SECTION 23 05 13
MOTOR REQUIREMENTS for HVAC

PART 1 GENERAL

1.1 SECTION INCLUDES
- A. Single-phase electric motors
- B. Three-phase electric motors

1.2 REFERENCES
- A. ABMA 9 - Load Ratings and Fatigue Life for Ball Bearings
- B. ABMA 11 - Load Ratings and Fatigue Life for Roller Bearings
- C. IEEE SA-P112 - Test Procedure for Polyphase Induction Motors and Generators
- D. NEMA MG 1 - Motors and Generators
- E. NFPA 70 - National Electrical Code
- F. 26 28 29 - Motor Controls – Section 26 28 39

1.3 SUBMITTALS
- A. Submit under provisions of Section 01 33 00.
- B. Product Data: Provide wiring diagrams with electrical characteristics and connection requirements.
- C. Test Reports: Indicate test results verifying nominal efficiency and power factor for three-phase motors larger than 5-HP.
- D. Manufacturer's Installation Instructions: Indicate setting, mechanical connections, lubrication, and wiring instructions.

1.4 OPERATION AND MAINTENANCE DATA
- A. Submit under provisions of Section 01 77 00.
- B. Operation Data: Include instructions for safe operating procedures.
- C. Maintenance Data: Include assembly drawings, bearing data including replacement sizes, and lubrication instructions.

1.5 QUALIFICATIONS
- A. Company specializing in manufacture of electric motors and their accessories, with minimum 5-years documented product development, testing, and manufacturing experience.

1.6 REGULATORY REQUIREMENTS
- A. Conform to NFPA 70 - National Electrical Code
- B. Provide certificate of compliance indicating approval of Premium efficiency motors.
- C. Products Requiring Electrical Connection: Listed and classified by Underwriters' Laboratories, Inc., as suitable for the purpose specified and indicated.

1.7 DELIVERY, STORAGE, AND HANDLING
- A. Deliver, store, protect, and handle products to site under provisions of Section 01 60 00.
- B. Protect motors stored on site from weather and moisture by maintaining factory covers and suitable weatherproof covering.

1.8 WARRANTY
- A. All motors shall be provided with a 5-year parts and labor warranty under provisions of Section 01 77 00.

PART 2 PRODUCTS

2.1 GENERAL CONSTRUCTION AND REQUIREMENTS

A. Motors less than 250-watts, for intermittent service, may use the equipment manufacturers' standard motor.

B. Electrical Service
   1. Refer to Section 26 05 19 for required electrical characteristics.
   2. Motors ½-HP and smaller: 115 Volts single-phase 60 Hz
   3. Motors ¾ to 2-HP: 208 Volts single-phase 60 Hz
   4. Motors 3-HP and larger: 480 Volts three-phase 60 Hz

C. Type
   1. Motors located in humid conditions or outdoors shall be TEFC type.
   2. Motors: Design for continuous operation in a 40°C environment
   3. Design for temperature rise in accordance with NEMA MG 1 limits for insulation class, service factor, and motor enclosure type.
   4. Motors with frame sizes 254T and larger: Energy Efficient Type.

D. Explosion-Proof Motors: UL approved and labeled for hazard classification, with over temperature protection.

E. Visible Nameplate: Shall indicate motor horsepower, voltage, phase, cycles, RPM, full load amps, locked rotor amps, frame size, manufacturer's name and model number, service factor, power factor, and efficiency.

F. Wiring Terminations
   1. Provide terminal lugs to match the branch-circuit conductor quantities, sizes, and materials indicated.
      a. Enclose terminal lugs in terminal box sized to NFPA 70, threaded for conduit.
   2. For fractional horsepower motors with a direct connection, provide threaded conduit connection in end frame.

G. Motor Starters
   1. Provide motor starters with under-voltage, phase loss, phase unbalance and phase reversal relay protection with automatic reset between 3 to 5 minutes after motor shut down.
   2. Provide motor starters with overload heaters sized from motor nameplate full load amperage for each phase.
      a. Overload heaters shall be manual reset.
      b. Refer to Sections 262839, "Motor Control", and electrical design.

H. Inverter Rated Motors
   1. All motors used in conjunction with variable frequency drives shall be a Premium efficiency and inverter duty rated.

2.2 SINGLE PHASE POWER - SPLIT PHASE MOTORS

A. Starting Torque: Less than 150% of full load torque

B. Starting Current: Up to seven times full load current

C. Breakdown Torque: Approximately 200% of full load torque

D. Drip-proof Enclosure: Class A (50°C temperature rise) insulation, 1.0 Service Factor, pre-lubricated ball bearings.

E. Enclosed Motors: Class A (50° C temperature rise) insulation, 1.0 Service Factor, and pre-lubricated ball bearings.

2.3 SINGLE PHASE POWER - PERMANENT-SPLIT CAPACITOR MOTORS

A. Starting Torque: Exceeding one fourth of full load torque

B. Starting Current: Up to six times full load current
C. Multiple Speed: Through tapped windings
D. Open Drip-proof or Enclosed Air Over Enclosure: Class A (50°C temperature rise) insulation, minimum 1.0 Service Factor, pre-lubricated sleeve or ball bearings, and automatic reset overload protector.

2.4 SINGLE PHASE POWER - CAPACITOR START MOTORS
A. Starting Torque: Three times full load torque
B. Starting Current: Less than five times full load current
C. Pull-up Torque: Up to 350% of full load torque
D. Breakdown Torque: Approximately 250% of full load torque
E. Motors: Capacitor in series with starting winding, provide capacitor - start /capacitor - run motors with two capacitors in parallel with run capacitor remaining in circuit at operating speeds.
F. Drip-proof Enclosure: Class A (50°C temperature rise) insulation, NEMA Service Factor, and pre-lubricated ball bearings.
G. Enclosed Motors: Class A (50°C temperature rise) insulation, 1.0 Service Factor, and pre-lubricated ball bearings.

2.5 SINGLE PHASE POWER – VARIABLE SPEED MOTORS
A. Brushless DC (BLDC) electronically commutated high efficiency motor.
B. Integrated (built-in) speed controller
C. Single-phase 115 V input
D. Operation range: 20% to 100% of full speed (80% turndown)
E. Motor sizes: ¼, ½, and ¾ HP
F. Control options: 0-10 VDC input wiring, motor mounted dial, or wall mounted dial.
G. Customization options: torque, size, Voltage, current and maximum speed.
H. HVAC Applications: small capacity, variable speed fans and pumps

2.6 THREE PHASE POWER - SQUIRREL CAGE MOTORS
A. Starting Torque: Between one and one-half times full load torque.
B. Starting Current: Six times full load current.
C. Power Output, Locked Rotor Torque, Breakdown, or Pullout Torque: NEMA Design B characteristics.
D. Design, Construction, Testing, and Performance: Conform to NEMA MG 1 for Design B motors.
E. Insulation System: NEMA Class B or better
F. Testing Procedure: In accordance with IEEE 112, load test motors to determine freedom from electrical or mechanical defects and compliance with performance data.
G. Motor Frames: NEMA standard T-Frames of steel, aluminum, or cast iron with end brackets of cast iron or aluminum with steel inserts.
H. Thermistor System (Motor Frame Sizes 254T and Larger): Three PTC thermistors imbedded in motor windings and epoxy encapsulated solid state control relay for wiring into motor starter; refer to Section 262839 - Motor Controls.
I. Bearings: Grease lubricated anti-friction ball bearings with housings equipped with plugged provision for re-lubrication, rated for minimum ABMA 9, L-10 life of 20,000 hours.
    1. Calculate bearing load with NEMA minimum V-belt pulley with belt centerline at end of NEMA standard shaft extension.
    2. Stamp bearing sizes on nameplate.
J. Sound Power Levels: To NEMA MG 1

K. Part Winding Start Above 254T Frame Size: Use part of winding to reduce locked rotor starting current to approximately 60% of full winding locked rotor current while providing approximately 50% of full winding locked rotor torque.
L. Weatherproof Epoxy Sealed Motors: Epoxy seal windings using vacuum and pressure with rotor and starter surfaces protected with epoxy enamel; bearings double shielded with waterproof non-washing grease.
M. Nominal Efficiency: As scheduled at full load and rated voltage when tested in accordance with IEEE 112.
N. Nominal Power Factor: As scheduled at full load and rated voltage when tested in accordance with IEEE 112.

2.7 THREE PHASE POWER – VARIABLE SPEED MOTORS
A. Provide premium efficiency AC inverter duty rated motor suitable for variable frequency drive.
B. Refer to Specification 23 29 23 Variable Frequency Motor Controls.
C. General-purpose motors are not acceptable.

PART 3 EXECUTION

3.1 APPLICATION
A. Single-phase motors for shaft mounted fans: Split phase type.
B. Single-phase motors for shaft mounted fans or blowers: Permanent split capacitor type
C. Single-phase motors for fans, pumps, blowers, and air compressors: Capacitor start type
D. Single-phase motors for fans, blowers, and pumps: Capacitor start, capacitor run type
E. Motors located in exterior locations, wet air streams, air-cooled condensers, direct drive axial fans, dust collection systems: Totally enclosed type (TEFC).
F. Motors located in outdoors: Totally enclosed weatherproof, factory epoxy-sealed type (TEFC).
G. Motors located in draw thru air handling units and cooling towers:
1. Totally enclosed weatherproof, factory epoxy sealed type with special moisture protection package.
2. Fan cooled feature in totally enclosed motors is not required.
3. For additional details refer to Sections 23 70 00 (Air Handling Units) and 23 65 00 (Cooling Towers).

3.2 INSTALLATION
A. Install in accordance with manufacturer's instructions.
B. Install securely on firm foundation.
1. Mount ball bearing motors with shaft in any position.
C. Check line voltage and phase and ensure agreement with nameplate.

3.3 NEMA OPEN MOTOR SERVICE FACTORS SCHEDULE

HP	3600 RPM	1800 RPM	1200 RPM	900 RPM
1/6 - 1/3	1.35	1.35	1.35	1.35
½	1.25	1.25	1.25	1.15
¾	1.25	1.25	1.15	1.15
1	1.25	1.15	1.15	1.15
1½ -150	1.15	1.15	1.15	1.15

3.4 PERFORMANCE SCHEDULE: THREE- PHASE, ENERGY EFFICIENT, OPEN DRIP-PROOF

HP	RPM (Syn)	NEMA Frame	Minimum Percent Efficiency	Minimum Percent Power Factor
3	1200	213T	86	60
5	1200	215T	87	65
7½	1200	254T	89	73
10	1200	256T	89	74
15	1200	284T	90	77
20	1200	286T	90	78
25	1200	324T	91	74
30	1200	326T	91	78
40	1200	364T	93	77
50	1200	365T	93	79
60	1200	404T	93	82
75	1200	405T	93	80
100	1200	444T	93	80
125	1200	444T	93	84
3	1800	182T	86	86
5	1800	184T	87	87
7½	1800	213T	88	86
10	1800	215T	89	85
15	1800	256T	91	85
20	1800	256T	91	86
25	1800	284T	91	85
30	1800	286T	92	88
40	1800	324T	92	83
50	1800	326T	93	85
60	1800	364T	93	88
75	1800	365T	93	88
100	1800	404T	93	83
125	1800	405T	93	86
150	1800	444T	93	85
200	1800	445T	94	85
3	3600	145T	84	85
5	3600	182T	85	86
7½	3600	184T	86	88
10	3600	213T	87	86
15	3600	215T	89	89
20	3600	254T	90	89
25	3600	256T	90	92
30	3600	284T	91	91
40	3600	286T	92	92
50	3600	324T	93	89
60	3600	326T	93	91
75	3600	324T	93	88
100	3600	365T	92	88

3.5 PERFORMANCE SCHEDULE: THREE- PHASE, ENERGY EFFICIENT, TOTALLY ENCLOSED, FAN COOLED

HP	RPM (Syn)	NEMA Frame	Minimum Percent Efficiency	Minimum Percent Power Factor
3	1200	213T	85	63
5	1200	215T	86	66
7½	1200	254T	89	68
10	1200	256T	89	75
15	1200	284T	90	72
20	1200	286T	90	76
25	1200	324T	90	71
30	1200	326T	91	79
40	1200	364T	92	78
50	1200	365T	92	81
60	1200	404T	92	83
75	1200	405T	92	80
100	1200	444T	93	83
125	1200	445T	93	85
3	1800	182T	87	83
5	1800	184T	88	83
7½	1800	213T	89	85
10	1800	215T	90	84
15	1800	254T	91	86
20	1800	256T	91	85
25	1800	284T	92	84
30	1800	286T	93	86
40	1800	324T	93	83
50	1800	326T	93	85
60	1800	364T	93	87
75	1800	365T	93	87
100	1800	405T	94	86
125	1800	444T	94	87
150	1800	445T	94	88
200	1800	447T	95	87
3	3600	182T	82	87
5	3600	184T	85	88
7½	3600	213T	86	86
10	3600	215T	86	86
15	3600	254T	88	91
20	3600	256T	89	89
25	3600	284T	90	92
30	3600	286T	91	92
40	3600	324T	91	91
50	3600	326T	90	92
60	3600	326T	91	93
75	3600	364T	91	91
100	3600	365T	92	92

END OF SECTION