

Technical Report on Electric Motor Prime Mover for Beam Pumping Unit Service

API TECHNICAL REPORT 11L6
SECOND EDITION, MAY 2008



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Upstream Segment

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Technical Report on Electric Motor Prime Mover for Beam Pumping Unit Service

1 Scope

This technical report covers polyphase, squirrel-cage, induction motors for use as the prime mover for beam pumping units (size range of 200 HP and below). It includes a user Motor Data Sheet (Annex A) and an Electric Motor Performance Data Sheet Request Form (Annex B). Motors to be operated from solid-state or other types of variable frequency/variable voltage power supplies for adjustable speed applications will require individual consideration to provide satisfactory performance and are beyond the scope of this document.

2 Normative References

The following reference documents are indispensable for the application of this technical report. For dated references, only the edition cited applies. For undated references, the latest edition of the reference document (including any amendments) applies.

ABMA-9¹, *Load Ratings and Fatigue Life for Ball Bearings*

ABMA-11, *Load Ratings and Fatigue Life for Roller Bearings*

ASTM B117², *Standard Practice for Operating Salt Spray (Fog) Apparatus*

IEEE Std 100³, *The Authoritative Dictionary of IEEE Standards Terms*

IEEE Std 112, *IEEE Standard Test Procedure for Polyphase Induction Motors and Generators*

IEEE Std 841-1986, *Recommended Practice for Chemical Industry Severe Duty Squirrel-Cage Induction Motors—600V and Below*

NEDA 12.34.1⁴, *Segregation of Losses and Smoothing of Stray-Load Loss*

NEMA MG 1⁵, *Motors and Generators*

NEMA MG 13-1984, *Frame Assignments for Alternating Current Integral Horsepower Induction Motors*

NEMA MG 13-1956, *Frame Assignments for Alternating Current Integral Horsepower Induction Motors (U-Frame Descriptions)*

NFPA 70⁶, *National Electric Code*

3 Terms and Definitions

For the purpose of this document, the definitions of technical terms found in the IEEE Std 100 apply.

¹American Bearing Manufacturers Association, 2025 M Street, N.W., Suite 800, Washington, D.C. 20036, www.abma-dc.org.

²ASTM International, 100 Barr Harbor Drive, West Conshohocken, Pennsylvania 19428, www.astm.org.

³Institute of Electrical and Electronics Engineers, 445 Hoes Lane, Piscataway, New Jersey 08854, www.ieee.org.

⁴National Electric Distributors Association, 1111 Alderman Drive, Suite 400, Alpharetta, Georgia 22209, www.nedassociation.org.

⁵National Electrical Manufacturers Association, 1300 North 17th Street, Suite 1752, Rosslyn, Virginia 22209, www.nema.org.

⁶National Fire Protection Association, 1 Batterymarch Park, Quincy, Massachusetts 02169-7471, www.nfpa.org.

4 Basic Design

4.1 General

4.1.1 Standard Motor Technical Report

The standard motor design under this technical report meets the minimum requirements identified in Table 1. Other options indicated in parentheses are available and outlined in this document. These options must be identified on the data sheet.

Table 1—Standard Motor Design Requirements

Requirement	Value	TR Section
Size Rating	as specified by user 200 HP (150 kw)* and below	4.1.3
Synchronous Speed	1200 RPM, (900)* (1000)*	4.1.4
Voltage	460/796 (460)* (380)*	4.1.5
Frequency	60 Hz (50 Hz)*	4.1.5
Phase	3	4.1.5
Enclosure	ODP-guarded (TEFC)*	4.1.6
NEMA Design	D (Ultra-high Slip)*	4.1.7
Frame	T (U)*	4.1.8
Frame Material	Cast Iron (Other)	4.1.9
Insulation	Class F (Class F Encapsulated)* (Class H)*	4.1.10
Service Factor	1.15 (1.0 Ultra-high Slip)*	4.1.10
Mounting	F-2	4.1.11
Leads	6 (3, 9, 12)*	4.1.12
Bearing Life	L-10 minimum 26,280 hours	4.1.13
*Other API acceptable values		

Except as otherwise specified, motor electrical performance and characteristics shall be in accordance with NEMA MG 1.

4.1.2 Service Conditions

Motors conforming to this technical report shall be suitable for operation in accordance with their full load rating under the following service conditions or the conditions specified on the user Motor Data Sheet (see Annex A):

- ambient temperature in a range of $-25\text{ }^{\circ}\text{C}$ to $40\text{ }^{\circ}\text{C}$ ($-13\text{ }^{\circ}\text{F}$ to $104\text{ }^{\circ}\text{F}$);
- maximum altitude of 1000 m (3300 ft) above sea level;
- outdoor sever duty application, including blowing dust or snow, corrosive atmospheres, high humidity, and cyclic loading;
- full voltage across-the-line starting;
- belted duty; and
- power supply variations as in 4.2.1.

4.1.3 Size Rating

Motors covered by this technical report shall be rated in horsepower (HP) or kilowatt (kw) on a continuous-duty basis.

4.1.4 Synchronous Speed Rating

The synchronous speed rating at 60 Hz is 1200 RPM or as specified on the attached Motor Data Sheet (see Annex A). This technical report also permits the motor synchronous speed of 900 RPM or 1000 RPM.

4.1.5 Voltage, Frequency and Phase Ratings

Voltage ratings shall be 460/796 or 460 Volts AC, 60 Hertz, 3 Phase or 380V, 50 Hertz, 3 Phase. The 50 Hz synchronous speed is 1000 RPM.

4.1.6 Motor Enclosures

Motor enclosures shall be open drip proof (ODP) or totally enclosed fan cooled (TEFC) suitable for unclassified areas. As a minimum, enclosures shall meet ODP—guarded specifications in accordance with NEMA MG 1 or TEFC specification in accordance with NEMA MG 1.

4.1.7 NEMA Motor Designs and Starting Characteristics

Motors shall be NEMA Design D as specified by NEMA MG 1 with a slip of 5 % to 8 % or ultra-high slip design. Motors shall be capable of accelerating load under conditions as specified in NEMA MG 1.

4.1.8 Frame Assignments

Motors furnished in accordance with this technical report, shall as a minimum comply with the frame size assignments as per NEMA MG 13–1984 for T-frame motors or according to NEMA MG 13–1956 for U-frame motors.

4.1.9 Motor Frame Material

For cast iron or other materials used, the motor manufacturer shall identify the material used for motor frames, and shields, and other structural parts; corrosion resistant treatment; test for corrosion resistance.

4.1.10 Insulation System (Service Factor, and Temperature Rise)

The thermal rating of the insulation system shall be a minimum of Class F as defined in NEMA MG 1. When operated at rated voltage, frequency and load, the temperature rise shall not exceed 80 °C by resistance for Class F insulation, 90 °C by resistance for Class F encapsulated, or 125 °C by resistance for Class H insulation in accordance with IEEE 112. Standard motors shall have a 1.15 Service Factor. Ultra-high slip motors shall have a 1.0 Service Factor without exceeding the allowable temperature rise of the insulation system as determined in accordance with IEEE 112.

4.1.11 Mounting

The power terminal box shall be located on the right side of the enclosure facing the shaft end of the motor in accordance with NEMA Type F-2 construction.

4.1.12 Motor Leads

The preferred number of motor leads should be six. As an option for voltage and torque variation, the user may specify 3, 9, or 12 leads.

4.1.13 Bearing Life

Bearings shall be selected to provide L-10 rating life of 26,280 hours minimum (3 years continuous) per ABMA-9 or ABMA-11 as applicable. Calculations shall be based on external loads calculated for NEMA bolted application limits in accordance with NEMA MG 1 and internal loads defined by the manufacturer. Regressible bearings shall be provided on frame sizes above 286T.

4.2 Other Electrical Design Considerations

4.2.1 Power Supply Variations

4.2.1.1 Motors shall operate on a continuous basis at rated load with variation in the voltage or the frequency not exceeding the following conditions:

- a) $\pm 10\%$ of rated voltage, with rated frequency;
- b) $\pm 5\%$ of rated frequency, with rated voltage; and
- c) combination of voltage and frequency variation of 10% (sum of absolute values) of the rated values, provided that the frequency variation does not exceed $\pm 5\%$ of rated frequency.

4.2.1.2 Motors shall operate on a continuous basis at rated load and frequency when the voltage unbalance at the motor terminals is less than or equal to 1% as calculated according to NEMA MG 1.

4.2.1.3 When elevation or ambient temperatures other than specified in 4.1.2 are noted on the data sheet, the motor shall be derated in accordance with NEMA MG 1.

4.2.2 All motors shall have nonhygroscopic insulation systems including loads and connections. Internal winding encapsulation may be specified. Coil ends shall be braced to prevent insulation cracking and fatigue from movement due to starting, operating under cyclic load conditions, and vibrations inherent to a beam pumping system.

4.2.3 The motor insulation system shall be protected against the severe conditions listed in 4.1.2. As minimum the insulation system must pass the salt spray test as specified in ASTM B117.

4.2.4 The motor leads in the motor terminal box shall be constructed of copper motor lead wire and be permanently identified.

4.3 Other Mechanical Design Considerations

4.3.1 Bearings and Lubrication

4.3.1.1 Regressible type bearings should be regressible without any disassembly, and shall contain a reservoir equipped with an outlet for elimination of purged grease. Inlet and outlet openings shall have removable plugs.

4.3.1.2 Regressible bearings should be supplied with as grease compatible with operating conditions specified in 4.1.2. The manufacturers preferred type of grease shall be stated in the maintenance and operating instructions provided with the motor.

4.3.1.3 Temperature rise of the bearing shall not exceed $60\text{ }^{\circ}\text{C}$ at rated load under belted conditions.

4.3.2 Rotors and Rotor Cage

Rotor cage construction shall be of copper, aluminum, magnesium or their respective alloys. Rotors shall have a permanent corrosion protective coating. The shaft extension shall be protected against corrosion for shipment and extended storage by a removable protective coating.

4.3.3 Enclosures and Frames

4.3.3.1 Motors with shipping weights over 30 lb shall have lifting lug(s), eye bolt(s), or other suitable means on the frame for lifting.

4.3.3.2 Alignment dowels, rabbet fits or similar construction shall be provided to facilitate correct reassembly of frame components, end bells or plates, bearing housing mounting plates, and bearing housings.

4.3.3.3 On TEFC motors, non-threaded, $3/16$ -in. diameter hole(s) shall be provided at the low point(s) of the motor enclosure to allow for drainage of condensation. Holes larger than $3/16$ -in. diameter must be provided with threaded plugs or automatic drainage fittings.

4.3.4 Paint Requirements

4.3.4.1 Manufacturer's standard paint color shall be as specified on the Motor Data Sheet (see Annex A).

4.3.5 Accessories

4.3.5.1 Motor nameplates, attachment hardware and connection diagram shall be stainless steel and shall be located on the same side of the motor above the terminal box. Nameplates with permanent markings shall contain the following data in accordance with *NEC 430-7(a)*, *(b)* and *NEMA MG 1.37-40*, and this technical report:

- manufacturer's name;
- rated volts and full load amps;
- motors for dual voltage use slash between voltages and amperes;
- rated frequency and number of phases;
- rated full load speed;
- rated temperatures rise or the insulation system class and rated ambient temperature;
- duty cycle rating;
- rated horsepower;
- locked rotor indicating code letter;
- a motor provided with winding temperature detectors and complying with *NFPA 70, National Electrical Code, Section 430-32(a)(2)* or *(c)(2)*, shall be marked "Thermally Protected,"
- manufacturer's (model number or serial number);
- type and frame designation;
- NEMA design letter;

- service factor;
- enclosure type;
- drive shaft bearing;
- opposite drive shaft bearing;
- motor terminal connection diagram for each voltage; and
- manufacture date or date code.

4.3.5.2 Terminal housings shall be able to rotate at a maximum of 90 ° increments and shall have a securable bolted or screwed cover with a gasket. The terminal box shall be provided with conduit entrance hole(s) sized in accordance with NEMA MG 1. On TEFC motors a moisture resistant barrier shall separate the terminal housing and the motor cavity.

4.3.5.3 For open motors, rodent barriers shall be placed over frame and bracket openings. Barriers shall be made of stainless or hot dipped galvanized steel. The openings shall prevent the passage of a rod $\frac{1}{2}$ in. in diameter.

4.3.5.4 Fastening devices and other external hardware shall be stainless steel, hot dipped galvanized, or cadmium plated materials. Fans on the TEFC motors shall be constructed from non-sparking materials.

4.3.5.5 An external grounding connection point shall be provided by drilled and tapped $\frac{3}{8}$ in.–16 UNC hole, located opposite the drive end or on the same side as the junction box in a part of the metal that is an integral part of the frame. An internal grounding lug in accordance with NEMA MG 1 shall be installed inside the terminal housing. When specified on the user data sheet, the manufacturer shall install an external ground lug sized in accordance with NFPA 70.

4.3.5.6 When motor space heaters are specified on the user Motor Data Sheet, they shall be designed to maintain a temperature of 5 °C above ambient as specified in IEEE 841 or required by NFPA 70 (see Annex A).

4.3.6 Temperature Protection

If thermal motor protection is specified, the motor shall be protected by a minimum of one operative, hermetically sealed, winding temperature detector per phase, set to operate and open the motor control circuit at the maximum operating temperature of the insulating system.

5 Tests

5.1 Motor Testing Requirements

The original manufacturer of the equipment governed by this technical report shall institute an equipment testing program to assure that the equipment meets the quality control objectives of the manufacturer. The testing of the equipment shall conform to IEEE 112.

5.1.1 Routine tests required and the test methods shall be selected by the manufacturer. These tests shall include, but not be limited to, the following:

- insulation resistance test;
- high potential test*;
- winding resistance test;
- no load current and power test;
- locked rotor current and power*;
- current balance test; and
- vibration test.

NOTE *The test values obtained during these tests must be within minimums and tolerances specified in NEMA MG 1.

5.1.2 Each of the motor designs shall be initially tested in compliance with IEEE 112, Method B (Dynamometer), NEDA 12.34.1, and Annex B of this technical report for efficiency, to determine the motor performance data. The motor performance data shall be furnished upon request. These tests shall include the following:

- temperature rise test;
- efficiency;
- losses;
- power factor;
- locked rotor torque; and
- breakdown torque.

5.1.2.1 The motors shall also be initially tested and the results reported for the non-standard conditions identified on the Electric Motor Performance Data Request (EMPDR) Form (see Annex B). The test results shall be reported on the form and furnished to the customer when requested.

5.1.3 Whenever the design is modified to the extent that it affects the motor performance data as specified in 5.1.2.1, the new design shall be retested as required in 5.1.2 and 5.1.2.1.

Annex A—Motor Data Sheet

A.1 Motor Data Sheet

Annex A is the motor data sheet that the unit shall submit to the manufacturer in addition to these technical reports in order to describe particular requirements or application.

Horsepower: (Up to 200)* _____ **Volts:** 460 V (230 – 800)* _____
Phase: 3-phase 1-phase **Synchronous Speed:** 1200 (900 – 1800)* _____
Frequency: 60 Hz 50 Hz **Service Factor:** 1.15 (1.0 – 1.25)* _____
Frame Material: Cast Iron Steel Aluminum **Frame Type:** T U
Enclosure: Open Drip-proof Guarded TEFC
Area of Classification: Unclassified
 Class I Division 1 Class I Division 2 Group (A, B, C, D)* _____

Torque and Slip: NEMA D 5 % – 8 % NEMA C Ultra-high Slip
Environmental Exposures to: 4.1.2
 Salt laden air Heavy Snow Blowing Sand Fungus
 Elevations above 3300 ft (1000 m) _____
 Low Temp < -13 °F (-25 °C) _____ High Temp > 104 °F (40 °C) _____

Leads: 3 Leads 6 Leads 9 Leads 12 Leads
Bearing Type: Sealed up to 25 HP, regreaseable 30 HP and above
 Sealed Regreaseable

Optional Accessories:
 Heaters 120 VAC Heaters 230 VAC Heaters 460 VAC
 Accessible Grease Plug Extension Manufacturer Provides Grounding Lug

User Preference:
 Paint-Color Manufacturer Standard Paint—White Paint—(Other Color)_____
 2 Winding Temperature Detectors Per Phase Stainless Steel Rodent Barrier
 Electric Motor Performance Data Required (Annex B) Yes No
 Certified Temperature and Performance Test Required with Quotation Yes No

- API Standard Unless Specified Otherwise on the User Data Sheet
- API Acceptable Specifications
- * API Acceptable Range

Comments: _____

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Annex B—Electric Motor Performance Data Request Form

Manufacturer		Description	
Size/HP	Mode	NEMA Rating	Frame
Voltage	Phases	Frequency (Hz)	
Model No.		Enclosure	
Service Factor			

Locked rotor torque (in.-lb)	Locked rotor current (amps)
Stator temp. at full load (°C)	Ambient temp. during test (°C)
Class insulation	Minimum slow down speed (RPM)
Rotor and shaft inertia (lb ft-ft)	
Breakdown torque (in.-lb) (if applicable)	Breakdown speed (RPM) (if applicable)
Pull up torque (in.-lb) (if applicable)	Pull up speed (RPM) (if applicable)

Measurement at	Speed (rpm)	Torque (in.-lb)	Current (amps)	Power Factor (%/100)
110 % of synchronous speed	_____	_____	_____	_____
105 % of synchronous speed	_____	_____	_____	_____
Synchronous speed	_____	_____	_____	_____
25 % of load torque	_____	_____	_____	_____
50 % of load torque	_____	_____	_____	_____
75 % of load torque	_____	_____	_____	_____
Full load torque	_____	_____	_____	_____
125 % of full load torque*	_____	_____	_____	_____
150 % of full load torque*	_____	_____	_____	_____
175 % of full load torque*	_____	_____	_____	_____
200 % of full load torque*	_____	_____	_____	_____

*Or terminate when minimum slow down speed or breakdown torque speed is reached.

Typical Data

Test Data

Test date: _____ Approved by: _____

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Bibliography

- [1] *NEC Table 430—Table for Motor Circuits, National Electrical Code*⁷

⁷National Fire Protection Association, 1 Batterymarch Park, Quincy, Massachusetts 02169, www.nfpa.org.



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