**SECTION 23 05 13**

**MOTOR REQUIREMENTS for HVAC**

**PART 1 GENERAL**

1. SECTION INCLUDES
	1. Single-phase electric motors
	2. Three-phase electric motors
2. REFERENCES
	1. ABMA 9 ‑ Load Ratings and Fatigue Life for Ball Bearings
	2. ABMA 11 ‑ Load Ratings and Fatigue Life for Roller Bearings
	3. IEEE SA-P112 ‑ Test Procedure for Polyphase Induction Motors and Generators
	4. NEMA MG 1 ‑ Motors and Generators
	5. NFPA 70 ‑ National Electrical Code
	6. 26 28 29 - Motor Controls – Section 26 28 39
3. SUBMITTALS
	1. Submit under provisions of Section 01 33 00.
	2. Product Data: Provide wiring diagrams with electrical characteristics and connection requirements.
	3. Test Reports: Indicate test results verifying nominal efficiency and power factor for three-phase motors larger than 5-HP.
	4. Manufacturer's Installation Instructions: Indicate setting, mechanical connections, lubrication, and wiring instructions.
4. OPERATION AND MAINTENANCE DATA
	1. Submit under provisions of Section 01 77 00.
	2. Operation Data: Include instructions for safe operating procedures.
	3. Maintenance Data: Include assembly drawings, bearing data including replacement sizes, and lubrication instructions.
5. QUALIFICATIONS
	1. Company specializing in manufacture of electric motors and their accessories, with minimum 5-years documented product development, testing, and manufacturing experience.
6. REGULATORY REQUIREMENTS
	1. Conform to NFPA 70 - National Electrical Code
	2. Provide certificate of compliance indicating approval of Premium efficiency motors.
	3. Products Requiring Electrical Connection: Listed and classified by Underwriters' Laboratories, Inc., as suitable for the purpose specified and indicated.
7. DELIVERY, STORAGE, AND HANDLING
	1. Deliver, store, protect, and handle products to site under provisions of Section 01 60 00.
	2. Protect motors stored on site from weather and moisture by maintaining factory covers and suitable weatherproof covering.
8. WARRANTY
	1. All motors shall be provided with a 5-year parts and labor warranty under provisions of Section 01 77 00.

**PART 2 PRODUCTS**

1. GENERAL CONSTRUCTION AND REQUIREMENTS
	1. Motors less than 250-watts, for intermittent service, may use the equipment manufacturers’ standard motor.
	2. 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
	3. 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.
	4. Explosion-Proof Motors: UL approved and labeled for hazard classification, with over temperature protection.
	5. 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.
	6. Wiring Terminations
		1. Provide terminal lugs to match the branch-circuit conductor quantities, sizes, and materials indicated.
			1. 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.
	7. 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.
			1. Overload heaters shall be manual reset.
			2. Refer to Sections 262839, “Motor Control”, and electrical design.
	8. Inverter Rated Motors
		1. All motors used in conjunction with variable frequency drives shall be a Premium efficiency and inverter duty rated.
2. SINGLE PHASE POWER ‑ SPLIT PHASE MOTORS
	1. Starting Torque: Less than 150% of full load torque
	2. Starting Current: Up to seven times full load current
	3. Breakdown Torque: Approximately 200% of full load torque
	4. Drip-proof Enclosure: Class A (50°C temperature rise) insulation, 1.0 Service Factor, pre-lubricated ball bearings.
	5. Enclosed Motors: Class A (50° C temperature rise) insulation, 1.0 Service Factor, and pre-lubricated ball bearings.
3. SINGLE PHASE POWER ‑ PERMANENT‑SPLIT CAPACITOR MOTORS
	1. Starting Torque: Exceeding one fourth of full load torque
	2. Starting Current: Up to six times full load current
	3. Multiple Speed: Through tapped windings
	4. 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.
4. SINGLE PHASE POWER ‑ CAPACITOR START MOTORS
	1. Starting Torque: Three times full load torque
	2. Starting Current: Less than five times full load current
	3. Pull‑up Torque: Up to 350% of full load torque
	4. Breakdown Torque: Approximately 250% of full load torque
	5. 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.
	6. Drip-proof Enclosure: Class A (50°C temperature rise) insulation, NEMA Service Factor, and pre-lubricated ball bearings.
	7. Enclosed Motors: Class A (50°C temperature rise) insulation, 1.0 Service Factor, and pre-lubricated ball bearings.
5. SINGLE PHASE POWER – VARIABLE SPEED MOTORS
	1. Brushless DC (BLDC) electronically commutated high efficiency motor.
	2. Integrated (built-in) speed controller
	3. Single-phase 115 V input
	4. Operation range: 20% to 100% of full speed (80% turndown)
	5. Motor sizes: ¼, ½, and ¾ HP
	6. Control options: 0-10 VDC input wiring, motor mounted dial, or wall mounted dial.
	7. Customization options: torque, size, Voltage, current and maximum speed.
	8. HVAC Applications: small capacity, variable speed fans and pumps
6. THREE PHASE POWER ‑ SQUIRREL CAGE MOTORS
	1. Starting Torque: Between one and one-half times full load torque.
	2. Starting Current: Six times full load current.
	3. Power Output, Locked Rotor Torque, Breakdown, or Pullout Torque: NEMA Design B characteristics.
	4. Design, Construction, Testing, and Performance: Conform to NEMA MG 1 for Design B motors.
	5. Insulation System: NEMA Class B or better
	6. Testing Procedure: In accordance with IEEE 112, load test motors to determine freedom from electrical or mechanical defects and compliance with performance data.
	7. Motor Frames: NEMA standard T-Frames of steel, aluminum, or cast iron with end brackets of cast iron or aluminum with steel inserts.
	8. 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.
	9. 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.
	10. Sound Power Levels: To NEMA MG 1
	11. 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.
	12. 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.
	13. Nominal Efficiency: As scheduled at full load and rated voltage when tested in accordance with IEEE 112.
	14. Nominal Power Factor: As scheduled at full load and rated voltage when tested in accordance with IEEE 112.
7. THREE PHASE POWER – VARIABLE SPEED MOTORS
	1. Provide premium efficiency AC inverter duty rated motor suitable for variable frequency drive.
	2. Refer to Specification 23 29 23 Variable Frequency Motor Controls.
	3. General-purpose motors are not acceptable.

**PART 3 EXECUTION**

1. APPLICATION
	1. Single-phase motors for shaft mounted fans: Split phase type.
	2. Single-phase motors for shaft mounted fans or blowers: Permanent split capacitor type
	3. Single-phase motors for fans, pumps, blowers, and air compressors: Capacitor start type
	4. Single-phase motors for fans, blowers, and pumps: Capacitor start, capacitor run type
	5. Motors located in exterior locations, wet air streams, air-cooled condensers, direct drive axial fans, dust collection systems: Totally enclosed type (TEFC).
	6. Motors located in outdoors: Totally enclosed weatherproof, factory epoxysealed type (TEFC).
	7. 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).
2. INSTALLATION
	1. Install in accordance with manufacturer's instructions.
	2. Install securely on firm foundation.
		1. Mount ball bearing motors with shaft in any position.
	3. Check line voltage and phase and ensure agreement with nameplate.
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

1. PERFORMANCE SCHEDULE: THREE- PHASE, ENERGY EFFICIENT, OPEN DRIP‑PROOF

 **Minimum Minimum**

 **RPM NEMA Percent Percent**

**HP (Syn) Frame Efficiency 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

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

 **Minimum Minimum**

 **RPM NEMA Percent Percent**

**HP (Syn) Frame Efficiency 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