Section 16220

ELECTRIC MOTORS

PART 1 - GENERAL

1.1 THE REQUIREMENT

A. General: The 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.

1.2 REFERENCE SPECIFICATIONS, CODES, AND STANDARDS

A. All work specified herein shall conform to or exceed the applicable requirements of the referenced portions of the following publications to the extent that the provisions thereof are not in conflict with other provisions of these Specifications.

NEC	National Electrical Code
NEMA MG 1	Motors and Generators
NEMA MG 2	Safety Standard for Construction and Guide for Selection, Installation and Use of Electric Motors and Generators
NEMA MG 10	Energy Management Guide for Selection and Use of Polyphase Motors
IEEE 43	Recommended Practice for Testing Insulation Resistance of Rotating Machinery
IEEE 85	Standard Test Procedure for Airborne Sound Measurement on Rotating Electric Machinery
IEEE 112	Standard Test Procedure for Polyphase Induction Motors and Generators.
IEEE 113	Guide on Test Procedures for DC Machines
IEEE 115	Test Procedure for Synchronous Machines

1.3 CONTRACTOR SUBMITTALS

A. Submittals shall be made in accordance with the requirements of Section 16010, Electrical General Provisions.

B. Complete motor data shall be submitted with the driven machinery shop drawings. Motor data shall include:

1. Machine name and specification number of driven machine.

2. Motor manufacturer

3. Motor type or model and dimension drawing

4. Nominal horsepower

5. NEMA design

6. Frame size

7. Enclosure

8. Winding insulation class and treatment

9. Rated ambient temperature

10. Service factor

11. Voltage, phase, and frequency rating

12. Full load current at rated horsepower for application voltage

13. Starting code letter, or locked rotor kVA, or current

14. Special winding configuration such as part-winding, star-delta: Include winding diagram

15. Rated full load speed

16. Power Factor at full load

17. Noise certification and data sheet.

18. Replica of motor nameplate

19. Bearing types and catalog numbers

C. Shop drawings submitted by the manufacturer of equipment with motors not shown by the Contract Documents shall specify the size and type of controls required.

D. If water cooling is required for motor thrust bearings, the shop drawing submittals shall indicate this requirement.

1. The following submittals and specific information shall be provided.

2. General Description:

a. Motor dimensional drawings: Net motor weight shall be noted on the dimensional drawings. Shipping weight shall also be noted if motors are to be shipped separately from the driven equipment.

b. Complete motor rating and enclosure type

c. Lists of special characteristics and features being provided as specified

d. Thrust bearing life

e. Type of thrust bearing lubrication

f. Type of guide bearing lubrication

g. Statement that carbon brushes are being provided that are suitable for the low speed, continuous operation specified

3. Motor 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. Motor no-load current at rated voltage

f. Full load current at rated voltage

g. Full load current at 110 percent voltage

h. Starting current at rated voltage

i. Full load speed

j. Certified copy of test report for identical motor tested in accordance with NEMA MG 1-12.53a and IEEE Standard 112, Test Method B, showing full load efficiency not less than specified value. Motors not as specified will be rejected.

k. Recommended maximum kVAR of power factor correction capacitors when capacitors are switched with motor

l. Time in seconds motor can be subjected to locked rotor current at rated voltage without damage to motor with (1) motor initially at rated ambient temperature, and (2) with motor initially at rated temperature rise.

m. Speed torque curves

4. Motor Tests and Test Reports:

a. Certified copies of test reports on actual motors being provided

b. Short commercial tests, including running light current at rated voltage, high potential, and locked rotor current

1.4 QUALITY ASSURANCE

A. Quality assurance shall be in accordance with all applicable requirements of Section 16010, Electrical General Provisions.

B. Adjustable frequency driven motors shall be tested as an assembly with the drive and the driven equipment prior to delivery to the site.

1.5 SERVICES OF MANUFACTURER'S REPRESENTATIVE

A. Where motors are part of packaged equipment such as Bridge Crane and Air-Conditioning Unit, a qualified manufacturer's representative shall supervise the unpacking, installation and field testing.

PART 2 - PRODUCTS

2.1 MOTOR DESIGN AND MANUFACTURERS

A. Unless otherwise specified in Divisions 11, 13, 14 and 15 in which the design equipment is specified, all 3-phase motors shall be squirrel-cage induction, constant speed, have anti-friction bearings and be in accordance with all NEMA standards. The motors shall be totally enclosed fan cooled (TEFC) with Class F insulation, and have a minimum service factor of 1.15 at 40°C ambient, and stainless steel automatic breather-drains at the lowest point of the motor enclosure. All two-speed motors shall have dual windings.

B. All single-phase motors, unless otherwise specified, shall meet all NEMA standards, be TEFC, with anti-friction bearings, Class F insulation, and have a 1.15 service factor at 40°C ambient.

C. All motors larger than 3 horsepower shall be premium efficiency, cast iron, corrosive resistant, hostile environment design, BALDOR "ECP", Reliance "XE", U. S. Motors "Corro-Duty," National Oil Well, or equal. Motors less than 3 horsepower shall be of cast iron, steel or aluminum construction, premium efficiency, and corrosive resistant, hostile environment design.

D. The CONTRACTOR and equipment manufacturer, regardless of Contract Documents, shall be responsible for providing motors and controls adequately sized so the nameplate rating will not be exceeded under the maximum design capacity of the equipment supplied. The service factor shall not be used without prior approval from the ENGINEER.

E. All motor nameplates shall be stainless steel, permanently secured to the motor, and provide the following information: (1) NEMA design letter, (2) voltage, (3) phases, (4) frequency, (5) horsepower, (6) full load current, (7) class of insulation, (8) full load RPM, (8) ambient temperature/service factor, (10) time rating, (11) KVA code, (12) frame size, (13) Mfg. type or model, (14) Mfg. catalog number with date code, and (15) serial number.

2.2 MATERIALS

A. Materials and equipment shall be standard products of established manufacturers who have produced continuously the type of equipment specified. All equipment and material shall be new and of high quality insuring long life and reliable operation.

2.3 SERVICE CONDITIONS

A. Motors shall be designed and manufactured for continuous severe duty service.

2.4 RATING AND APPLICATION

A. Motors shall be rated in accordance with the following, unless otherwise specified.

1. Motors below 1/2 hp shall be rated 115 volts, single phase, 60 Hertz and shall be of the capacitor-start, induction-run type.

2. Motors 1/2 hp through 200 hp inclusive shall be rated 460 volts, three phase, 60 Hertz.

3. Motors 250 hp and above shall be rated three phase, 60 Hertz and voltage as specified.

B. The design and construction of all motors shall be coordinated with the driven equipment requirements.

C. Motors shall be designed for full-voltage starting and rated for continuous operation as shown on the Contract Drawings.

D. Motors shall operate successfully under running conditions at rated load at plus or minus 10 percent of rated voltage or plus or minus 5 percent of rated frequency or a combination of the two.

E. In sizing motors, the horsepower rating of the motor, as stamped on the nameplate, shall not be exceeded during any operating conditions of the driven equipment.

F. Starting current at full voltage shall not exceed 650 percent of the motor full load current for all integral horsepower alternating current motors.

G. 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.

H. Motor fans shall be suitable for rotation in either direction. They shall be nonsparking, corrosion resistant material, accurately balanced before assembly on the motor.

I. All motors shall be NEMA Design "B" unless otherwise specified on the motor data sheet, or required by the application.

J. Totally enclosed motors shall be "Severe Duty Chemical Service" type including shaft seals, internal surfaces coated with corrosion resistant paint or epoxy varnish, external surfaces coated with alkyd paint or epoxy enamel.

K. All motors shall be "premium efficiency" design, capable of operating at a higher normal efficiency than the standard industry design.

1. Motors built in NEMA Frames 143T through 445T shall have the guaranteed efficiency stamped on the nameplate. The basis for motor efficiency evaluation shall be IEEE test procedure 112, Method B, using accuracy improvement by segregated loss determination including stray load loss measurements.

2. Motors built in frames larger than 445T shall have the guaranteed efficiency stamped on the nameplate. The test method used in determining efficiency (e.g. Method B-Dynamometer, Method E-Input or Method F-Equivalent Circuit) shall be designated by the CONTRACTOR.

2.5 TERMINAL BOXES

A. Terminal boxes of the split type shall be furnished for each motor unless the base or housing of the motor is of a design which incorporates provisions for incoming cables.

B. Terminal boxes shall have sufficient interior space to permit incoming power cables as sized per contract documents to be properly terminated. If necessary, over-sized power terminal boxes shall be provided by the manufacturer. For the blower motors, terminal box shall be sized adequately to accommodate installation of three current transformers by the CONTRACTOR.

C. Separate terminal boxes shall be furnished for each accessory device, such as space heaters, temperature detectors, and other items.

D. All boxes shall be heavy duty class, weather tight and thoroughly coated internally and externally with corrosion-resistant paint.

2.6 INSULATION

A. The insulation system shall be Class F with Class B temperature rise .

B. Motors constructed in NEMA Frame 364 and larger, except totally enclosed motor, shall be vacuum pressure impregnated with 100 percent solids epoxy resins. The completed insulation shall have a minimum resistance of 10 megohms after 168 hours of testing in a humidity chamber maintained at 100 percent relative humidity and 40 degrees C ambient. In addition, motors with form wound coils shall also meet NEMA MG1-20.48 Qualification Test.

C. Totally enclosed motors shall be dipped and baked in epoxy resin. The completed insulation shall have a minimum resistance of 1.5 megohms after testing as in 2.5B above.

2.7 BEARINGS AND LUBRICATION - HORIZONTAL MOTORS

A. All horizontal motors rated 200 hp and below shall have anti-friction bearings, selected to provide an L10 life of 100,000 hours for direct connected motors and 17,500 hours for belt or chain drive motors when belted or chain driven in accordance with the information contained on the data sheets. Further, bearings shall be regreasable while running via installed grease fittings.

B. Bearings on horizontal motors rated 250 hp and larger shall be anti-friction or sleeve-type as indicated on the individual Motor Data sheet(s). Bearings shall be constructed and provided with seals so that dirt, moisture, or lubricant leakage around seals will not enter the motor.

C. Motors which have split capsule type sleeve bearing and split bearing brackets shall be designed to permit bearing replacement without removing the bottom bearing bracket. Reservoirs shall be provided with drains, tapped fill openings and separate level gage glasses. Oil throwers and catchers and close running shaft seals shall be designed to prevent oil escape from the bearings and creepage along the shaft. Vents for equalizing bearing oil pressure shall be provided with screens and caps to prevent the entrance of rodents and the like.

D. Motors with sleeve bearings shall have a minimum motor rotor end float and a maximum coupling end float in accordance with NEMA MG1.

E. The requirement for bearing temperature protection will be specified on the individual motor data sheets. When specified, protection shall be resistance type bearing temperature detectors 120 ohms at 0 degrees C tip sensitive with leads brought out to the head of the device where suitable connection can be made. The detector holder and head assembly shall be suitable for the area classification in which the motors will be installed. The detectors shall sense the temperature at the outer shell of sleeve type bearings.

F. Motors shall be greased type and lubricated with Chevron SRI grease NLGI-2 or equal.

2.8 BEARINGS AND LUBRICATION - VERTICAL MOTORS

A. Vertical motors shall be solid shaft or hollow shaft and bearings shall be anti-friction type grease.

B. Motors for "Process" or "In-Line" service shall be "In-Line, Solid Shaft" type construction with a clamped and locked bearing arrangement. Mounting and shaft extension dimensions and tolerances shall be in accordance with NEMA MG1-18.620 or 18.625. The bearings shall be rated for a L10 minimum life of 2 years or 17,500 hours at the maximum expected up or down thrust the driven equipment may impose during startup or operation at any capacity including shutoff.

2.9 SPACE HEATERS

A. Space heaters shall be supplied to maintain the interior of the motor enclosure above the dew point on all motors 30 hp and larger installed outdoors and on all motors 50 hp and larger installed indoors.

B. Heaters shall be unaffected by the accumulation of moisture and shall have terminals adequately protected against moisture under severe weather conditions. Heaters shall be mounted on noncombustible material and shall operate without thermal damage to the motor or themselves. Heaters shall be rated 120 volts single phase. They shall have a maximum sheath temperature of 200 degrees C.

C. Leads for the heaters shall be brought out into a terminal box separate from the main power leads terminal box or in a separate cabinet, if required.

D. Where motors are provided with space heaters, warning nameplate shall be red background with white letters and shall read: "CAUTION - CONTAINS AN EXTERNAL VOLTAGE SOURCE."

2.10 WINDINGS AND VIBRATION PROTECTION

A. Stator windings shall be copper.

B. All Motors from 20 to 100 hp controlled by variable frequency drives shall be supplied with thermostats in two phases as a minimum. All motors above 100 hp controlled by variable frequency drives shall be equipped with 6 RTDs in stator windings and 2 RTDs in motor bearings. The RTDs shall be 100 ohms platinum.

C. All constant speed motors 200 hp and larger shall be equipped with six RTDs in stator windings (two per phase) and two RTDs in motor bearings. The RTDs shall be 100 ohms platinum.

D. Motors **for TFPS pumps**~~200 hp and above~~ shall be equipped with a vibration monitoring system. Refer to Specification 17240. The vibration monitoring system shall be wired to control panel or PLC to activate an alarm in case of abnormal motor vibration.

2.11 GROUNDING

A. Each motor shall have a threaded hole in the motor frame with either a bronze bolt and lock washer or a bronze post-type connector for connection to an external ground conductor. The hole shall be for a 1/2 inch bolt or post-type connector except for motors of 100 hp or less where the size of the bolt or post-type connector may be 3/8 inch. The hole in the motor frame shall be threaded to a depth not less than 1 1/2 times the diameter of the hole to ensure a firm connection. If necessary, a metal pad shall be bonded to the motor frame to provide this depth for the threaded hole. The grounding means shall be located on the same side of the motor as the main lead terminal box.

2.12 SUBMERSIBLE MOTORS

A. The pump motor shall be a squirrel-cage induction, shell type design, housed in an air-filled or an oil-filled, watertight chamber, NEMA B type with a service factor of 1.15 based upon nameplate rating. The manufacturer shall furnish an unqualified warranty guaranteeing (full replacement at no cost to the DISTRICT) the performance of the motors furnished under this project for a period of five years when operating under the specified conditions. The stator winding and stator leads shall be insulated with moisture resistant Class H insulation, which shall be rated at a temperature of 155 degrees C. The motor shall be designed for continuous duty, capable of sustaining a minimum of 12 starts per hour. The temperature rise of the motor shall not be in excess of that specified in NEMA MG-1 for class B insulating materials when operating continuously under load. The junction chamber, containing the terminal board, shall be hermetically sealed from the motor. Connection between the cable conductors and stator leads shall be made with threaded compressed type binding post permanently affixed to a terminal board. The submersible electrical cable shall be of sufficient length to reach the junction box indicated.

1. The cooling system may be of the oil filled or air filled motor housing type. Thermal sensors shall be provided for motors 10 horsepower and larger to monitor stator temperatures. The stator shall be equipped with three thermal sensors, embedded in the end coils of the stator winding (one sensor in each stator phase). These shall be used in conjunction with external motor overload protection and wired to the control panel. The design shall be suitable for continuous motor operation at listed motor rating in 95 degree F water.

2. The cooling system may rely on radiation of excess heat energy to the fluid in the wet well or, alternatively, the pumped fluid via a closed circuit circulating system utilizing either oil or glycol, or a combination of these. It is specifically required that the cooling system must be compatible with the contemplated control schedule, which may require that the motor case to be exposed continuously or intermittently. Cooling systems shall not employ the pumped fluid to directly cool the motor through wastewater passageways incorporated into the motor shell. It is preferred that the motor be cooled by the wastewater via fins incorporated into

the motor shell. If an internal liquid circulation system is employed for cooling purposes, the liquid shall be glycol or heat transfer oil, which shall in turn circulate past heat exchange surfaces incorporated into the cavity behind the pump impeller.

3. If the motor is an oil-filled type, it shall be positively cooled by circulating oil through the windings to passages within the pump designed as a heat exchanger to transfer heat to the pumped fluid. Vanes cast into the rear impeller shroud shall be provided to circulate pumped flow past a heat exchanger in the shaft seal area to provide the required cooling. Cooling water passages in the motor's shell are specifically prohibited. The system shall be designed to prevent clogging by virtue of dimensions and configuration and shall be specifically configured to maintain motor temperatures within conservative limits.

4. Moisture Detectors: All motors shall be provided with an electronic moisture detection system. The leakage sensor shall be located in the motor housing and shall be specifically designed to detect the presence of water in the motor housing. All moisture detectors shall be wired to the junction box for connection to the specified monitoring system.

2.13 INVERTER DUTY MOTORS:

A. Motors for use with adjustable frequency controllers shall be inverter duty motors specifically designed for inverter service for the speed range and load torque characteristic required by the associated driven equipment. Inverter duty motors shall be specifically certified compatible with the adjustable frequency controller and driven equipment.

B. Motors for use with adjustable frequency controllers shall not exceed NEMA MG 1, Class B temperature rise when operating over the specified speed range on the adjustable frequency controllers specified with the specified load speed/torque characteristic.

C. Inverter duty rated motors shall have 4:1 turndown with variable torque motor controllers or constant torque motor controllers rating designed to operate from 25% of base speed to base speed continuously with full load current and torque without exceeding the Class F insulation with B temperature rise.

D. Torque requirement for greater turndown and slower speed applications is a custom design; refer to the driven equipment specification for additional requirements. Inverter duty rated motors shall be designed to operate over the speed or frequency range specified.

E. Motor insulation shall be designed to meet 2000-volt peak at a minimum of 0.1 micro-second rise time which exceeds the NEMA MG 1, Part 31: 1600-volt peak requirement for the 460 volt motors.

F. Provide inverter duty motors with temperature protection per the requirements of Section 16220-2.10.B for monitoring by the adjustable frequency controller and shutdown where the temperature exceed 165 degree-Centigrade.

G. Inverter duty motors shall have electrically insulated bearings or shall be equipped with a shaft-grounding unit mounted on the fan housing with stub shaft extended from the motor shaft. Larger motors, using the shaft-grounding unit, shall be equipped with two brushes, totally enclosed, and sealed against environmental contamination.

2.14 BALANCE AND VIBRATION

A. Motors shall be dynamically balanced. Method of measuring dynamic balance shall be when measured in accordance with NEMA MG1-12.06 or MG1-20.52 and with the maximum amplitude values as shown in NEMA MG1-12.05.

B. Motors shall have maximum peak-to peak amplitude of vibration in accordance with MG1-20.52 when measured in accordance with MG1-12.06 B or MG1-20.53.

2.15 NOISE

A. Maximum sound pressure levels 3 feet from any motor shall not exceed 85dbA.

B. All motors shall be "quiet line" type and shall be so indicated on the submittals, Quiet Line type motors shall be capable of operating at a lower noise level than the standard industry design.

C. Measurement procedures shall in general be guided by the provisions of IEEE Publication No. 85.

2.16 NAMEPLATES

A. Each motor shall have a corrosive-resistant nameplate containing information in accordance with NEMA MG1. In addition the service factor and efficiency shall be included. For motors of 250 hp and larger, the nameplate shall also state any limitations on the number of starts per day, and conditions of restarting.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Motors shall be installed in accordance with Division 11, EQUIPMENT, Division 13, SPECIAL CONSTRUCTION, Division 14, CONVEYING SYSTEMS, Division 15, MECHANICAL, Division 16, ELECTRICAL and in accordance with the manufacturers recommendations.

B. CONTRACTOR shall make provision to protect motors from moisture by connecting space heaters. The space heaters shall be connected while in storage and/or before equipment start-up.

* * * * * *