

SPECIFICATIONS - DETAILED PROVISIONS
Section 16151 - Vertical Hollowshaft Electric Motors

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SECTION 16151
VERTICAL HOLLOWSHAFT ELECTRIC MOTORS

PART 1 - GENERAL

1.01 SCOPE

- A. This section specifies the electrical requirements for vertical hollowshaft (VHS) squirrel-cage induction motors. VHS motors shall be supplied by the manufacturer of the driven equipment as specified in this section, Specification Section 16150, 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 VHS motors, accessories, and appurtenances as specified herein, as specified in Section 16150, 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 SPECIFIC PROJECT REQUIREMENTS

Specific project requirements are provided in Section 11936.1, Vertical Turbine Pumps (Custom) for rated horsepower and speed. Contractor shall coordinate the base dimensions of the pump discharge head assembly and the VHS driver prior to fabrication and delivery to project site.

1.03 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 VHS motor driven equipment.
 - 2. Section 11936 - Vertical Turbine Pumps

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3. Section 16010 - General Electrical Requirements
4. Section 16050 - Basic Electrical Materials and Methods
5. Section 16150 – Induction Motors
6. Section 16160 - Variable Frequency Drives
7. Section 16480 - Motor Control Centers, Switchboards, and Panelboards
8. Section 17005 - General Instrumentation and Control Components

1.04 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
- 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)

1.05 SUBMITTALS

- A. Contractor shall prepare and submit complete Shop Drawings as specified in Section 16150.
- B. Contractor shall prepare and submit complete Operation and Maintenance Manuals as specified in Section 16150.

1.06 QUALITY ASSURANCE

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

Motors shall comply with all requirements specified in Section 16150, as applicable to VHS motors, except as modified herein.

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 with variable torque.
 - e. Compatible with the VFD system to be supplied including peak output voltage and switching frequencies.
 - f. Motor bearings shall be protected from shaft current produced by common mode voltages and other electromagnetic interaction of the motor and VFD.
 - g. 30 hp and larger motors shall be provided with a shaft grounding device (ring) on the drive end.
 - h. 100 hp and larger motors shall be provided with insulated bearings and a shaft grounding device.
 - i. 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.
 - j. Rated for a service factor of 1.0.
 - k. Where the driven equipment specifications require torsional calculations and analyses, VHS motor manufacturer shall provide the driven equipment manufacturer with all necessary information and data for the proposed motor.

2. 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). 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, VHS motor electrical requirements shall be as follows:

- A. Voltage and Frequency
 1. Motors shall be rated for 460 V, 3-phase, and 60 Hz power.
 2. 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-hygroscopic materials. As a minimum, motors shall be furnished with two dips and bakes in 100% solids, polyester or epoxy resin.
2. Motors constructed in NEMA frames 320 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. VHS motors installed indoors shall be furnished with one VPI cycle of 100% solid resins. VHS motors installed outdoors shall be furnished with two VPI cycles of 100% solid resins to provide moisture-resistant windings.

2.03 MECHANICAL REQUIREMENTS

A. Frame Sizes

Motor frame sizes shall be NEMA frame size designations for sizes 180 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 VHS 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.
3. Unless specified otherwise in the individual equipment sections of the driven equipment, VHS motor enclosures shall be Open Drip-Proof (ODP) Weather Protected Type I, or Totally Enclosed Fan Cooled (TEFC).
4. Enclosures for severe duty VHS motors shall be TEFC.
5. All frames shall be provided with cast-in lifting lugs, unless cast-in lifting lugs are provided on the end shields.
6. Condensation drains shall be provided in the lowest point of the lower end shield.

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C. Windings and Winding Protection

Windings and winding protection shall be provided as specified in Section 16150.

D. Bearings

1. 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 and lubrication shall be suitable for the specified ambient temperature and temperature rise.
2. VHS motor bearings shall be capable of withstanding high thrust loads. VHS motor manufacturer shall design thrust bearings to carry upward or downward thrust that a pump or other driven equipment may impose during starting, shutdown, or during any other operation.
3. Unless specified otherwise, bearings shall be rated for an L-10 life of 8,800 hours (minimum).
4. Thrust Bearings
 - a. As a minimum, VHS motors shall be provided with an angular contact thrust bearing and ball type guide bearing.
 - b. Tandem angular contact thrust bearings or spherical roller type bearings shall be provided as required for extra high thrust applications.
 - c. Back-to-back angular contact bearings shall be provided where required for upward thrust protection.
 - d. Drive couplings shall be suitable for the thrust protection provided.
5. Guide Bearings
 - a. Guide bearings shall be deep-groove ball type and shall be located at the bottom of the motor.
 - b. Guide bearings or bearing assemblies shall be provided with sufficient means for preventing the leakage of lubricant or the entrance of foreign matter along the shaft.

6. Lubrication

- a. Thrust bearings shall be oil or grease lubricated. Oil lubricated bearings contained in an oil reservoir shall be provided with an oil sight level gauge and oil fill and drain openings with plugs.
- b. Guide bearings shall be grease lubricated.
- c. Grease lubricated bearings shall be provided with grease fittings and relief plugs extended to the outer periphery of the end shield to allow for in-service lubrication. Relief plugs shall be provided to protect against over lubrication.

E. Steady Bushing

Unless specified otherwise, each VHS motor shall be provided with a steady bushing. Steady bushings shall be constructed of SAE 660 bearing bronze (or equivalent). Steady bushings shall be designed to eliminate shaft whip and provide the mechanical stability of a vertical solid shaft motor. Steady bushing selection and installation shall be coordinated with the manufacturer of the driven equipment.

2.04 ACCESSORIES AND OPTIONS

VHS motors shall be furnished with accessories and options specified in Section 16150, and the following:

A. Non-Reversing Ratchet

When possible, provide non-reversing ratchets for VHS motors driving pumping equipment. Contractor shall coordinate with the pumping equipment manufacturer and VHS motor manufacturer to ensure it is suitable for the pumping application. Contractor is responsible for confirming the driven assembly inertial force does not exceed the capacity of the non-reversing ratchet. If non-reversing ratchet cannot resist the torque generated from inertial forces, then the motor and driven equipment shall be capable of withstanding reverse rotation without damaging the motor or driven equipment.

For inverter rated VHS motors operating with VFD systems, motor manufacturer shall ensure that the non-reversing ratchet will not interfere with motor operation at the minimum pumping unit speed, including causing a locked rotor or VFD tripping.

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.
 - 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.

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- 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 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 16151

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