and Methods
 - 4. Section 16151 - Vertical Hollowshaft Electric Motors
 - 5. Section 16160 - Variable Frequency Drives

6. Section 16480 - Motor Control Centers, Switchboards, and Panelboards
7. Section 17005 - General Instrumentation and Control Components

1.03 REFERENCE STANDARDS AND CODES

All equipment and materials, including installation of same, shall meet or exceed the applicable requirements of the following standards and codes (latest edition):

- A. American Bearing Manufacturer's Association (ABMA)
 1. ABMA 9 - Load Ratings and Fatigue Life for Ball Bearings
 2. ABMA 11 - Load Ratings and Fatigue Life for Roller Bearings
- B. Institute of Electrical and Electronics Engineers (IEEE)
 1. IEEE 43 – Recommended Practice for Testing Insulation Resistance of Rotating Machinery
 2. IEEE 85 – Test Procedure for Airborne Sound Measurements on Rotating Electric Machinery
 3. IEEE 112 - Standard Test Procedure for Polyphase Induction Motors and Generators
 4. IEEE 114 - Standard Test Procedure for Single-Phase Induction Motors
 5. IEEE 303 – Recommended Practice for Auxiliary Devices for Rotating Electrical Machines in Class I, Division 2 and Zone 2 Locations and Class II, Division 2 and Zone 22 Locations
 6. IEEE 841 - Standard for Petroleum and Chemical Industry – Premium Efficiency, Severe Duty, Totally Enclosed Fan-Cooled (TEFC) Squirrel Cage Induction Motors – Up to and Including 500 hp
 7. IEEE 1349 – Guide for the Application of Motors in Hazardous (Classified) Locations
- C. National Electrical Manufacturers Association (NEMA)
 1. MG 1 - Motors and Generators

2. MG 2 – Safety Standard for Construction and Guide for Selection, Installation and Use of Electric Motors and Generators
 3. MG 13 – Frame Assignment for Alternating-Current Integral-Horsepower Induction Motors
- D. National Fire Protection Association (NFPA)
1. NFPA 70 - National Electrical Code (NEC)
- E. Underwriters Laboratories (UL)
1. UL 674 - Electric Motors and Generators for Use in Hazardous (Classified) Locations

1.04 SUBMITTALS

All submittals shall be in accordance with the General Conditions and requirements specified herein.

A. Shop Drawings

Contractor shall prepare and submit complete information, drawings, and data for motor driven equipment as specified in the individual specification sections for same. Motor submittal information shall be provided as part of the submittals for the driven equipment. As a minimum, motor submittal information, drawings, and data shall include the following:

1. Machine name and specification section number of driven machine.
2. Motor manufacturer, motor type or model.
3. Motor manufacturer product literature, specifications, features and accessories, materials of construction, and data in sufficient detail to demonstrate compliance with Specification requirements.
4. Motor data summary sheet, listing: nominal horsepower; NEMA design; frame size; enclosure type; winding insulation class and treatment; rated ambient temperature; service factor; voltage, phase, and frequency rating; full load current at rated horsepower for application voltage; starting code letter, or locked rotor kVA, or current; special winding configuration such as part-winding, star-delta (include winding diagram); rated full load speed; power factor at full load; noise certification and data sheets (where required); and bearing types and catalog numbers.

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5. Motor performance characteristics:
 - a. Guaranteed minimum efficiency at rated load at rated voltage.
 - b. Guaranteed minimum power factor at rated load at rated voltage.
 - c. Expected efficiency at 1/2, 3/4, and full load at rated voltage.
 - d. Expected power factor at 1/2, 3/4, and full load at rated voltage.
 - e. Full load current at 110 percent voltage.
 - f. Starting current at rated voltage (motor locked rotor design code).
6. Motor outline, cross-section, and assembly drawings, with dimensions and motor net weight. Motor wiring diagrams, including wiring for all accessories and components.
7. Motor output shaft diameter, length, keying, drilling, etc. Motor coupling for connection to driven equipment (if applicable).
8. Bearing types and catalog numbers.
9. Special characteristics and features of motor(s) to be supplied.
10. Time in seconds motor can be subjected to locked rotor current at rated voltage without damage to motor with: (1) motor initially at the rated ambient temperature, and (2) motor initially at the rated temperature rise.
11. Thermal protection system (where required) including recommended alarm and trip settings for winding RTDs (if applicable).
12. Motor nameplate drawing.
13. Motor noise data sheets and certification (where required).
14. Vertical motor data (where applicable):
 - a. Thrust bearing life.
 - b. Type of thrust bearing lubrication.
 - c. Type of guide bearing lubrication.

15. Inverter duty motor data (where applicable):
 - a. Manufacturer's inverter duty motor specifications, including motor winding voltage rating.
 - b. Maximum distance (in feet) motor may be located from variable frequency drive.
 - c. Torque output rating: variable or constant.
 - d. Operating speed range, continuous duty.
 - e. Motor manufacturer's certification statement that the proposed motor is suitable to drive the selected equipment over the specified speed range with the selected motor.
 - f. Motor noise data sheets and certification.
16. Factory test reports, including all factory test results.

B. Operation and Maintenance (O&M) Manuals

Contractor shall prepare a detailed O&M Manual for each type and size of motor required by the individual equipment sections for the driven equipment. Motor O&M Manuals shall be provided as a part of the O&M Manuals for the driven equipment. Equipment O&M Manuals shall be provided in accordance with the requirements of the District's General Conditions and Section 01430.

Motor O&M Manual information and data shall include, but not be limited to, the following:

1. Motor Performance Data and Drawings
 - a. Manufacturer's product literature, specifications, performance capabilities, features and accessories, materials of construction, and illustrations.
 - b. As-built motor outline, cross-section, and assembly drawings.
 - c. As-built motor wiring diagrams, including wiring for all accessories and components.

2. Motor Installation Requirements
 - a. Complete, detailed installation instructions for all motors, accessories, and components.
 - b. Alignment and adjustment instructions.
3. Motor Service and Maintenance Data
 - a. Maintenance data shall include all information and instructions required by District's personnel to keep motors properly lubricated and adjusted.
 - b. Unloading, handling, and long term storage requirements.
 - c. Explanation with illustrations as necessary for each maintenance task.
 - d. Recommended schedule of maintenance tasks.
 - e. Troubleshooting instructions.
 - f. List of maintenance tools and equipment.
 - g. Parts list with part illustrations.
 - h. Name, address and phone number of manufacturer and manufacturer's local service representative.
4. Manufacturer's Warranty
5. Provide a signed written certification report with the Final Operation and Maintenance Manuals, certifying that each motor has been properly installed, lubricated, and adjusted, and is suitable for satisfactory continuous operation under varying operating conditions, and meets all requirements specified in the Contract Documents.

1.05 QUALITY ASSURANCE

- A. All motors shall be UL listed and labeled.
- B. Induction motors shall be manufactured by U.S. Motors, Baldor, General Electric, or equal.

- C. Motors shall be provided with an extended warranty by the manufacturer against material and workmanship defects. The extended warranty shall be the manufacturer's standard policy, and shall be in addition to the Contractor's Contract warranty requirements.
1. Premium efficient motors shall be warranted for 36 months.
 2. Inverter duty motor shall be warranted for 36 months.
 3. Severe duty motors shall be warranted for 60 months.

PART 2 - PRODUCTS

2.01 GENERAL REQUIREMENTS

All electric motors shall comply with NEMA MG 1. Motors shall be suitable for the starting method indicated on the Drawings. All motors shall be sized to carry continuously all loads which may be imposed by the driven equipment through their full range of operation.

A. Minimum Service Conditions (Unless Specified Otherwise)

Motors shall be capable of operating continuously and satisfactorily in ambient temperatures from minus 10°C (+14°F) to plus 50°C (+122°F) and at a maximum elevation of 3,300 feet.

B. Minimum Requirements

1. Motors driving identical equipment shall be identical.
2. Motor nameplate horsepower:
 - a. Motors shall be sized so that the brake horsepower (BHP) requirement of the driven equipment does not exceed 90 percent of the motor full load nameplate horsepower, unless specified otherwise.
 - b. The motor horsepower indicated on the Drawings or specified in the driven equipment specification section are based on information and estimates from the manufacturer(s) of the driven equipment. The nameplate horsepower of the supplied motor shall not be less than the motor horsepower indicated on the Drawings or specified in the driven equipment specification section.

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- c. If the minimum specified motor horsepower is not adequate to satisfy the sizing requirements herein or any other requirements of the Contract Documents, motors with the necessary horsepower shall be provided at no additional cost to the District. In addition, any changes to equipment and material related to an increase in motor horsepower shall be made by the Contractor at no additional cost to the District. These related changes shall include, but not be limited to, the following: circuit breakers, motor starters, motor overload devices, motor power feed conductors, and conduit sizes.
3. Motors shall be rated for continuous operation at the specified service factor and specified minimum service conditions.
4. All motors shall be NEMA Design B unless specified otherwise in the driven equipment specification section, or required by the application.
5. Motors shall be rated for full voltage across-the-line starting.
6. Starting current at full voltage shall not exceed 650 percent of the motor full load current for all integral horsepower motors.
7. The motor shall be capable of accelerating the driven machine from zero to top speed with motor power supply at 90 percent of rated voltage without overheating.
8. Motors shall be designed for high power factor. Minimum motor power factor at full load shall be 80 percent.
9. Maximum locked-rotor kVA/hp code letter shall be Code G for motors 15 hp and larger, unless specified otherwise.
10. Two-speed motors shall be two-winding motors. Two-speed, one-winding motors are not acceptable.
11. All motors shall have a safe stall (locked-rotor) time equal to or greater than the maximum accelerating time under the worst voltage conditions specified.
12. Motors shall be designed for operation in either direction of rotation without a physical change to the motor.
13. Motor fans shall be suitable for bi-directional rotation, and shall be accurately balanced before assembly on the motor.

C. Special Service Conditions

1. Motors driven by Variable Frequency Drive (VFD) systems shall comply with the following:
 - a. Inverter duty rated and labeled.
 - b. Meeting the requirements of NEMA MG 1, Part 31 including winding insulation.
 - c. Satisfactory for operation with standard power feed conductors (no requirements for special cables).
 - d. Capable of operating continuously at 10% of full speed.
 - e. Rotors shall be stiff shaft design, statically and dynamically balanced. First lateral critical speed shall be at least 20% above the maximum running speed of the driven equipment.
 - f. Compatible with the VFD system to be supplied including peak output voltage and switching frequencies.
 - g. Motor bearings shall be protected from shaft current produced by common mode voltages and other electromagnetic interaction of the motor and VFD.
 - h. 30 hp and larger motors shall be provided with a shaft grounding device (ring) on the drive end.
 - i. 100 hp and larger motors shall be provided with insulated bearings and a shaft grounding device.
 - j. Sound pressure levels shall be limited to a maximum of 10 dB greater for motors used with PWM drives than for motor operation on sine wave power at a distance of 3 feet from any motor surface.
 - k. Rated for a service factor of 1.0.

2. Motors located in NEC hazardous Class I, Division 1 or Class I, Division 2 areas shall be properly rated for the hazardous location classification and ignition temperatures. As a minimum, motors located in Class I, Division 1 areas shall be rated explosion-proof, and shall be UL listed and labeled. Motors shall be in compliance with the requirements of UL 674. In addition, motor winding thermostats, motor starting, and motor controls shall be in accordance with the motor manufacturer's recommendations, and shall satisfy the requirements of the NEC and UL.
3. Motors located in wet or corrosive areas shall be rated for severe duty. As a minimum, severe duty motors shall comply with the following:
 - a. Fan material shall be strong and durable, and shall be abrasion and corrosion resistant.
 - b. Enclosures shall be totally enclosed fan cooled (TEFC) or totally enclosed non-ventilated (TENV). Motor case construction shall be corrosion resistant cast iron, including one-piece frame, end shrouds, conduit box, and fan shroud.
 - c. External surfaces shall have a high bond heavy build double epoxy enamel finish. The finish shall provide maximum corrosion protection and withstand the effects of outdoor weathering including sunlight.
 - d. All hardware shall be constructed of stainless steel.
 - e. Permanent bearing isolators shall be installed on the shaft extension and fan ends.
 - f. Motors shall be designed and constructed to IEEE Standard 841.

2.02 ELECTRICAL REQUIREMENTS

Unless indicated otherwise on the Drawings, or specified otherwise in the individual equipment sections of the driven equipment, motor electrical requirements shall be as follows:

A. Voltage and Frequency

1. Motors 1/2 hp through 500 hp:

Motors shall be rated for 460 V, 3-phase, and 60 Hz power.
2. Motors smaller than 1/2 hp:

Motors shall be rated for 115/230 V, 1-phase, 60 Hz power, and shall be of the capacitor-start, induction-run type.

3. Motors shall operate successfully under running conditions at rated load with variation in the voltage or the frequency not exceeding the following conditions:
 - a. +/-10% rated voltage at rated constant volts/hertz ratio, except for specific torque boost situations.
 - b. +/-5% rated frequency at rated constant volts/hertz ratio.
 - c. Motors shall operate successfully under running conditions at rated load and volts/hertz ratio when the voltage unbalance at the motor terminals does not exceed 1%.

B. Operating Characteristics

With rated volts/hertz ratio applied under specified service conditions, motor performance shall be as follows for critical operating characteristics:

1. Torque

Motors shall meet or exceed the minimum locked rotor (starting) and breakdown torques specified in NEMA MG 1-12 for Design B for the rating specified when operating on sine wave power. Torque and slip characteristics shall be as recommended by the manufacturer of the driven equipment and as specified.

2. Current

Locked rotor currents shall not exceed NEMA Design B values.

3. Efficiency

Unless specified otherwise, all motors shall be premium efficiency in accordance with NEMA MG 1. Motor efficiency will be determined according to NEMA MG 1-12, IEEE Test Procedure 112 Method B, using accuracy improvement by segregated loss determination including stray load loss measurements.

4. Temperature Rise

Temperature rise above the specified maximum ambient temperature, for each of the various parts of the motor, shall not exceed the values indicated in NEMA MG 1-12.

5. Time Rating

All motors shall be rated for continuous duty.

C. Service Factor

All motors shall be rated for a 1.15 service factor on sine wave power, unless specified otherwise. Service factor shall not be used for motor sizing.

D. Insulation

1. Motors shall be designed for a Class B temperature rise, and shall be provided with Class F insulation systems per NEMA MG 1. Insulation system shall be resistant to attack from moisture, acids, alkalis, and mechanical or thermal shock. Motor insulation and related components shall be constructed of non-wicking, non-hydroscopic materials. As a minimum, motors shall be furnished with one dip and bake in 100% solids, polyester or epoxy resin.
2. Motors constructed in NEMA frames 284 and larger, shall be provided with winding insulations that are vacuum pressure impregnated (VPI) with 100% solids, polyester or epoxy resin per approved manufacturer's standards. As a minimum, motors shall be furnished with one VPI cycle of 100% solid resins. Motors installed outdoors shall be furnished with two VPI cycles of 100% solid resins to provide moisture-resistant windings.
3. Where required elsewhere in the Specifications or where indicated on the Drawings, a completely encapsulated insulation system shall be provided. Stator windings and end-turns in squirrel-cage induction motors shall be completely filled with an insulating resin which shall also form a protective coating. Winding insulations shall be vacuum pressure impregnated with 100% solids, polyester or epoxy resin per approved manufacturer's standards. Encapsulated windings shall be tested in accordance with NEMA MG 1-20.35.7.

2.03 MECHANICAL REQUIREMENTS

A. Frame Sizes

Motor frame sizes shall be NEMA frame size designations for sizes 143 through 447. Motor frame sizes larger than NEMA frame designations shall be per approved motor manufacturers. NEMA frames shall be in accordance with NEMA MG 1.

B. Enclosures

1. Enclosures for induction motors shall be approved for the installation conditions, and as specified.
2. Unless specified otherwise, motor housings, motor frames, end shields, inner bearing caps, and fan covers shall be constructed of cast iron or heavy gauge fabricated steel.
3. The enclosure types shall be the following, unless specified otherwise in the individual equipment sections of the driven equipment.
 - a. Motors installed indoors shall be Open Drip-Proof (ODP).
 - b. Motors installed outdoors shall be ODP Weather Protected Type I, or Totally Enclosed Fan Cooled (TEFC).
 - c. Vertical motors installed indoors and outdoors shall be ODP Weather Protected Type I.
 - d. Motors to be installed in hazardous (classified) areas shall be provided as specified herein, and shall conform to the requirements of NEC Article 500.
4. Motors shall have drain openings suitable located for the type of enclosure and assembly being provided.
5. TEFC motors shall be furnished with tapped drain holes with stainless steel drain plugs for frames smaller than 284 and automatic breather and drain devices for frames 284 and larger. TEFC horizontal motors shall be furnished with drain holes at each end support bracket.
6. Openings on weather protected enclosures shall be covered with corrosion resistant metal guard screens have a mesh size no larger than 1/2 inch square.

C. Windings and Winding Protection

1. Windings shall be copper magnet wire rated at 200°C and moisture resistant. Magnet wire insulation material shall be of the type designed to resist transient spikes, high frequencies, and short time rise pulses produced by inverters. Windings shall be firmly held in the stator slots to prevent coil shifts. Sharp edges and burs shall be removed from the stator core slots prior to inserting the winding. All coils shall be phase insulated and laced down such that the windings will not move during repetitive starting. All stator connections shall be securely made.
2. Motors 50 hp and larger shall be provided with three resistance temperature detectors (RTDs) or PTC thermistors in the windings. Any overload condition shall cause all phases to open. Motor temperature detectors shall be furnished with controllers for installation in Motor Control Centers or Motor Control Panels.

D. Bearings

Provide bearings that are designed for the specified conditions under continuous operation, with proportions, mountings, and adjustments consistent with best modern practices for all applied radial and thrust loads at specified speeds. Bearings shall be designed to withstand any inertial forces associated with starting and stopping of the motor. Bearings shall be anti-friction type and the bearing chamber shall be coated with a rust inhibiting grease or oil. When possible, provide end brackets with lube fill and relief plugs, which allow re-greasing while the motor is in service.

1. Bearings shall be designed to provide the following minimum L-10 bearing life:
 - a. Direct connected 100,000 hours.
 - b. Belt connected 50,000 hours.

Bearings and lubrication shall be suitable for the specified ambient temperature and temperature rise.

2. Ball Bearings

Ball bearings shall be double shielded, grease or oil lubricated. Provide lubrication from readily accessible inlet and outlet plugs or fittings. Provide bearing protection with internal shaft slingers or inner bearing caps.

3. Roller Bearings
Provide roller bearings for V-belt drive applications.
 4. Oil Lubricated Bearing Housing
Furnish with adequate reservoir depth to provide space for settling of foreign matter. Provide drain plug accessible from motor exterior, and a visual oil level indicator.
 5. Ball Bearing Couplings on Horizontal Motors
Construct to absorb total movement and thermal expansion of motor driven equipment shafts.
 6. Sleeve Bearings
Sleeve bearings shall be furnished with proper oil rings. The use of wicks or packings are not acceptable.
 7. Couplings for Sleeve Bearing Motors
Provide type to prevent motor rotating thrust surface from contacting sleeve bearing thrust collar.
 8. Lubrication Fittings
Except on motors equipped with factory-sealed bearings, provide lubrication fittings with easily accessible grease/oil supply, flush, drain, relief, and extension tubes (where necessary).
- E. Motor Shaft
Motor shaft shall be 1045 Hot Rolled Steel.
- F. Fan Cooled
Motors specified as fan cooled shall be equipped with ventilating fans constructed of non-corroding and non-sparking materials.

2.04 ACCESSORIES AND OPTIONS

A. Grounding

Lugs shall be provided in all motor terminal boxes for grounding.

B. Terminal Boxes

1. Motors shall be equipped with terminal boxes for all conduit and wire connections, as specified and as required.
2. Gaskets shall be provided between each terminal box and motor frame, and terminal box and cover plate. Terminal boxes shall be attached to the motor frames with high strength zinc plated and chromated steel bolts and cap screws.
3. Terminal boxes for motor main power leads shall be over-sized (meeting or exceeding volumes provided in IEEE 841), diagonally split, and rotatable in 90° increments. Terminal boxes shall be provided with threaded conduit entrances.
4. A separate terminal box shall be provided for motor space heater power leads and motor winding temperature sensor wiring. Space heater leads and motor winding temperature sensor wiring shall be terminated on terminal blocks.
5. The internal temperature of motor terminal boxes shall allow use of 75°C rated conductors.

C. Space Heaters

Space heaters shall be designed to maintain the winding temperature at 5°C above the ambient temperature when the motor is not in use. Unless specified otherwise, space heaters shall be 115 V, 1-phase, 60 Hz, and shall be thermostatically controlled.

Unless specified otherwise, space heaters shall be provided on all motors 30 hp and larger to be installed outdoors, and on all motors 50 hp and larger to be installed indoors.

Space heaters shall be unaffected by the accumulation of moisture and shall have terminals adequately protected against moisture under severe weather conditions. Space heaters shall be mounted on noncombustible material and shall be capable of operating continuously without thermal damage to the motor or themselves. Space heaters shall have a maximum sheath temperature of 200°C.

Power leads for motor space heaters shall be brought out into a terminal box separate from the motor main power leads terminal box.

Where motors are provided with space heaters, a warning nameplate shall be provided on the motor space heater terminal box. The warning nameplate shall have red background with white letters and shall read: "CAUTION - CONTAINS AN EXTERNAL VOLTAGE SOURCE."

D. Lifting Devices

All motors weighing 150 pounds or more shall have suitable lifting devices for installation and removal.

E. Finish

Unless specified otherwise, motor castings, enclosures, terminal boxes, etc. shall be factory coated with a red-oxide zinc-chromate primer, and finished with a corrosion resistant epoxy coating. Motor field finish coatings shall be in accordance with Specification Section 09900, the Protective Coating Schedule on the Drawings, and manufacturer's written instructions.

F. Nameplates

Provide stainless steel nameplates of ample size with clear stamped or engraved numerals and letters. Motor nameplate data shall conform to NEMA MG 1 requirements, and shall include the following information, as a minimum:

1. Motor manufacturer, serial number, model number, type, frame size, enclosure type, rated horsepower, rated full load rpm, rated voltage, rated frequency, number of phases, rated full load amperes, NEMA design code, locked rotor code letter, torque, service factor, power factor, full load nominal efficiency, insulation class, maximum ambient temperature, time rating, altitude, thermal protection, space heater wattage and voltage, bearings, mounting, and other essential data.
2. Nameplate data shall be completely in English.
3. Nameplates shall be secured to the motor frame with corrosion resisting stainless steel pins in accessible locations.

G. Hardware

Unless specified otherwise, external screws and bolts shall be Grade 5, hex head and plated to resist corrosion.

H. Dynamic Balance and Vibration

1. All motors shall be dynamically balanced. Methods of measuring dynamic balance shall be in accordance with NEMA MG 1-7.
2. Motors shall have a maximum peak-to-peak amplitude of vibration in accordance with NEMA MG 1-7.8.

PART 3 - EXECUTION

3.01 FACTORY TESTS

A. All Motors Smaller than 100 hp

Motors shall be given a standard commercial test.

B. All Motors 100 hp and Larger

Motors shall be given complete tests including:

1. No load running current.
2. Locked rotor current.
3. Full load heat run.
4. High potential test.
5. Winding resistance.
6. Bearing inspection.
7. Locked and idle saturation curves.
8. Service factor heat run.
9. Percent slip.
10. Breakdown torque.
11. Locked rotor torque.
12. Efficiency at full, 3/4, and 1/2 load.

13. Power factor at full, 3/4, and 1/2 load.
14. Balance to 0.001 inches total amplitude.
15. Noise test.
16. All tests (except locked rotor current) shall be made at full voltage and rated frequency.

3.02 DELIVERY, STORAGE, AND HANDLING

- A. Contractor shall carefully inspect all motors at the time of delivery. Contractor shall notify the District in writing of any damage to the motor or motor components and accessories. Contractor shall repair or replace damaged motors to the satisfaction of the District, all at no additional cost to the District.
- B. Storage and handling of motors shall be in accordance with the manufacturer's written recommendations. Motors shall not be stored outdoors, and shall be protected from exposure to dirt, fumes, water, corrosive liquids and gases, and physical damage.
- C. Contractor shall make provisions to protect motors from moisture by temporary connection of motor space heaters or installation of temporary heating equipment. Motors shall be protected against condensation until permanent motor power is provided.
- D. Motor shafts shall be periodically rotated according to the manufacturer's instructions.

3.03 INSTALLATION

- A. Provide all the equipment installations and wiring installations, including connections as indicated on the Drawings, specified herein, and required.
- B. Assure proper fits for all equipment and materials in the spaces shown on the Drawings.
- C. Coordinate locations of all conduit stub-ups with actual locations of motor terminal boxes for power and motor auxiliary device connections.
- D. General Requirements
 1. Motors shall be installed in accordance with requirements of the individual driven equipment specifications, and in accordance with the manufacturer's recommendations.

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2. Provide the required wiring for motor power, including installation of motor connections in accordance with the motor manufacturer's requirements.
 3. Provide the required wiring for all control equipment that shall be furnished and installed by other sections of the Specifications.
 4. Provide the required wiring for heaters in the motor frames and the required controls to de-energize the heaters when the motors operate.
- E. Install equipment local control stations on steel stanchions and building structures near their respective motors as shown on the Drawings.
- F. Provide power, control, alarm, and grounding installations for all motors as indicated on the Drawings and required.
- G. Connections of devices sensitive to electromagnetic interferences such as RTDs, thermistors, thermal protection switches, vibration sensors and other applicable instrumentation wiring shall be provided in accordance with the manufacturer's written instructions. Shielded conductors shall be provided and routed in dedicated conduits, all in separate conduits runs end to end.
- H. Align the motor shaft with driven equipment according to manufacturer's written instructions.
- I. Field damaged factory finish on equipment shall be touched-up with paint that is equal in quality and color to the original factory finish and in accordance with Specification Section 09900.

3.04 FIELD CHECKS AND TESTS

- A. Field Checks
1. Check power and accessory connections for all motors.
 2. Confirm correct rotation for all motors.
 3. Confirm that the motor and coupled load are properly aligned, rotate freely, and are not binding.
 4. Check all motors for correct clearances and proper installation of all safety guards and screens.
 5. Check all motors for correct lubrication and correct any identified deficiencies in accordance with the manufacturer's written instructions.

B. Field Tests

1. Contractor shall megger (1000 volts, DC) each motor winding before energizing the motor. If the insulation resistance is found to be low, Contractor shall notify the District and shall not energize the motor. Insulation resistance shall be measured after one (1) minute of megger test run, and all readings shall be recorded.
2. Operating tests shall be performed on the motor driven equipment to observe that motors start, run, and stop satisfactorily. Contractor shall submit field data to the District. The data shall indicate the full load current for each motor, and current rating for the overload relay in each motor starter and controller.

END OF SECTION 16150

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