SECTION 16220 - MOTORS

PART 1 - GENERAL

1.01 SUMMARY

A. Section applies, in general, to all electric or DC motor-driven equipment provided under Divisions 2 through 16 Sections. This Section shall supplement the detailed Equipment Specifications, but in cases of conflict, the Specifications indicated in this Section shall govern.

1.02 SUBMITTALS

A. Shop Drawings: Submit in accordance with Section 01300, Shop Drawings covering the items included under this Section. Shop Drawing submittals shall include:
   1. Summary Sheet: Submit sheet that lists in tabular or matrix style the manufacturer, model and applicable part number for each piece of equipment. List shall include ratings and selected options.
   2. Product Data: Submit manufacturer's data (cut sheet) on motors and associated accessories. Only submit sheets that contain the equipment submitting. If a sheet contains other information, the spurious information shall be crossed out.
   3. Submittals for motors shall accompany the specific equipment the motor is to be supplied with.
      a. Submit product literature for each motor.
      b. Certification of motor bearing vibration testing.
      c. Certificate of compatibility with variable frequency drives.
      d. Other certified standard commercial test reports.

B. Operation and Maintenance Manuals: Submit in accordance with requirements of Section 01782, operation and maintenance manuals for items included under this Section.
   1. Summary Sheet: Submit sheet that lists in tabular or matrix style the manufacturer, model and applicable part number for each piece of equipment. List shall include:
      a. Megger readings
      b. Amp draw per phase under load,
      c. Recommended maintenance schedule.

1.03 QUALITY ASSURANCE

A. Electrical Codes, Ordinances, and Industrial Standards: The design, testing, assembly, and methods of installation of the wiring materials, electrical equipment, and accessories proposed under this Contract shall conform to the National Electrical Code and to applicable State and local requirements. UL listing and labeling shall be adhered to under this Contract. Any equipment that does not have a UL, FM, CSA, or other listed testing laboratory label, shall be furnished with a notarized letter signed by the supplier stating that the equipment furnished has been manufactured in accordance with the National Electrical Code and OSHA requirements. Any additional cost resulting from any deviation from codes or local requirements shall be borne by CONTRACTOR.

PART 2 - PRODUCTS

2.01 MANUFACTURERS

A. Subject to compliance with specified requirements, motors shall be standard design and construction. Manufacturers offering products which shall be incorporated in Work include:
   1. Motors:
      a. Baldor.
      b. Dayton.
      c. U.S. Electric Motors.
      d. Marathon Blue Chip Series
      e. Siemens, Inc.
      f. General Electric Co.
      g. Reliance Electric Co.

B. For motors that are integrally constructed as a piece of equipment, such as appliances, hand tools, etc., and where manufacturer would be required to redesign equipment to meet these general specifications, it is the intent to allow such standard motors to be used, provided they do not exceed 1-1/2 horsepower and are suitable for use on standard power systems.

2.02 MATERIALS

A. Shop primers shall be Tnemec "77 Chem-Prime," or equal.

B. Rust preventive compound shall be equal to Dearborn Chemical "No-Ox-ID2W," Houghton "Rust Veto 344," or Rust-Oleum "R-9".

2.03 MANUFACTURED UNITS

A. Electrical Motors: Motor design and application shall comply with current ANSI, IEEE, NEMA, and AFBMA standards and with the NEC where applicable. They shall be squirrel cage induction motors rated 60 hertz, continuous duty for use in 40 degrees C ambient temperature. Motors shall comply with NEMA MG1-1993, Rev. 1, Part 31, Definite Purpose Inverter-Fed Motors whether used with variable frequency drives or not.
   1. The motors shall be sized within their rated loads under the specified conditions without utilizing the top 15 percent of the 1.15 service factor. Motor sizing measured at the motor output shaft shall include all loadings on the motor. Motor loadings shall include the maximum or specified load condition of the driven equipment plus all drive losses of components, located between the motor and the driven equipment.
   2. The motor winding temperature rise shall be NEMA Standard for the class of insulation used at the rated service factor load.
   3. Bearings shall be regreasable, double-shielded, antifriction ball bearings suitable for radial and thrust loading.
   4. The motors shall be capable of handling unfiltered voltage peaks of up to 1600 volts, and rise times of 0.1 micro-seconds.
   5. The motors shall be connected to VFDs utilizing VFD rated cable as directed per the drawings and specifications.

B. Motors 50 horsepower and larger shall have embedded passive temperature switches in the windings for use in the motor control circuit that will limit the winding temperature as defined by NEMA Standard MG1-12.53 Type 1. The contact shall be normally closed and rated to operate a 120 volt AC control relay (40 VA).

C. All integral horsepower motors shall have oversize conduit boxes with clamp-type grounding terminals inside which are effectively connected to all noncurrent-carrying motor parts.

D. All explosion-proof motors shall meet NEC Class 1, Division I, Group D, requirements with T2A temperature rating.

E. Unless these general specifications are supplanted by the detailed equipment specifications, motors shall be rated and constructed as follows:
   1. Below 1/2 Horsepower: Motors shall be rated 115/230 volts, single phase, but shall be suitable for use on 208 volt power system. They shall have permanently lubricated sealed bearings (antifriction type where high radial or axial thrusts are produced by the driven equipment). Standard motors shall be totally enclosed fan cooled, totally enclosed air-over, or totally enclosed nonventilated capacitor start type as shown on Equipment Schedule(s) or specified in the equipment specifications. Totally enclosed explosion-proof motors shall be provided where required per equipment specifications section.
   2. From 1/2 to 1-1/2 Horsepower: Motors shall be rated 115/230 volts single phase or shall be rated 230/460 volts 3-phase as indicated by Equipment Schedule(s). In either case they shall be suitable for use on 208 volt power systems under their given load conditions. They shall have bearings as in 2.03 F.1. The standard enclosures shall be totally enclosed fan cooled, totally enclosed nonventilated, totally enclosed explosion-proof, or open drip-proof as shown on Equipment Schedule(s) or specified in the equipment specifications.
   3. From 2 to 200 Horsepower: Motors shall be rated 230/460 or 460 volt, 3-phase. They shall be grease lubricated, ball bearing, Class B insulated, minimum or as specified. Horizontal motors shall be open drip-proof, totally enclosed fan-cooled or totally enclosed explosion-proof (NEC, Class I, Group D) as shown on Equipment Schedule(s) or specified in the equipment specifications. Vertical motors shall meet NEMA standard open drip-proof specifications as a vertical motor when called for or totally enclosed fan cooled or totally enclosed explosion-proof as shown on Equipment Schedule(s).

F. Horizontal and vertical motors may also be weather protected, Type I, and shall have encapsulated or sealed windings.

G. Open drip-proof type motors shall have encapsulated or sealed windings when called for on Drawings or Equipment Schedules.

H. Special duty and severe environment application shall have motors which are designed specifically to meet the special conditions as specified.

I. Motors above 200 Horsepower: Motors shall be of special design as detailed in specific sections of the Specifications. All special purpose motors, such as wound-rotor, multi-speed, variable speed, etc., shall be as detailed in specific Sections of the Specifications.

J. The following symbols will be employed on Equipment Schedule(s) to indicate the required motor enclosure and construction features:
   1. TE Totally Enclosed, may be nonventilated, fan-cooled or air-over type.
   2. TENV Totally Enclosed Nonventilated.
   3. TEFC Totally Enclosed Fan-cooled.
   4. TEEP Totally Enclosed Explosion-proof, Class I, Div. I, Group D.
   5. ODP Open Drip-proof.
   6. WPI Weather Protected Type I.

7. E/S Encapsulated or Sealed Windings.
   a. All motors with encapsulation or sealed windings shall have a water-tight conduit box.

K. See NEMA Standard MG1 for definition of above terms.

L. Motor Efficiency: Where Equipment Schedule(s) indicate that motors shall be designed for high efficiency, they shall meet or exceed the Motor Operating Characteristics shown on High Efficiency Motor Schedule No. 16220.2, appended to this Section. Guaranteed minimum efficiency at full load shall be based on IEEE Standard 112, Test Method B. Nominal motor efficiencies are average expected values. Manufacturer's motor Shop Drawings shall indicate full compliance with the High Efficiency Motor Schedule No. 16220.2.

M. Medium Voltage Motors (600 volts – 13.2 kV):
   1. Horizontal Motors: The motors shall be induction motors designed for operating on a 3-phase, 60 hertz power system at the voltage indicated on Equipment Schedule(s). The design, construction, and performance characteristics of the motors shall conform to applicable provisions of the latest NEMA, IEEE, and ANSI standards. They shall perform in accordance with their nameplate ratings and be free of any defective material or workmanship.
      a. The motors shall have a horsepower rating based on continuous operation (24 hours per day) at full load without exceeding the rated temperature rise above an ambient of 40 degrees C. The horsepower rating shall be adequate to operate the driven equipment under all normally expected operating conditions without overloading. Minimum full-load efficiency shall be at 92.5 percent and minimum full load power factor shall be 89 percent. Service factor shall be 1.0. Motor insulation shall be Class B or better. The motor temperature rise shall be NEMA standard for the class of insulation used for the rated service factor load. Motor shaft loading shall not exceed rated horsepower.
      b. Motor manufacturer shall be responsible for obtaining the speed-torque characteristics of the driven equipment. Speed-torque curves showing the torque characteristics of both the motor and the driven equipment on the same graph together with WK^2 of both the motor and the driven equipment shall be submitted to ENGINEER. This information is to be included with submittal of outline Drawing for approval.
      c. Motor shall be furnished with twelve (12) 100-ohm (or as required to be accepted as inputs to the motor protective device) platinum RTD Type temperature sensors for the stator windings; 2 sensors per phase per winding; and 2 temperature sensors for motor bearings; 1 sensor per bearing. RTD sensors shall be the 3-wire type and shall be wired to a terminal strip in a common frame mounted terminal box.
      d. Motor insulation shall be full Class B. Coils shall be form wound, vacuum pressure impregnated and compactly shaped to fill the slots. Vacuum pressure impregnation shall be done by treating the entire stator with a minimum of 2 impregnations after the coils are placed in the lots. Winding and end connections shall be fully sealed against contaminants. The stator complete with winding shall be given additional dips and brakes. Motor end turns shall be adequately braced with nonshrinking material and shall withstand the stresses caused by full voltage starting.
      e. Motors shall have weather protected Type I enclosures with top discharge air ventilation openings. Openings shall be equipped with easily removable guard screens. Motors shall have air inlet filters and space heaters.
      f. Space heaters shall be 120 volt AC single phase in frame Sizes under 8600. Space heaters shall be 480 volt, 3-phase in frame Sizes 8600 and larger. Motors with space heaters shall include heater leads in a separate conduit box mounted on the motor frame. The conduit box shall have an access cover.

g. Motors shall have terminal boxes of adequate size for the construction of stress cones on incoming cable, surge arrestors and capacitors, and power factor correction capacitors. Terminal leads shall be minimum of 12 inches long and shall be equipped without lugs. Terminal boxes for motor leads shall have the following minimum dimensions: 20-inch H, 15-inch W, 10-inch D. They shall be diagonally split and furnished undrilled for conduit. The boxes shall be gasketed and suitable for mounting in any direction without allowing water to enter. Each motor shall be equipped with surge arrestor and capacitor overvoltage protection or equal. A power factor correcting capacitor shall be provided for full load power factor correction of 0.96 minimum. Power factor correction capacitors may be floor-mounted with all connections to the motor terminal box being made through flexible conduit.

h. Bearing shall be of adequate size to take the load of the rotor, together with that of such parts of the shaft not carried by the driven machinery. A suitable base of high-grade cast iron shall be provided for mounting the motor.

i. Nameplates shall be metal and be installed with data as required by NEMA and also show locked rotor current and lead connection diagram.

j. The maximum overall noise level shall not exceed the level defined in the latest revision of NEMA Standard MG1-12.49 or MG1-20.49, whichever is applicable to the particular machine.

k. Certified routine shop tests shall be made on each motor for motors 1,500 horsepower or smaller. Full running shop tests shall be made on each motor larger than 1,500 horsepower. Test results shall be submitted to ENGINEER for ENGINEER's record.

l. Provisions for mounting a vibration motor sensor on each motor shall be provided. The mountings for the vibration sensors shall consist of a threaded mounting hole 1/2-20 UNF 2B 0.400-inch minimum depth full threads. Hole shall be located perpendicular, within 0.010-inch/inch, to the center line of a raised 2.0-inch diameter machined flat surface. Machined surface shall be flat within 0.005 inch. The machine surface is to be located on a raised boss on the bearing housing. The machined surface is to be oriented vertically and parallel plus or minus 3 degrees to the shaft center line such that the threaded hole is horizontal and perpendicular to the shaft center line within plus or minus 5 degrees.

2. Vertical Motors: The motors shall be induction motors designed for operation on a 3-phase, 60 hertz power system at the voltage indicated on Equipment Schedule(s). Motor housing shall be designed for vertical use and meet the NEMA specifications as a vertically oriented motor. The design, construction and performance characteristics of the motors shall conform to applicable provisions of the latest NEMA, IEEE, and ANSI Standards. They shall perform in accordance with their nameplate rating and be free of any defective material or workmanship.

   a. The motors shall have a horsepower rating based on continuous operation (24 hours per day) at full load without exceeding 40 degrees C. The horsepower rating shall be adequate to operate the driven equipment under all normally expected operating conditions without overloading. Minimum full load efficiency shall be 92.5 percent and minimum full load power factor shall be 89 percent. Service factor shall be 1.0. Motor insulation shall be Class B or better. The motor temperature rise shall be NEMA standard for the class of insulation used for the rated service factor load. Motor shaft loading shall not exceed rated horsepower.

   b. Motor manufacturer shall be responsible for obtaining the speed torque characteristics of the driven equipment. Speed-torque curves showing the torque characteristics of both the motor and the driven equipment on the same graph together with WK^2 of both the motor and the driven equipment shall be submitted to ENGINEER. This information is to be included with submittal of outline Drawing for approval.

c. Motors shall have passive temperature switches for use in the motor control circuit that will limit the winding temperature as defined by NEMA Standard MG1-12.53 Type 1. The contacts shall be normally open and rated to operate a switchgear control relay in either a 250 volt AC (40 VA) or 125 volt DC (12W) control circuit.

d. Coils shall be form wound, vacuum pressure impregnated and compactly shaped to fill the slots. Vacuum pressure impregnation shall be done by treating the entire stator with a minimum of 2 impregnations after the coils are placed in the slots. Winding and end connections shall be fully sealed against contaminants. The stator complete with winding shall be given additional dips and brakes. Motor end turns shall be adequately braced with nonshrinking material and shall withstand the stress caused by full voltage starting.

e. Motors shall have weather-protected Type I enclosures with top discharge air ventilation openings. Openings shall be equipped with easily removable guard screens. Motors shall have air inlet filters and space heaters.

f. Space heaters shall be 120 volt AC single phase in frame Sizes under 8600. Space heaters shall be 480 volt 3-phase in frame Sizes 8600 and larger. Motors with space heaters shall include heater leads in a separate conduit box mounted on the motor frame. The conduit box shall have an access cover.

g. Motors shall have terminal boxes of adequate size for the construction of the stress cones on the incoming cable and any other connections such as surge and power factor correction capacitors and surge arrestors. Terminal leads shall be minimum of 12 inches long and shall be equipped without lugs. Terminal boxes for motor leads shall have the following minimum dimensions: 20-inch H, 15-inch W, 10-inch D. They shall be diagonally split and furnished undrilled for conduit. The boxes shall be gasketed and suitable for mounting in any direction without allowing water to enter. Each motor shall be equipped with a General Electric Co. or Westinghouse "Surge-Pac," or equal, overvoltage protection. A power factor correcting capacitor shall be provided for full load power factor correction of 0.96 minimum. The Surge-Pac and capacitor shall meet the Specifications of Division 16. The terminal box, Surge-Pac, and power factor correction caps shall be floor-mounted with all connections to the motor housing being made through flexible conduit.

h. Line and thrust bearing shall be of adequate size to take the load of the rotor, together with that of such parts of the shaft not carried by the driven machinery. A suitable base of high-grade cast iron shall be provided for mounting the motor. Adequate provisions must be made at the top of the motor for adjustments to the drive shaft. The motors shall have a protected head cover with a suitable lifting ring or rings.

i. Nameplates shall be metal and be installed with data as required by NEMA and also show locked rotor current and lead connection diagram.

j. The maximum overall noise level shall not exceed the level defined in the latest revision of NEMA Standard MG1-12.49 or MG1-20.49, whichever is applicable to the particular machine.

k. Certified routine shop tests shall be made on one motor out of each size group for motors 1,500 horsepower or smaller. Full running shop tests shall be made on each motor larger than 1,500 horsepower. Test results shall be submitted to ENGINEER for ENGINEER's record.

l. Provisions for mounting a vibration motor sensor on each motor shall be provided. The mountings for the vibration sensors shall consist of a threaded mounting hole 1/2-20 UNF 2B 0.400-inch minimum depth full threads. Hole shall be located perpendicular, within 0.010-inch/inch, to the centerline of a raised 2.0-inch diameter machined flat surface. Machined surface shall be flat within 0.005 inch. The machined surface is to be located on the upper part of the motor, as close top the thrust bearings as practical and between lifting lugs. The machined surface is to be oriented vertically and parallel plus or minus 3 degrees

to the shaft centerline such that the threaded hole is horizontal and perpendicular to the shaft centerline within plus or minus 5 degrees.

2.04 FABRICATION

A. Electric motors shall be shop-finished with 2 coats of enamel paint per manufacturer's recommendations.

PART 3 - EXECUTION

3.01 INSTALLATION

A. Comply with manufacturer's written installation and alignment instructions.

B. Lubricate oil-lubricated bearings.

C. Provide electrical wiring and connections as specified in Division 16 Sections.

3.02 FIELD QUALITY CONTROL

A. Inspect all terminations for proper connection.

B. Check motor for proper rotation.

3.03 INSTALLATION CHECK

A. Installation Check: Manufacturer shall provide the services of a factory-trained representative to check the installation of all equipment installed in this Section. The services shall be as noted in Section 01650. Equipment supplier's representative shall revisit Site as often as necessary until all trouble is corrected and equipment installation and operation is satisfactory to ENGINEER.

B. Manufacturer's representative shall provide all necessary tools and testing equipment required including noise level and vibration sensing equipment.

C. Inspection Report: A written report of the installation check shall be submitted to ENGINEER. The report shall be as noted under Section 01650 certifying that the equipment:
   1. Has been properly installed and lubricated;
   2. Is in accurate alignment;
   3. Is free from any undue stress imposed by any connection or anchor bolts;
   4. Has been operated under full load condition and that it operated satisfactorily to ENGINEER; and
   5. That OWNER's representative has been instructed in the proper maintenance and operation of the equipment.
   6. Furnish OWNER a copy of all test data recorded during the installation check including noise level and vibration readings.

HIGH EFFICIENCY MOTOR SCHEDULE NO. 16220.2
MOTOR OPERATING CHARACTERISTICS

		Efficiency (percent)						
		Guar.						
	RPM	Min.		Nominal		Power Factor (percent)		
HP	Syn.	Full	1/2	3/4	Full	1/2	3/4	Full
1	1800	81.5	78.1	81.0	81.5	54.2	67.3	75.8
	1200	75.5	69.5	75.6	78.5	38.4	49.4	58.3
	3600	78.5	78.4	80.2	81.5	75.3	84.4	88.8
1.5	1800	81.5	79.2	82.9	84.0	52.1	65.1	74.0
	1200	81.5	80.5	83.4	84.0	44.0	56.6	85.6
	3600	81.5	78.8	82.9	84.0	66.3	78.4	85.0
2	1800	81.5	78.8	82.6	84.0	48.9	61.7	70.0
	1200	84.0	83.0	83.6	86.5	46.6	59.6	68.0
	3600	84.0	75.4	84.3	86.5	69.7	80.0	85.6
3	1800	86.5	86.9	88.5	88.5	62.3	73.9	79.9
	1200	86.5	84.5	87.5	88.5	45.9	58.3	68.0
	3600	86.5	86.2	88.2	88.5	71.7	81.7	86.4
5	1800	88.5	84.0	88.2	88.5	68.5	79.2	84.6
	1200	86.5	85.8	88.2	88.5	50.8	63.8	71.9
	3600	86.5	82.9	86.7	88.5	75.9	84.3	88.1
7.5	1800	88.5	89.2	90.3	90.2	66.5	77.2	82.4
	1200	86.5	87.5	88.8	88.5	58.6	68.8	73.7
	3600	86.5	87.7	89.0	88.5	77.1	84.5	87.6
10	1800	88.5	89.3	90.4	90.2	67.6	77.4	81.9
	1200	88.5	89.0	90.3	90.2	60.1	70.2	74.9
	3600	88.5	82.3	87.4	90.2	81.1	87.2	90.4
15	1800	90.2	91.0	91.9	91.7	68.5	78.1	82.3
	1200	88.5	89.9	90.6	90.2	67.4	77.1	81.4
	3600	90.2	89.1	91.1	91.7	83.7	88.5	90.5
20	1800	90.2	90.9	91.9	91.7	68.9	78.1	81.8
	1200	90.2	91.0	91.0	91.7	69.8	78.5	81.9
	3600	90.2	91.6	92.0	91.7	81.9	88.6	90.6
25	1800	91.7	92.8	93.2	92.4	72.7	81.4	84.5
	1200	90.2	90.0	91.4	91.7	79.8	84.5	85.5
	3600	90.2	90.6	91.7	91.7	81.1	87.8	90.3
30	1800	91.7	92.8	93.3	93.0	71.5	80.6	84.2
	1200	90.2	91.7	92.0	91.7	78.9	85.4	86.8
	3600	90.2	89.1	91.2	91.7	83.8	88.6	89.9
40	1800	91.7	91.0	92.6	93.0	71.6	80.6	84.2
	1200	91.7	93.0	93.3	93.0	80.9	86.4	88.0
	3600	90.2	88.7	90.8	91.7	82.5	90.8	92.0
50	1800	93.0	92.4	93.7	94.1	76.4	83.7	86.3
	1200	91.7	93.0	93.3	93.0	80.9	87.3	88.9
	3600	91.7	89.9	92.0	93.0	84.9	89.9	91.6
60	1800	93.0	93.2	94.0	94.1	76.3	84.0	86.8
	1200	91.7	92.5	93.1	93.0	75.8	82.9	85.5
	3600	93.0	91.0	93.1	94.1	82.6	88.7	90.9
75	1800	93.0	92.6	93.8	94.1	76.4	83.8	86.6
	1200	93.0	93.5	94.2	94.1	75.1	82.4	84.7
	3600	93.0	91.3	93.3	94.1	86.1	89.7	91.0
100	1800	94.1	93.8	94.8	95.0	83.8	87.6	89.0
	1200	93.0	93.1	93.9	94.1	72.5	80.0	83.2
	3600	93.0	91.2	93.1	94.1	83.0	88.3	89.0
125	1800	93.7	93.5	94.6	95.0	79.2	84.6	86.0
	1200	93.0	93.5	94.2	94.1	75.2	82.3	85.2
	3600	93.0	91.8	93.4	94.1	85.3	89.3	89.1
150	1800	94.1	93.7	94.7	95.0	81.6	86.4	86.6
	1200	94.1	94.1	94.9	95.0	77.2	84.4	85.7
	3600	94.1	92.7	94.3	95.0	83.3	87.5	88.5
200	1800	94.5	94.2	94.9	95.0	80.0	85.6	86.7
	1200	94.3	94.2	94.9	95.0	78.0	84.5	86.0
	3600	94.3	94.8	95.5	95.3	83.0	87.5	88.5
250	1800	94.3	96.0	96.0	95.8	79.5	85.6	83.0

END OF SECTION