General-purpose Form-wound Squirrel Cage Induction Motors—250 Horsepower and Larger

API STANDARD 547
FIRST EDITION, JANUARY 2005

API
American Petroleum Institute

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Downstream Segment

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General-purpose Form-wound Squirrel Cage Induction Motors—250 Horsepower and Larger

1 General

1.1 SCOPE

This standard covers the requirements for form-wound induction motors for use in general-purpose petroleum, chemical and other industrial severe duty applications. These motors:

a. Are rated 250 hp (185 kW) through 3000 hp (2250 kW) for 4, 6 and 8 pole speeds.
b. Are rated less than 800 hp (600 kW) for two-pole (3000 RPM or 3600 RPM) motors of totally-enclosed construction.
c. Are rated less than 1250 hp (930 kW) for two-pole motors of WP II type enclosures.
d. Drive centrifugal loads.
e. Drive loads having inertia values within those listed in NEMA MG 1 Part 20.
f. Are not induction generators.

Note: Motors larger than that covered above and motors in other applications should be specified in accordance with API Std 541.

1.2 USUAL SERVICE CONDITIONS

Unless otherwise specified, motors conforming to this standard shall be suitable for operation within their rating under the following service conditions:

a. Exposure to an ambient temperature in the range of – 25°C to + 40°C (– 13°F to + 104°F).
b. Exposure to a maximum altitude of 3300 ft (1000 m) above sea level.
c. Indoor or outdoor severe duty applications, such as humid, chemical (corrosive), or salty atmospheres.
d. Horizontal mounting.
e. Installation in a Class 1 Division 2 or Zone 2 location.
f. Constant frequency sinusoidal input power.
g. Not subject to frequent transient overvoltages (e.g., switching surges, lightning).
h. Direct coupled.

1.3 UNUSUAL SERVICE CONDITIONS

Unusual service conditions should be brought to the attention of those responsible for the design, manufacture, application, and operation of the motor. Among such unusual conditions are:

a. Exposure to:
   1. Combustible, explosive, abrasive, or conductive dust.
   2. Dirty operating conditions where the accumulation of dirt will interfere with normal ventilation.
   3. Nuclear radiation.
   4. Abnormal shock, vibrations, or mechanical loading from external sources.
   5. Abnormal axial or side thrust imposed on the motor shaft.
   6. Altitude or ambient temperature outside the range covered in 1.2.
   7. Reciprocating or positive displacement loads.

b. Conditions under which the variation from rated voltage or frequency, or both, exceeds the limits given in NEMA MG 1.
c. Conditions under which the ac supply voltage is unbalanced by more than the limits given in NEMA MG 1.
d. Operation at speeds other than rated speed.
e. Operation from solid-state or other types of adjustable frequency/adjustable voltage power supplies for adjustable speed applications.
f. Load inertia greater than and/or starting conditions more severe than given in NEMA MG 1.
g. Vertical mounting.

Note: A round bullet (•) at the beginning of a paragraph indicates that either a decision is required or further information is to be provided by the purchaser. This information should be indicated on the data sheets (see Appendix A); otherwise it should be stated in the quotation request or in the order.

1.4 DIMENSIONS AND STANDARDS

1.4.1 Both the SI and U.S. Customary system of units and dimensions are used in this standard. Any data, drawings, or hardware (including fasteners) related to equipment supplied to this standard shall use the U.S. Customary system.

1.4.2 This document recognizes two different systems of standards for the manufacturing and testing of electrical motors: the North American ANSI, IEEE, and NEMA standards; and the international IEC and ISO standards. The North American standards are the base documents. When specified by the purchaser, the corresponding international standards are acceptable for use as alternatives; however, this must not be construed that they are identical to the North American standards. The selection of which system of standards to be utilized shall depend upon the machine's application and site location.

Note: The purchaser should be aware that specific requirements contained within corresponding standards may differ.

1.5 REFERENCED PUBLICATIONS

The editions of the following standards, codes, and specifications that are in effect at the time of publication of this standard shall, to the extent specified herein, form a part of this standard. The applicability of changes in standards, codes, and specifications that occur after the inquiry shall be mutually agreed upon by the purchaser and the vendor.

API

Std 541	*Form-wound Squirrel-cage Induction Motors—500 Horsepower and Larger*
Std 670	*Machinery Protection Systems*

ABMA[1]

Std 20	*Radial Bearings of Ball, Cylindrical Roller and Spherical Roller Types, Metric Design: Basic Plan for Boundary Dimensions, Tolerances and Identification Code*

ASTM[2]

A 345	*Flat-Rolled Electrical Steels for Magnetic Applications*

IEC[3]

60034	*Rotating Electrical Machines*
60072	*Dimensions and Output Series for Rotating Electrical Machines*
60079	*Electrical Apparatus for Explosive Gas Atmospheres*
EN 10126	*Cold Rolled Electrical Non-Alloyed Steel Sheet and Strip Delivered in the Semi-Processed State*
EN 10165	*Cold Rolled Electrical Alloyed Steel Sheet and Strip Delivered in the Semi-Processed State*

IEEE[4]

43	*Recommended Practice for Testing Insulation Resistance of Rotating Machinery*
112	*Test Procedures for Polyphase Induction Motors and Generators*
275	*Recommended Practice for Thermal Evaluation of Insulation Systems for Alternating-Current Electric Machinery Employing Form-Wound Preinsulated Stator Coils for Machines Rated 6900 V and Below*
429	*Recommended Practice for Thermal Evaluation of Sealed Insulation Systems for AC Electric Machinery Employing Form-Wound, Preinsulated Stator Coils for Machines Rated 6900 V and Below*
522	*IEEE Guide for Testing Turn-to-Turn Insulation on Form-Wound Stator Coils for Alternating-Current Rotating Electric Machines*

ISO[5]

3506	*Mechanical Properties of Corrosion-resistant Stainless Steel Fasteners*

NEMA[6]

MG 1	*Motors and Generators*

NFPA[7]

70	*National Electrical Code*
497	*Recommended Practice for the Classification of Flammable Liquids, Gases, or Vapors and of Hazardous (Classified) Locations for Electrical Installations in Chemical Process Areas.*

2 Basic Design

2.1 GENERAL

2.1.1 Motors shall be rated on a continuous-duty basis. The output rating shall be expressed in power available at the shaft at the specified speed, frequency, and voltage.

Note: Motors should be applied within their rating based on a service factor of 1.0. In those applications requiring a prolonged overload capacity, the use of a higher power rating is recommended to avoid the reduction of insulation and bearing life associated with operation above the 1.0 service factor.

2.1.2 Unless otherwise specified, the A - weighted maximum sound pressure level of the motor shall not exceed 85 dBA at any location at a reference distance of 3 ft (1 m) with motor operating at no load, full voltage, rated frequency, and sinusoidal power. The measuring and reporting of sound pressure level data shall be in accordance with NEMA MG 1 Part 9.

• **2.1.3** The motor and all of its auxiliary devices shall be suitable for and in accordance with the area classification system specified by the purchaser on the data sheets. Auxiliary devices shall be listed or certified where required in accordance with the area classification system specified.

[1]American Bearing Manufacturers Association, 2025 M Street, NW, Suite 800,Washington, D.C. 20036. www.abma-dc.org
[2]ASTM International, 100 Barr Harbor Drive, West Conshohocken, Pennsylvania 19428-2959. www.astm.org
[3]International Electrochemical Commission, 3, rue de Varembé, PO Box 131, CH-1211, Geneva 20, Switzerland. www.iec.ch
[4]Institute of Electrical and Electronics Engineers, 445 Hoes Lane, Piscataway, New Jersey 08854-1331. www.ieee.org
[5]International Organization for Standardization, ISO publications are available from the American National Standards Institute (ANSI), 25 West 43rd Street, 4 Floor, New York, New York 10036. www.iso.org, www.ansi.org
[6]National Electrical Manufacturers Association, 1300 North 17th Street, Suite 1847, Rosslyn, Virginia 22209. www.nema.org
[7]National Fire Protection Association, 1 Batterymarch Park, Quincy, Massachusetts 02169. www.nfpa.org

2.2 ELECTRICAL DESIGN

Unless otherwise specified in this standard, motor electrical performance and characteristics shall be in accordance with NEMA MG 1.

2.2.1 VOLTAGE AND FREQUENCY

The standard 3-phase voltage ratings are:

a. 60 Hz: 2300 V, 4000 V, 6600 V and 13200 V.
b. 50 Hz, 3000 V, 3300 V, 6000 V, 6600 V and 10000 V.

Dual voltage motors are acceptable only for 2300/4000 V ratings.

Note: When motors supplied under this standard are to be applied on a non-sinusoidal source and/or an adjustable speed application, the manufacturer should be consulted to determine if the motor will operate successfully over the required speed range. Refer to NEMA MG 1 Part 30. Proper selection of the motor and drive is required to avoid the following conditions:

1. Motor rms current exceeding the continuous sinusoidal nameplate rating due to excessive voltage harmonics or improper volt/hertz levels.
2. Excessive winding temperature due to insufficient cooling, excessive torque levels, or improper volt/hertz levels; and increased losses due to harmonics.
3. Insufficient motor accelerating torque at reduced speeds due to insufficient volt/hertz levels or limitations in the drive's short-time current capacity.
4. Increased noise levels due to increased fan noise (above base speed), excitation of mechanical resonances, and/or magnetic noise caused by supply source harmonics.
5. Mechanical failure of the motor or coupling due to torque pulsations, operation at or near mechanical resonances, or excess speed.
6. Winding failures due to repetitive high-amplitude voltage spikes created by the drive's carrier frequency and motor feeder cable system.
7. Damage to the motor and drive due to improper application of power factor correction capacitors or harmonic filters.
8. Higher motor temperatures that may limit application in Division 2 or Zone 2 hazardous (classified) locations.
9. Shaft-to-bearing voltages/currents resulting from common mode currents flowing through stray system capacitances to ground via the bearings. These currents are induced from the ASD's high rate of change (dv/dt) of output voltage.
10. Extended operation at slow speed.

2.2.2 MOTOR DESIGN AND STARTING CHARACTERISTICS

2.2.2.1 Where applicable, motors shall meet the requirements for Design B torque-current characteristics based on the power/speed ratings defined per NEMA MG 1 Part 12. Type test and/or design information shall be supplied when requested to verify design characteristics.

2.2.2.2 Motor ratings above those defined for NEMA Design B shall meet, as a minimum, the "standard torque" characteristics defined in NEMA MG 1 Part 20. Type test and/or design information shall be supplied when requested to verify design characteristics.

2.2.2.3 In addition, motor ratings within the rating parameters of NEMA MG 1 Part 20 shall be capable of accelerating a load with 80% of rated voltage at the motor terminals where the load torque requirement varies with the square of the speed and the full load torque requirement is equal to or less than the rated full load torque of the motor. The load inertia for this condition must be less than or equal to the maximum inertia set within NEMA MG 1 Part 20 for 4 pole and slower motors, and less than or equal to $^1/_2$ the inertia listed for 2 pole motors.

2.2.2.4 When the motor speed-torque curve at the conditions specified in 2.2.2.3 is plotted over the load speed torque curve, the motor developed torque shall exceed the load torque by a minimum of 10% (motor rated torque as base) at all locations throughout the speed range up to the motor breakdown torque point.

2.2.2.5 When specified and when the purchaser provides a specific load torque and inertia condition other than above, the motor manufacturer shall evaluate and design the motor starting capability for a minimum 10% of rated full load torque margin at 80% rated voltage against the specific load requirements, prior to final purchase agreement.

2.2.2.6 The machine shall be designed for a lifetime minimum of 5000 full voltage starts. Design features outlined in section 2.3 shall be demonstrated in the stator construction and/or documented as part of the design. Rotor design shall have proven field service and shall be demonstrated or documented to include features of 2.4.5.

2.2.2.7 With rated voltage and frequency applied, motors shall not exceed a maximum locked-rotor current of 650% of the full-load current.

2.3 WINDING AND INSULATION SYSTEMS

2.3.1 Stator windings shall have an epoxy base, vacuum pressure impregnated, nonhygroscopic insulation system, including lead and coil connections. Bus bars shall also be insulated. As a minimum, the insulation system shall meet the criteria for Class F insulation listed in NEMA MG 1 or IEC 60034-1 as applicable. The allowable temperature rise above ambient, 40°C (104°F), shall not exceed that listed for Class B insulation. For ambient temperatures above 40°C the allowable temperature rise shall be reduced by the amount equal to the temperature above 40°C, so as not to exceed the total temperature limits (ambient, rise and hot spot) for Class B insulation. For windings operating at voltages at 6000 volts (line-line) or greater, the use of corona suppressant materials is required.

2.3.2 The insulation system shall be capable of withstanding the surge test specified in 4.3.4.

2.3.3 All stator insulation systems shall be service proven and shall have been subjected to thermal evaluation in accordance with IEEE 275.

2.3.4 The stator windings, including the lead connections, shall have a sealed insulation system that is capable of withstanding a sealed winding conformance test in accordance with NEMA MG 1 Part 20. The sealed insulation system shall be a proven design with temperature classification per IEEE 429. This standard shall not be interpreted to require the immersion test unless specified by the purchaser.

2.3.5 The entire stator winding insulation system, including winding connections and terminal leads, shall be tightly secured to prevent insulation cracking and fatigue as a result of motion and vibrations during starting, operation and electrical transient conditions which produce electromechanical forces in the stator windings. The windings shall withstand electromagnetic and mechanical forces under normal operating conditions, the starting requirements specified in 2.2.2.3 and 2.2.2.6 and the forces associated with phase-to-phase and 3-phase short-circuits with 110% of rated voltage.

2.3.6 The insulation system, including leads, shall be compatible with mineral oil based lubricants. Type test and/or design information shall be supplied when requested on identical lead insulating material to verify this requirement has been satisfied.

2.4 MECHANICAL DESIGN

2.4.1 Enclosures

2.4.1.1 General Requirements

Enclosure parts shall be made of cast or nodular iron, cast steel, or steel plate. All enclosure parts shall have a minimum rigidity equivalent to that of sheet steel with a nominal thickness of 1/8 in. (3.0 mm). Designs in which the stator laminations form a part of the external enclosure are not acceptable. The motor shall be Totally-enclosed Fan-cooled (TEFC) (IP44-54/IC411) or Weather-protected Type II (WP II) (IP24W/IC01) as defined below.

2.4.1.2 Totally-enclosed Fan-cooled motors (TEFC) shall meet the following criteria:

a. The stator frame shall be of cast iron construction.
b. Fan covers shall be made of metal having a minimum rigidity equivalent to that of steel plate with a nominal thickness of 1/8 in. (3.0 mm). Purchaser-approved fiber-reinforced materials may be used. The air intake opening shall be guarded by a grill or a metal screen. Protective grills or metal screens shall be fabricated from not less than 0.049 in. (1.25 mm) AISI (American Iron and Steel Institute) 300 series stainless steel with a maximum mesh of 1/4 in. (6.4 mm). Where the motor will be installed offshore AISI 316 material shall be supplied.
c. Sheet metal covers or wrappers used to form air passages over the enclosure shall have a minimum rigidity equivalent to that of steel plate with a nominal thickness of 1/8 in. (3.0 mm).
d. Corrosion-resistant, replaceable automatic drainage fittings shall be provided within 5 degrees of the lowest point of the motor enclosure (when viewing the end of the frame from an axial direction). This connection shall be shown on the outline drawing.

2.4.1.3 Weather-protected Type II (WP II) enclosures, shall meet the following criteria:

a. Ventilation openings shall be limited to a maximum size of 1/4 in. (6.4 mm) by design or by the use of metal screens. The screens shall be fabricated from not less than 0.049 in. (1.25 mm) AISI 300 series stainless steel with a maximum mesh of 1/4 in. (6.4 mm). Where the motor will be installed offshore AISI 316 material shall be supplied.
b. Motor shall be constructed so that any accumulation of water will drain from the motor.
c. Airflow inlet filters in standard types and sizes shall be furnished. Air filters shall be designed to permit easy removal and replacement while the motor is running.
d. Filters shall be of the permanent type and shall be selected to remove 90% of particulates 10 micron and larger or as specified on the data sheet. Entire filter element and assembly shall be constructed of AISI 300 series stainless steel. On enclosures equipped with filters, the screens downstream of the filters shall have a maximum mesh of 1/2 in. (13 mm).
e. Threaded connections shall be furnished for the future connection of an instrument to measure the pressure drop across the filters.
• f. When specified, a switch or gauge to measure the pressure drop across the filters shall be provided.

2.4.2 Frame and Mounting Plates

2.4.2.1 The frame shall be of cast or nodular iron, cast steel, or welded steel plate construction, with removable end brackets or end plates to permit removal of the rotor and facilitate replacement of stator coils.

2.4.2.2 Motors shall be equipped with vertical jackscrews located at each foot to facilitate alignment.

2.4.2.3 Mounting plates, if furnished, shall be supplied with horizontal jackscrews (for motor movement in the horizontal plane) the same size as or larger than the vertical jackscrews. The lugs holding these jackscrews shall be attached to the mounting plates so that they do not interfere with the installation or removal of the drive element and the installation or removal of shims used for alignment.

2.4.2.4 The horizontal and vertical jackscrews shall be 5/8 in. minimum diameter with UNC threads (M16 ISO 68).

2.4.2.5 The frame support or supports shall be provided with two pilot holes for dowels. The holes shall be within 45 degrees of vertical as near the vertical as practical and shall be located to provide adequate space for field drilling, reaming, and placement of dowels.

2.4.2.6 Lifting lugs, through holes, or eyebolts shall be provided for lifting major components and the assembled motor. Any special mechanisms for lifting major components and the assembled motor shall be supplied in the quantities shown on the data sheets.

2.4.2.7 Mounting surfaces shall meet the following criteria:

a. They shall be machined to a finish of 250 microinches (6 micrometers) arithmetic average roughness (Ra) or better.
b. To prevent a soft foot, they shall be in the same horizontal plane within 0.005 in. (125 micrometers).
c. Each mounting surface shall be machined within a flatness of 0.0005 in. per linear foot (40 micrometers per linear meter) of mounting surface.
d. Different mounting planes shall be parallel to each other within 0.002 in. per ft (170 micrometers per meter).
e. The upper machined or spot faced surface shall be parallel to the mounting surface.
f. Hold-down bolt holes shall be drilled perpendicular to the mounting surface or surfaces, machined or spot faced to a diameter two times that of the hole and to allow for equipment alignment to be 1/2 in. (13 mm) larger in diameter than the hold down bolt.

2.4.3 Fans

External fans shall be non-sparking metallic or conductive plastic, suitable for Class I, Division 2, or Zone 2. Bi-directional fans are preferred. If a uni-directional fan is used, the rotation of the fan shall be indicated by a rotation arrow in accordance with 2.4.11 mounted on the motor.

2.4.4 Hardware

All the enclosure's bolts, studs, and other fastening devices up through 1/2 in. (M12) size, shall be AISI 300 series or ISO 3506 stainless steel. Where the motor will be installed offshore AISI 316 material shall be supplied.

2.4.5 ROTATING ELEMENT

2.4.5.1 General

2.4.5.1.1 No shaft-straightening technique is permitted during or after fabrication of the rotor.

• **2.4.5.1.2** When vibration probes are specified, the probe-mounting and shaft preparation requirements of API Std 541 shall apply.

2.4.5.2 Assembly

Die cast aluminum rotors are acceptable for motors through 1000 hp. For motors above 1000 hp the cage construction shall be of fabricated copper or fabricated aluminum. All brazing materials must be phosphorous-free to prevent hydrogen sulfide attack.

2.4.6 DYNAMICS

"Stiff-rotor" motor (a "stiff-rotor" motor is a motor that operates below its first mechanical rotor-system resonant speed, as excited by a rotor unbalance) construction is required, as determined with the motor mounted on a massive foundation as described in API Std 541. Lateral natural frequencies, which can lead to resonance amplification of vibration amplitudes, shall be above the maximum normal operating speed frequency by at least 15%. The motor shall be capable of demonstrating a minimum 15% separation margin during an unbalance response (coastdown) test.

2.4.7 Bearings, Bearing Housings and Seals

2.4.7.1 Bearings

2.4.7.1.1 Hydrodynamic radial bearings with oil ring lubrication shall be provided.

2.4.7.1.2 Hydrodynamic radial bearings shall be split for ease of assembly. The bearings on each end of the motor shall be identical.

2.4.7.1.3 The design of the bearing housing shall not require removal of the lower half of the end bell or plates, ductwork, or the coupling hub to permit replacement of the bearing liners, pads, or shells.

2.4.7.1.4 Sleeve bearing temperatures shall not exceed 200°F (93°C) with the motor operating at rated output in an environment of maximum ambient temperature.

2.4.7.1.5 At ambient temperature, the fit between the outside of the bearing shell and the bearing housing shall be zero clearance to an interference fit.

• **2.4.7.1.6** When specified antifriction bearings may be supplied. The following conditions shall be met:

a. The dN factor is less than 300,000.

b. Antifriction bearings meet an ABMA L10 rating life of 100,000 hours in direct coupled applications with continuous operation at rated conditions.

c. Ball and roller bearing manufacturing tolerance limits shall be in accordance with Table 4 of ABMA 20-1996. Ball bearings shall have ABMA C/3 or C/4 clearances.

2.4.7.2 Bearing Housings

2.4.7.2.1 Bearing housings and shaft seals shall be designed to meet the requirements of IP55 per NEMA MG 1 as a minimum.

2.4.7.2.2 A permanent indication of the proper oil level to within 0.040 in. (1 mm) of the actual operating oil level shall be clearly marked on the outside of the bearing housing with metal tags, marks inscribed in the castings, or other durable means. If the oil-level indicator breaks, the resulting drop in oil level shall not result in loss of bearing lubrication, that is, reduction of the oil level below the level required for oil-ring operation.

2.4.7.2.3 The housings shall be equipped with constant-level sight-feed oilers at least 8 oz. (0.25 L) in size, with a positive level positioner (not a set screw), glass containers, protective wire cages, and supplemental support in addition to the piping.

2.4.7.2.4 Housings for ring-oil-lubricated bearings shall be provided with plugged ports positioned to allow visual inspection of the oil rings while the equipment is running.

2.4.7.2.5 Bearing housings shall be located by cylindrical precision dowels or rabbitted fits.

2.4.7.3 Shaft Seals

2.4.7.3.1 Shaft seals for hydrodynamic radial bearings shall conform to the following:

a. Primary bearing housing/enclosure seals shall be made from a non-sparking material.

b. For WP II motor enclosures, primary seals shall be split labyrinth type end seals on both sides of each bearing enclosure.

c. TEFC motors whose enclosure mates with and completes the inboard section of the bearing housing shall have a split labyrinth type end seal on the outboard end of the bearing housings where the shaft passes through the bearing enclosure.

d. The seals shall not contact the shaft while under normal operation and shall have a minimum life expectancy of 5 years under usual service conditions. Lip type seals shall not be used.

e. Oil shall not leak past the seals during both stationary and normal, rated operating conditions.

2.4.7.3.2 Shaft seals for antifriction bearings shall conform to the following:

a. For grease lubricated bearings, replaceable labyrinth shaft seals shall be used and shall be the non-contact or non-contacting-while-rotating type with a minimum expected seal life of five years under usual service conditions.

b. Oil or oil-mist lubricated bearings shall have seals as above, or lip type seals on both outboard and inboard sides of the bearing to reduce oil migration into the environment and motor interior.

c. Cast iron inner bearing caps shall be provided to minimize grease or oil migration to the motor interior.

2.4.7.4 Bearing Insulation

2.4.7.4.1 Bearings shall be electrically insulated. A shorting device shall be provided in the bearing housing on the drive end. For double-end drivers, the coupling on one end also shall be electrically insulated and the bearing housing shorting device provided on the opposite end.

2.4.7.4.2 The bearing insulation shall be permanent and non-deteriorating during assembly and disassembly of the bearing. This shall have been verified by a type test where a bearing having an identical insulation system is assembled and disassembled a minimum of 10 times; followed by a measurement of its insulation resistance. The bearing insulation resistance shall be a minimum of 10 megohms at a test voltage of 50 V DC minimum.

2.4.8 Lubrication

Hydrodynamic bearings shall use mineral oil and shall be arranged for ring-type lubrication in accordance with the bearing manufacturer's recommendations.

2.4.9 End Play and Couplings

2.4.9.1 Hydrodynamic radial bearing motors shall have a total end play of at least $^1/_2$ in. (13 mm). The design of the motor shall ensure that the magnetic center shall be within 20% of the total end float from the center of the end float limit indicators (e.g., $^3/_{32}$ in. for a $^1/_2$ in. total end float) or 2.6 mm for a 13 mm total end float.

2.4.9.2 Flexible couplings used with hydrodynamic radial bearing motors shall be of the limited-end-float-type. The total end float shall be limited to $^3/_{16}$ in. (5 mm).

2.4.9.3 Hydrodynamic bearing equipped motors shall have a permanent indicator to show the actual limits of total rotor end float and magnetic center.

2.4.10 Stator Lamination Core Plate

Stator lamination core plate shall be of at least C-5 quality in accordance with ASTM A 345, or EN 10126/EN10165. C3 quality plate shall not be used in any form. The stator core shall be capable of withstanding winding burnout for rewind at a stator core temperature of 750°F (400°C) without damage or loosening.

2.4.11 Nameplates, Rotation Arrows and End Float Indicators

2.4.11.1 Nameplates, rotation arrows and end float indicators shall be of AISI 300 series stainless steel, securely fastened by pins of similar material, and attached at readily visible locations. All information (including title fields) shall be permanently inscribed, embossed or engraved. Nameplates shall be provided on the motor and on or adjacent to each auxiliary device or junction box.

2.4.11.2 As a minimum, the data listed below shall be included on the motor's nameplate(s).

a. Manufacturer's name.
b. Serial number.
c. Horsepower or kilowatts.
d. Voltages.
e. Phase.
f. Full load power factor and efficiency.
g. Frequency, in hertz.
h. For antifriction bearings, the ABMA bearing designation.
i. Full-load current (amps).
j. Locked-rotor amperes (amps) and safe stall time (hot and cold).
k. Full-load speed, in revolutions per minute.
l. Time rating.
m. Temperature rise, in degrees Celsius; the maximum ambient or cooling-air temperature for which the motor was designed; and the insulation system's class designation.
n. Service factor.
o. Number of starts per hour.
p. Location of the magnetic center and end float limits
q. Enclosure type.
r. Total motor weight and rotor weight.
s. Year of manufacture.

2.4.11.3 Separate connection diagrams or data nameplates shall be located near the appropriate connection box for the following:

a. Motors with more than three power leads.
b. Space heaters (operating voltage and wattage, and for Class I, Division 2, locations, the NFPA 70 "T" identification number for space heaters).
c. Temperature detectors (resistance, in ohms, or junction type).
d. Connections of proper rotation (including bidirectional).

• **2.4.11.4** When specified, the purchaser's identification information shall be stamped on a separate nameplate.

3 Accessories

3.1 TERMINAL BOXES

3.1.1 Terminal boxes and auxiliary equipment enclosures shall be constructed of cast or nodular iron, cast steel, cast aluminum, steel plate, or aluminum plate with a minimum rigidity equivalent to that of steel plate with a nominal thickness of 1/8 in. (3 mm). Minimum dimensions and usable volumes of the main terminal box shall not be less than those specified by NEMA MG 1 Part 20 Type II.

3.1.2 Accessory leads shall terminate in a box or boxes separate from the main terminal box.

3.1.3 As a minimum, terminal boxes and auxiliary equipment enclosures shall meet the requirements for IP54 (NEMA 4) weather protection and for the area classification shown on the data sheets.

The terminal boxes shall be suitable for conductor entry as specified on the data sheets and fully accessible from the front.

All auxiliary device wires shall be terminated on 600 V rated terminal blocks.

All vertical gasketed surfaces shall be provided with a drip shield at the top. The gasket material shall be impervious to oil attack. Type test and or design information shall be supplied when requested on identical gasket material to verify that this requirement has been satisfied.

3.1.4 Grounding for field wiring inside terminal box shall conform to the requirements of NEMA MG 1 Part 4 or IEC 60072.

3.1.5 The main terminal box shall be supplied with the following items:

a. Drains.
b. Breathers.
c. Adequate space for termination of shielded cables.
d. When bus is supplied, it shall be copper and silver or tin-plated.
e. When ground bus is supplied, it shall be copper
f. When specified, space heaters supplied in accordance with 3.4.

3.1.6 Wiring and terminal blocks in all terminal boxes shall be clearly identified. The method for marking the wiring shall be a stamped sleeve of the heat-shrinkable type. The terminal blocks shall be permanently and suitably labeled. Stator leads shall be identified in accordance with NEMA MG 1 or IEC 60034-8. All wiring markings shall agree with the notations on the special nameplates required by 2.4.11.3.

3.1.7 All wiring shall have insulation that is impervious to attack by mineral oil.

3.2 WINDING TEMPERATURE DETECTORS

3.2.1 Stator winding Resistance Temperature Detectors (RTDs) shall be supplied.

3.2.1.1 RTD elements shall be platinum, three-wire elements with a resistance of 100 ohms at 32°F (0°C). These elements shall have tetrafluoroethylene-insulated, stranded, tinned copper wire leads with cross sections at least equal to 22 AWG (0.7 mm) in size. The leads shall meet the requirements of NFPA 70 or IEC 60079.

3.2.1.2 A minimum of two sensing elements per phase shall be installed, distributed around the circumference in the stator winding slots.

3.3 BEARING TEMPERATURE DETECTORS

Bearing temperature detectors shall be provided in motors with hydrodynamic bearings. Detectors shall be installed so that they measure bearing metal temperature. Bearing temperature detectors shall be installed in such a way that they do not violate the integrity of the bearing insulation. RTD elements shall be platinum, three-wire elements with a resistance of 100 ohms at 32°F (0°C). These elements shall have tetrafluoroethylene-insulated, stranded, tinned copper wire leads with cross sections at least equal to 22 AWG (0.7 mm) in size. The leads shall meet the requirements of NFPA 70 or IEC 60079.

3.4 SPACE HEATERS

Low dissipation space heaters (surface temperature of the heating element shall not exceed 160°C [320°F]) shall be provided and completely wired using high temperature insulation lead material of types FEPB, NI, and SA. The wiring shall be brought out to a separate terminal box. The heaters shall be installed inside the enclosure in a location suitable for easy removal and replacement. Heaters shall be located and insulated so that they do not damage components or finish. Any type of heater that contacts the surface of the stator winding is not acceptable.

3.5 GROUND CONNECTORS

Visible ground pads, made from corrosion resistant material, shall be provided at opposite corners of the motor frame. A ground connection point shall be provided by drilling and tapping the pad for a $^1/_2$ in. national coarse (NC) or 12.0 mm thread bolt.

4 Inspection, Testing, and Preparation for Shipment

4.1 FINAL TESTING

4.1.1 General

4.1.1.1 Tests shall be made on the fully assembled motor, using contract components, instrumentation, and accessories. Terminal boxes may be excluded.

4.1.1.2 All detection, protective, and control devices (except differential current, neutral and power transformers, surge capacitors and lightning arresters) shall be tested to verify acceptable performance in accordance with the device specifications.

4.1.2 Routine Test

Each motor shall be given a routine test to demonstrate that it is free from mechanical and electrical defects. These tests shall be conducted in accordance with the applicable portions of NEMA MG 1, and IEEE 112, or IEC 60034-2. The test shall include the following items:

a. Measurement of no-load current (each phase).

b. A determination of locked-rotor current.

c. A high-potential test on the stator windings, space heaters and RTDs.

d. An insulation resistance test by megohmmeter and polarization index per IEEE 43. The insulation resistance measurement and polarization index shall be performed at 2500 V DC, or at 5000 V DC for rated motor voltages of 4000 V and above. (The polarization index is the ratio of the 10-minute resistance value to the 1-minute resistance value.) The minimum acceptable value for the stator winding index is 2.0.

e. Measurement of stator resistance, using a digital low resistance meter.

f. Measurement of vibration.

g. A test of the bearing insulation.

h. A test of the bearing temperature rise. The motor shall be operated at no load for at least 1 hour after the bearing temperatures have stabilized. Stable temperature is defined as a change of not more than 1°C (1.8°F) in 30 minutes. Bearing temperature rise when stable shall not exceed 20°C (36°F) above ambient or the inlet oil temperature when oil is supplied from an external lubrication system. There shall be no oil leaks during the test and the vibration levels shall be in compliance with 4.1.3.1 and 4.1.3.2.

4.1.3 Vibration Tests

4.1.3.1 All fully assembled motors shall meet vibration levels of 0.10 in. per second (IPS), zero to peak (2.5 mm/second zero to peak or 1.8 mm/second rms) for both filtered and unfiltered measurements when tested at no load and full voltage and bolted to a massive, flat base. Measurements shall be made in the vertical and horizontal plane on both bearing housings, and axial direction on the drive end bearing housing. As a minimum, spectrum frequency sweeps shall range from 25% of running speed to four times line frequency.

4.1.3.2 When equipped with non-contacting eddy current probes or provisions for probes, the shaft vibration limits are the same as those identified in API Std 541 Figure 1.

4.1.3.3 Unfiltered and filtered radial and axial vibration, electrical input, and temperature data shall be recorded at 30-minute intervals during all mechanical running tests. If equipped with shaft probes per 4.1.3.2, shaft vibration shall also be recorded. If the vibration pulsates, the high and low values shall be recorded.

4.1.3.4 All purchased vibration probes, transducers, oscillator-demodulators, and accelerometers shall be in use during the test. If vibration probes are not furnished by the equipment vendor or if the purchased probes are not compatible with shop readout facilities, then shop probes and readouts that meet the accuracy requirements of API Std 670 shall be used.

4.1.4 Stator Surge Tests

Surge comparison tests shall be made of the turn insulation in the fully wound stator just before the coil-to-coil connections are made, at test levels and methods in accordance with Figure 1 of IEEE 522 or IEC 60034-15.

• 4.1.5 Special Tests

When special tests are specified, they shall be performed in accordance with the requirements of API Std 541, 4th edition, where applicable, i.e.:

a. Complete Test (4.3.5.1).

b. Unbalance Response (4.3.5.3).

c. Rated Rotor Temperature Vibration Test (4.3.5.2).

d. Sealed Winding Conformance Test (4.3.4.4).

4.2 PREPARATION FOR SHIPMENT

4.2.1 Preparation for shipment shall be performed after all testing and inspection have been completed and the purchaser has released the equipment for shipment. The preparation shall make the equipment suitable for at least 6 months of outdoor storage from the time of shipment, and shall include items a through i of 4.2.2 (as required). The vendor shall provide the purchaser with the instructions necessary to preserve the integrity of the storage preparation after the equipment arrives at the job site and before start-up. One copy of the manufacturer's standard installation instructions shall be packed and shipped with the equipment.

4.2.2 The motor shall be prepared for shipment in accordance with the following:

a. Exterior surfaces, except for machined surfaces or corrosion resistant material, shall be coated with manufacturer's standard paint. Exposed shafts and shaft couplings shall be wrapped with an easily removed waterproof coating or wrapping. Bearing assemblies shall be fully protected from the entry of moisture and dirt.

b. After thorough cleaning, internal areas of bearings and carbon steel oil systems' auxiliary equipment shall be coated with a suitable oil-soluble rust preventive.

c. For shipping purposes, threaded openings shall be provided with steel caps or solid-shank steel plugs. Nonmetallic threaded plugs shall only be used for terminal box openings.

d. The equipment shall be mounted on a rigid skid or base suitable for handling by forklift, truck or crane. This skid shall extend beyond all surfaces of the motor.

e. Lifting points and lifting lugs shall be clearly marked. Each motor shall be properly identified with item and serial numbers. Material shipped in separate crates shall be suitably identified with securely affixed, corrosion-resistant metal tags indicating the item and serial number of the equipment for which it is intended. The recommended lifting arrangement shall be identified on boxed equipment.

f. If vapor-phase-inhibitor crystals in bags are installed in large cavities to absorb moisture, the bags must be attached in an accessible area for ease of removal. Where applicable, bags shall be installed in wire cages attached to flanged covers, and corrosion-resistant tags attached with stainless steel wire shall indicate bag locations.

g. Motors that are disassembled for shipment or storage shall be provided with marine type plywood over all openings and sloped for proper watershed when protected with exterior covering.

h. The rotor shall be blocked to prevent axial and radial movement.

i. Space-heater leads shall be accessible without disturbing the shipping package and shall be suitably tagged for easy identification.

5 Guarantee and Warranty

The details of the guarantee and warranty will be developed jointly by the purchaser and the vendor during the proposal period.

6 Vendor's Data

6.1 PROPOSALS

6.1.1 The vendor shall complete the Vendors Sections of the data sheets in Appendix A.

6.1.2 The vendor shall provide complete performance curves and data to fully define the envelope of operations and the point at which the manufacturer has rated the equipment, including the following items:

a. Average torque versus speed during starting at rated voltage and at 80% voltage.

b. Current versus speed during starting at rated voltage and at 80% voltage.

c. When load curves and inertia are supplied with request for proposal, the estimated times for acceleration at rated voltage and at 80% voltage.

d. The locked-rotor (stalled) withstand time, with the motor at ambient temperature and at its maximum rated operating temperature, at rated voltage and at 80% voltage.

e. Expected and guaranteed efficiencies as determined in accordance with IEEE 112, or IEC 60034-2, or by certified data from previously tested designs. Efficiency shall be determined by IEEE 112 method A, the input output method. If testing limitations prevent the use of IEEE 112 method A, IEEE method F, the equivalent circuit method with direct measurement of stray-load losses may be used provided all assumptions made by the manufacturer are provided. The vendor shall specify on the data sheet the efficiency test method to be used. It is important to note that IEEE 112 and IEC 60034-2 test methods differ considerably. Therefore, comparisons of expected and guaranteed efficiencies cannot be made between IEEE and IEC values.

6.1.3 The vendor shall provide net weights and maximum erection weights with identification of the item. This data shall be stated individually where separate shipments, packages, or assemblies are involved. This data shall be entered on the data sheets.

6.1.4 The vendor shall provide a preliminary dimensional outline drawing showing the direction of rotation when viewed from the end opposite the drive end.

• **6.1.5** The vendor shall provide a separate price for each test that is specified and a packaged price for all the tests specified on the data sheets.

6.2 CONTRACT DATA

The vendor will provide three sets of prints as well as electronic files in .pdf format for all submitted data, drawings and instruction manuals.

6.2.1 Drawings

The drawings furnished shall contain enough information so that when they are combined with the manuals specified in 6.2.3, the purchaser will be able to properly install, operate, and maintain the ordered equipment. As a minimum, the following details shall be provided:

a. Overall dimensions and weights for each separately installed piece. Maintenance clearances and weight-handling capability required for erection and maintenance shall be included.

b. The direction of rotation.

c. As applicable, the size, type, location, and identification of all the purchaser's connections, including power, control, instrument wiring, etc.; connections plugged by the vendor shall be identified.

d. When applicable, the make, size, and type of couplings.

e. A list of any special weather-protection and climatization features supplied by the vendor and required by the purchaser.

f. A list of auxiliary or other equipment furnished by the vendor for mounting by the purchaser.

g. Rigging provisions for removal of (maintenance) parts that weight more than 45 lb. (20 kg).

6.2.2 Data

6.2.2.1 The vendor shall complete and provide three sets of the "as purchased" data sheets.

6.2.2.2 The vendor shall provide to the purchaser:

a. Completed "as-built" data sheets.

b. Certified copies of the test data.

6.2.3 Instruction Manuals

The vendor shall provide an Instruction Operations and Maintenance Manual containing as a minimum: written instructions for initial installation, startup, normal operation, maintenance and recommended spare parts.

APPENDIX A—MOTOR DATA SHEETS

American Petroleum Institute	INDUCTION MOTOR API 547 1st Edition -- DATA SHEETS **U.S. CUSTOMARY UNITS**	JOB NO. ____ ITEM / TAG NO. ____ PURCHASE ORDER NO. ____ REQ. / SPEC. NO. ____ REVISION NO. ____ DATE ____ BY ____ PAGE 1 OF 3

1 FOR/USER ____ DRIVEN EQUIPMENT ____

2 SITE/LOCATION ____ QUANTITY ____

3 SUPPLIER ____ SUPPLIER PROJECT NO. ____

4 Applicable To: Proposal ○ Purchase ○ As-built

5 NOTE: **(Excel code)** TO BE COMPLETED BY PURCHASER **(m or l)** □ BY MANUFACTURER WITH PROPOSAL **(o or n)** ▽ BY MANUFACTURER AFTER ORDER **(s or q)** ▷ BY MANUFACTURER OR PURCHASER **(w or u)**

MOTOR BASIC DATA

6 Applicable Standards (1.4.2): ● **NORTH AMERICAN (i.e., ANSI, NEMA)** ○ International (i.e., IEC, ISO)

7 Nameplate Rating (1.1): ____ hp ____ RPM (Synchronous)

8 ____ Volts (2.2.1) 3 Phase ____ Hertz

9 Motor Power Source: ● **SINE WAVE POWER** ○ ASD power (1.3.e, 2.2.1. Purchaser to advise details, see Page 2, lines 7 through 11)

10 **Usual Service Conditions (1.2.a, b, c, d, e, h):**

11 Ambient Temperature **-25 to +40 °C** ○ Other: ____ Site Elevation: **LESS THAN 3300 FT** ○ Other: ____

12 Motor Location: ○ Indoor ○ Outdoor ○ Outdoor with roof ○ Offshore

13 ○ Dust ○ Chemicals ____ ○ Corrosive Agents ____

14 Mounting: **HORIZONTAL** ○ Foot Mounted ○ Flange Mounted ▷ Flange details ____

15 Other: ____

16 Area Classification: **Class** 1 Group ____ ○ **Division** 2 or ○ **Zone** 2 Autoignition Temp ____ °C

17 ○ Nonclassified ○ Other: ____

18 Connection to load: **DIRECT COUPLED**

19 **Sound Pressure Level (2.1.2):** **LESS THAN 85 dBA @ 3 ft, NO-LOAD, FULL VOLT/FREQ., SINE WAVE POWER** ○ Other: ____

20 **Enclosure (2.4.1.1):** ○ TEFC (2.4.1.2)

21 ○ Weather-protected Type II (WP II) (2.4.1.3) ● **WP II AIR FILTERS (2.4.1.3.f)** ○ Pressure switch ○ Pressure gauge

22 **Bearings (2.4.7):** **HYDRODYNAMIC (2.4.7.1.1)** ○ Antifriction (2.4.7.1.6)

23 **Main Terminal Box (3.1.1):** **NEMA MG 1 PART 20 TYPE II**

24 ○ Box Location ____ Conductor Size ____ Qty. Per Phase ____ Type/Insulation ____ Cable Entry: ____

25 ○ Space Heaters (3.1.5.f): Temp. Code **T3C** or ○ T ____ Volts: ____ Phase: ____ □ kW ____

26 **Motor Starting (2.2.2.3)** **ACROSS-THE-LINE STARTING AT 80% OF RATED VOLTAGE**

27 ○ Loaded ○ Unloaded ○ Partially Loaded ____ %

28 ○ Other Starting Method Type ____ Reduced Voltage ____ Volts

29 Additional Information: ____

____

30 ____

ACCESSORIES:

31 ○ **Motor space heaters (3.4):** Temp. Code **T3C** or ○ T ____ Volts: ____ Phase: ____ □ kW ____

32 **Winding Temperature Detectors (3.2):** **PLATINUM, 3 WIRE, 100 Ohms at 0°C, 2 per PHASE**

33 ○ Stator RTD Box Location: ____

34 □ Recommended Settings: Alarm ____ °C □ Shutdown ____ °C

35 **Hydrodynamic Bearing Temperature Detectors (3.3):** **PLATINUM, 3 WIRE, 100 Ohms at 0°C**

36 ○ Bearing Temperature Sensor Wire Terminations: ▷ Terminal box at motor side ▷ In the Stator RTD T Box ▷ Conduit Head at Bearing

37 □ Recommended Settings: Alarm ____ °C □ Shutdown ____ °C

38 ○ **Vibration Probes (Option, 2.4.5.1.2, per API 541)** Details: ____

39 Additional Information: ____

40 ____

1 NOTE: **(Excel code)** ❍ TO BE COMPLETED BY PURCHASER **(m or l)** ☐ BY MANUFACTURER WITH PROPOSAL **(o or n)** ▽ BY MANUFACTURER AFTER ORDER **(s or q)** ▷ BY MANUFACTURER OR PURCHASER **(w or u)**

MISCELLANEOUS:

2 ❍ **Auxillary nameplate(s) with purchaser information (2.4.11.4):**

3 Details: ______ ______

4 Additional Information: ______

5 ______

SPECIAL CONDITIONS:

6 **Adjustable Speed Drive Operation (1.3.e, 2.2.1):**

7 ❍ ASD only ❍ ASD with DOL Start ❍ Bypass @ Utility Frequency

8 ❍ Variable Torque Speed Range: Min Speed ______ RPM ______ ft-lb. Max. Speed ______ RPM ______ ft-lb.

9 ❍ Constant Torque Speed Range: Min Speed ______ RPM Max. Speed ______ RPM ______ ft-lb.

10 ❍ Constant Power Speed Range: Min Speed ______ RPM Max. Speed ______ RPM ______ HP

11 Other Unusual Service Conditions (1.3): ______

12 ______

DRIVEN EQUIPMENT INFORMATION

13 Driven Equipment: Tag No. ______ Description ______ Location ______

14 Type of Load: ❍ Centrifugal Compressor ❍ Pump ❍ Fan Manufacturer: ______ Type/Model No. ______ RPM ______

15 Total Driven-equipment WK^2 (2.2.2.5) ______ lb.-ft^2 at ______ RPM Load Speed-torque Curve No. (2.2.2.5) ______

16 Rotation ***Viewed from Opposite Drive End of Motor:*** ❍ Clockwise ❍ Counterclockwise ▷ Bi-directional

17 Coupling (2.4.9.2): Type ______ Mfr. ______ Type/Model ______

18 Supplied By: ❍ Motor Mfr ❍ Driven Equipment Mfr ❍ Purchaser ❍ Others ______

19 Mounted By: ❍ Motor Mfr ❍ Driven Equipment Mfr ❍ Purchaser ❍ Others ______

20 Other: ______

ANALYSIS, SHOP INSPECTION, AND TESTS

#		Required	Observed	Witnessed
21	**Routine Test (4.1.2)**			
22	No load current	❍	❍	❍
23	Locked rotor current	❍	❍	❍
24	High-potential test (stator, heaters, RTDs)	❍	❍	❍
25	Insulation resistance test	❍	❍	❍
26	Stator resistance	❍	❍	❍
27	Vibration measurement	❍	❍	❍
28	Bearing insulation test	❍	❍	❍
29	Bearing temperature rise	❍	❍	❍
30	**Stator Surge Test (4.1.4)**	❍	❍	❍
31	Special Tests *(per API 541 as noted)*			❍
32	Complete Test *(541 Para 4.3.5.1)*	❍	❍	❍
33	Unbalance Response *(541 Para 4.3.5.3)*	❍	❍	❍
34	Rated Rotor Temperature Vibration Test *(541 Para 4.3.5.2)*	❍	❍	❍
35	Sealed Winding Conformance Test *(541 Para 4.3.4.4)*	❍	❍	❍
36	Other ______	❍	❍	❍
37	Other ______	❍	❍	❍

American Petroleum Institute

INDUCTION MOTOR
API 547 1st Edition -- DATA SHEETS
U.S. CUSTOMARY UNITS

JOB NO. ________ ITEM / TAG NO. ________
PURCHASE ORDER NO. ________
REQ. / SPEC. NO. ________
REVISION NO. ________ DATE ________ BY ________
PAGE 3 OF 3

NOTE: **(Excel code)** ○ TO BE COMPLETED BY PURCHASER **(m or l)** □ BY MANUFACTURER WITH PROPOSAL **(o or n)** ▽ BY MANUFACTURER AFTER ORDER **(s or q)** ▷ BY MANUFACTURER OR PURCHASER **(w or u)**

MOTOR DATA

□ Manufacturer ________ □ Type/Model No. ________ □ Frame Size/Designation ________

Qty. ________ ________ hp ________ RPM (Syn.) ________ Poles ________ Volts 3 Phase ________ Hz

Service Factor 1. ____ Insulation Class **CLASS F** Temperature Rise **CLASS B** Enclosure ________

Full-load Speed ________ RPM Full-load Torque (FLT) ________ ft-lb. Rotor WK^2 ________ lb.-ft^2

Locked-rotor Torque (LRT) ________ % FLT Pull-up Torque (PUT) ________ % FLT Breakdown Torque (BDT) ________ % FLT

Load Point 50% 75% 100% ○ Other: ________ %

Efficiency ____ % ____ % ____ % ____ % ○ Guar. Efficiency at ____ % Load = ____ %

Power Factor ____ % ____ % ____ % ____ % ▷ Test Method: ________

Current ____ Amps ____ Amps ____ Amps ____ Amps

Speed-torque Curve No. ________ Speed-current Curve No. ________ Speed-power Factor Curve No. ________

Voltage Magnitude 100% Other: ____ %

Locked-rotor Current ____ Amps ____ Amps Locked-rotor PF ____ %

Locked-rotor Withstand Time, Cold ____ Sec. ____ Sec. Sound Pressure Level (2.1.2) ____ dBA @ 3', no-load

Locked-rotor Withstand Time, Rated Temp ____ Sec. ____ Sec.

Weights: Net ________ lb. Stator ________ lb. Rotor ________ lb. Shipping ________ lb.

Other: ________

COMMENTS

American Petroleum Institute	INDUCTION MOTOR API 547 1st Edition -- DATA SHEETS **METRIC UNITS**	JOB NO. ______ ITEM / TAG NO. ______ PURCHASE ORDER NO. ______ REQ. / SPEC. NO. ______ REVISION NO. ______ DATE ______ BY ______ PAGE 1 OF 3

1 FOR / USER ______ DRIVEN EQUIPMENT ______

2 SITE / LOCATION ______ QUANTITY ______

3 SUPPLIER ______ SUPPLIER PROJECT NO. ______

4 Applicable To: Proposal ○ Purchase ○ As-built

5 NOTE: **(Excel code)** TO BE COMPLETED BY PURCHASER **(m or l)** ☐ BY MANUFACTURER WITH PROPOSAL **(o or n)** ▽ BY MANUFACTURER AFTER ORDER **(s or q)** ▷ BY MANUFACTURER OR PURCHASER **(w or u)**

MOTOR BASIC DATA

6 Applicable Standards (1.4.2): ● International (i.e., IEC, ISO) ○ **NORTH AMERICAN (i.e., ANSI, NEMA)**

7 Nameplate Rating (1.1): ______ kW ______ RPM (Synchronous)

8 ______ Volts (2.2.1) **3** Phase ______ Hertz

9 Motor Power Source: ● **SINE WAVE POWER** ○ ASD power (1.3.e, 2.2.1. Purchaser to advise details, see Page 2, lines 7 through 11)

10 **Usual Service Conditions (1.2.a, b, c, d, e, h):**

11 Ambient Temperature **-25 to +40 °C** ○ Other: ______ Site Elevation: **LESS THAN 1000 m** ○ Other: ______

12 Motor Location: ○ Indoor ○ Outdoor ○ Outdoor with roof ○ Offshore

13 ○ Dust ○ Chemicals ______ ○ Corrosive Agents ______

14 Mounting: **HORIZONTAL** ○ Foot Mounted ○ Flange Mounted ▷ Flange details ______

15 Other: ______

16 Area Classification: **Class** **1** Group ______ ○ **Zone** **2** Autoignition Temp ______ °C

17 ○ Nonclassified ○ Other: ______

18 Connection to load: **DIRECT COUPLED**

19 **Sound Pressure Level (2.1.2):** **LESS THAN 85 dBA @ 1 m, NO-LOAD, FULL VOLT/FREQ., SINE WAVE POWER** ○ Other: ______

20 **Enclosure (2.4.1.1):** ○ TEFC (2.4.1.2)

21 ○ Weather-protected Type II (WP II) (2.4.1.3) ● **WP II AIR FILTERS (2.4.1.3.f)** ○ Pressure switch ○ Pressure guage

22 **Bearings (2.4.7):** **HYDRODYNAMIC (2.4.7.1.1)** ○ Antifriction (2.4.7.1.6)

23 **Main Terminal Box (3.1.1):** **NEMA MG 1 PART 20 TYPE II**

24 ○ Box Location ______ Conductor Size ______ Qty. Per Phase ______ Type/Insulation ______ Cable Entry: ______

25 ○ Space Heaters (3.1.5.f): Temp. Code **T3C** or ○ T ______ Volts: ______ Phase: ______ ☐ kW ______

26 **Motor Starting (2.2.2.3)** **ACROSS-THE-LINE STARTING AT 80% OF RATED VOLTAGE**

27 ○ Loaded ○ Unloaded ○ Partially Loaded ______ %

28 ○ Other Starting Method Type ______ Reduced Voltage ______ Volts

29 Additional Information: ______

______

30 ______

ACCESSORIES:

31 ○ **Motor space heaters (3.4):** Temp. Code **T3C** or ○ T ______ Volts: ______ Phase: ______ ☐ kW ______

32 **Winding Temperature Detectors (3.2):** **PLATINUM, 3 WIRE, 100 Ohms at 0°C, 2 per PHASE**

33 ○ Stator RTD Box Location: ______

34 ☐ Recommended Settings: Alarm ______ °C ☐ Shutdown ______ °C

35 **Hydrodynamic Bearing Temperature Detectors (3.3):** **PLATINUM, 3 WIRE, 100 Ohms at 0°C**

36 ○ Bearing Temperature Sensor Wire Terminations: ▷ Terminal box at motor side ▷ In the Stator RTD T Box ▷ Conduit Head at Bearing

37 ☐ Recommended Settings: Alarm ______ °C ☐ Shutdown ______ °C

38 ○ **Vibration Probes (Option, 2.4.5.1.2, per API 541)** Details: ______

39 Additional Information: ______

40 ______

American Petroleum Institute	INDUCTION MOTOR API 547 1st Edition -- DATA SHEETS **METRIC UNITS**	JOB NO. ____ ITEM / TAG NO. ____ PURCHASE ORDER NO. ____ REQ. / SPEC. NO. ____ REVISION NO. ____ DATE ____ BY ____ PAGE 2 OF 3

1 NOTE: **(Excel code)** ❍ TO BE COMPLETED BY PURCHASER **(m or l)** ☐ BY MANUFACTURER WITH PROPOSAL **(o or n)** ▽ BY MANUFACTURER AFTER ORDER **(s or q)** ▷ BY MANUFACTURER OR PURCHASER **(w or u)**

MISCELLANEOUS:

2 ❍ **Auxillary nameplate(s) with purchaser information (2.4.11.4):**

3 Details: ____ ____

4 Additional Information: ____

5 ____

SPECIAL CONDITIONS:

6 **Adjustable Speed Drive Operation (1.3.e, 2.2.1):**

7 ❍ ASD only ❍ ASD with DOL Start ❍ Bypass @ Utility Frequency

8 ❍ Variable Torque Speed Range: Min Speed ____ RPM ____ Nm Max. Speed ____ RPM ____ Nm

9 ❍ Constant Torque Speed Range: Min Speed ____ RPM Max. Speed ____ RPM ____ Nm

10 ❍ Constant Power Speed Range: Min Speed ____ RPM Max. Speed ____ RPM ____ HP

11 Other Unusual Service Conditions (1.3): ____

12 ____

DRIVEN EQUIPMENT INFORMATION

13 Driven Equipment: Tag No. ____ Description ____ Location ____

14 Type of Load: ❍ Centrifugal Compressor ❍ Pump ❍ Fan Manufacturer: ____ Type/Model No. ____ RPM ____

15 Total Driven-equipment GD^2 (2.2.2.5) ____ kg-m^2 at ____ RPM Load Speed-torque Curve No. (2.2.2.5) ____

16 Rotation *Viewed from Opposite Drive End of Motor:* ❍ Clockwise ❍ Counterclockwise ▷ Bi-directional

17 Coupling (2.4.9.2): Type ____ Mfr. ____ Type/Model ____

18 Supplied By: ❍ Motor Mfr ❍ Driven Equipment Mfr ❍ Purchaser ❍ Others ____

19 Mounted By: ❍ Motor Mfr ❍ Driven Equipment Mfr ❍ Purchaser ❍ Others ____

20 Other: ____

ANALYSIS, SHOP INSPECTION, AND TESTS

		Required	Observed	Witnessed
21	**Routine Test (4.1.2)**			
22	No load current	❍	❍	❍
23	Locked rotor current	❍	❍	❍
24	High-potential test (stator, heaters, RTDs)	❍	❍	❍
25	Insulation resistance test	❍	❍	❍
26	Stator resistance	❍	❍	❍
27	Vibration measurement	❍	❍	❍
28	Bearing insulation test	❍	❍	❍
29	Bearing temperature rise	❍	❍	❍
30	**Stator Surge Test (4.1.4)**	❍	❍	❍
31	Special Tests *(per API 541 as noted)*			
32	Complete Test *(541 Para 4.3.5.1)*	❍	❍	❍
33	Unbalance Response *(541 Para 4.3.5.3)*	❍	❍	❍
34	Rated Rotor Temperature Vibration Test *(541 Para 4.3.5.2)*	❍	❍	❍
35	Sealed Winding Conformance Test *(541 Para 4.3.4.4)*	❍	❍	❍
36	Other ____	❍	❍	❍
37	Other ____	❍	❍	❍

American Petroleum Institute	INDUCTION MOTOR API 547 1st Edition -- DATA SHEETS **METRIC UNITS**	JOB NO. ______ ITEM / TAG NO. ______ PURCHASE ORDER NO. ______ REQ. / SPEC. NO. ______ REVISION NO. ______ DATE ______ BY ______ PAGE 3 OF 3

NOTE: **(Excel code)** ○ TO BE COMPLETED BY PURCHASER **(m or l)** □ BY MANUFACTURER WITH PROPOSAL **(o or n)** ▽ BY MANUFACTURER AFTER ORDER **(s or q)** ▷ BY MANUFACTURER OR PURCHASER **(w or u)**

MOTOR DATA

□ Manufacturer ______ □ Type/Model No. ______ □ Frame Size/Designation ______

Qty. ______ ______ kW ______ RPM (Syn.) ______ Poles ______ Volts 3 Phase ______ Hz

Service Factor 1. ______ Insulation Class **CLASS F** Temperature Rise **CLASS B** Enclosure ______

Full-load Speed ______ RPM Full-load Torque (FLT) ______ Nm Rotor GD^2 ______ kg-m^2

Locked-rotor Torque (LRT) ______ % FLT Pull-up Torque (PUT) ______ % FLT Breakdown Torque (BDT) ______ % FLT

Load Point 50% 75% 100% ○ Other: ______ %

Efficiency ______ % ______ % ______ % ______ % ○ Guar. Efficiency at ______ % Load = ______ %

Power Factor ______ % ______ % ______ % ______ % ▷ Test Method: ______

Current ______ Amps ______ Amps ______ Amps ______ Amps

Speed-torque Curve No. ______ Speed-current Curve No. ______ Speed-power Factor Curve No. ______

Voltage Magnitude 100% Other: ______ %

Locked-rotor Current ______ Amps ______ Amps Locked-rotor PF ______ %

Locked-rotor Withstand Time, Cold ______ Sec. ______ Sec. Sound Pressure Level (2.1.2) ______ dBA @ 1 m, no-load

Locked-rotor Withstand Time, Rated Temp ______ Sec. ______ Sec.

Mass Net ______ kg Stator ______ kg Rotor ______ kg Shipping ______ kg

Other: ______

COMMENTS

APPENDIX B—VENDOR DRAWING AND DATA REQUIREMENTS

INDUCTION MOTOR VENDOR DRAWING AND DATA REQUIREMENTS

JOB NO. ______________ ITEM NO. ____________________
PURCHASE ORDER NO. ____________ DATE ________________
REQUISITION NO. ______________ DATE ________________
INQUIRY NO. __________________ DATE ________________
PAGE 1 OF 3 BY ________________________

FOR ____
SITE ____
SERVICE ____
REVISION ____
UNIT ____
NO. REQUIRED ____

Proposal[a] Bidder shall furnish _______ copies of data for all items indicated by an X.

Review[b] Vendor shall furnish _______ copies and _______ transparencies of drawings and data indicated.

Final[c] Vendor shall furnish _______ copies and _______ transparencies of drawings and data indicated.
Vendor shall furnish _______ operating and maintenance manuals.

DISTRIBUTION RECORD

Final—Received from vendor
Due from vendor[c]
Review—Returned to vendor
Review—Received from vendor
Review—Due from vendor[c]

Proposal[a]	Review[b]	Final[c]	DESCRIPTION	Review—Due from vendor[c]	Review—Received from vendor	Review—Returned to vendor	Due from vendor[c]	Final—Received from vendor
			A.1 Dimensional outline drawings with major and minor connections.					
			a. Primary equipment					
			b. Auxiliary equipment.					
			c. Maintenance weights.					
			d. Size of shipping sections.					
			e. Sole plates.					
			f. Heat exchangers.					
			g.					
			h.					
			i.					
			j.					
			A.2 Foundation loading diagrams.					
			a.					
			b.					
			c.					
			A.3 Schematic wiring and/or flow diagrams.					
			a. Speed sensor.					
			b. Space heaters.					
			c. Locked rotor protection package.					
			d. Cooling and exchanger.					
			e. Lubrication (if applicable).					
			f. Vibration monitoring.					
			g. Temperature sensors.					
			h. Differential current transformers.					
			i. Phase current transformers.					
			j.					
			k.					

[a]Proposal drawings and data do not have to be certified or as-built.
[b]Purchaser will indicate in this column the time frame for submission of materials, using the nomenclature given at the end of this form.
[c]Bidder shall complete these two columns to reflect his actual distribution schedule and include this form with his proposal.

INDUCTION MOTOR VENDOR DRAWING AND DATA REQUIREMENTS

JOB NO. ____________ ITEM NO. ____________
PAGE 2 OF 3 BY ____________
DATE ____________ REV. NO. ____________

Proposal[a] Bidder shall furnish _______ copies of data for all items indicated by an X.

Review[b] Vendor shall furnish _______ copies and _______ transparencies of drawings and data indicated.

Final[c] Vendor shall furnish _______ copies and _______ transparencies of drawings and data indicated.
Vendor shall furnish _______ operating and maintenance manuals.

DISTRIBUTION RECORD

Final—Received from vendor
Due from vendor[c]
Review—Returned to vendor
Review—Received from vendor
Review—Due from vendor[c]

Proposal	Review	Final		DESCRIPTION	Review—Due from vendor	Review—Received from vendor	Review—Returned to vendor	Due from vendor	Final—Received from vendor
			B.1	Detail drawings and cross-sectional drawings.					
				a. Shaft end details.					
				b.					
				c.					
			B.2	Erection/assembly drawings.					
				a.					
				b.					
				c.					
			B.3	Calculations-torsional/lateral response.					
				a.					
				b.					
				c.					
			B.4	Predicted performance curves.					
				a. Power factor versus speed.					
				b. Motor and rotor healing.					
				c. Torque versus speed at rated voltage.					
				d. Torque versus speed at ______ percent voltage.					
				e. Current versus speed at rated voltage.					
				f. Current versus speed at ______ percent voltage.					
				g. Expected efficiency.					
				h. Acceleration time curves.					
				i.					
				j.					
				k.					
			C.1	Vendor's data reports (as-built).					
				a. X_m					
				b. R_s					
				c. R__					
				d. X_s					
				e. X__					
				f. X__					
				g. T__					
			C.2	Performance test reports.					

[a]Proposal drawings and data do not have to be certified or as-built.
[b]Purchaser will indicate in this column the time frame for submission of materials, using the nomenclature given at the end of this form.
[c]Bidder shall complete these two columns to reflect his actual distribution schedule and include this form with his proposal.

INDUCTION MOTOR VENDOR DRAWING AND DATA REQUIREMENTS

JOB NO. ____________ ITEM NO. ____________
PAGE 3 OF 3 BY ____________
DATE ____________ REV. NO. ____________

Proposal[a] Bidder shall furnish _______ copies of data for all items indicated by an X.

Review[b] Vendor shall furnish _______ copies and _______ transparencies of drawings and data indicated.

Final[c] Vendor shall furnish _______ copies and _______ transparencies of drawings and data indicated.
Vendor shall furnish _______ operating and maintenance manuals.

DISTRIBUTION RECORD

Final—Received from vendor
Due from vendor[c]
Review—Returned to vendor
Review—Received from vendor
Review—Due from vendor[c]

Proposal	Review	Final	DESCRIPTION	Review—Due from vendor	Review—Received from vendor	Review—Returned to vendor	Due from vendor	Final—Received from vendor
			C.3 Installation, maintenance, and operating instructions.					
			D.1 Recommended spare parts list.					
			a. Construction.					
			b. Start-up.					
			c. Maintenance (2-year).					
			E.1 Complete set of Assembly Photographs (see 6.2.4.5).					

[a]Proposal drawings and data do not have to be certified or as-built.
[b]Purchaser will indicate in this column the desired time frame for submission of materials, using the nomenclature given at the end of this form.
[c]Bidder shall complete these two columns to reflect his actual distribution schedule and include this form with his proposal.

APPENDIX C—DATA SHEET GUIDE

General

API Std 547 specifies the requirements for form-wound induction motors that are expected to be used in non critical industrial applications. In general they will be rated up to 3000 hp (2250 kW) for motors with 4 or more poles, 800 hp (600 kW) for 2 pole totally-enclosed motors; and 1250 hp (930 kW) for 2 pole WP II motors, drive centrifugal loads (e.g., fans or centrifugal pumps) with low inertias and are not used as induction generators. Motors that exceed these criteria may be specified using the more demanding API Std 541.

Features which are called up in the standard as being the default for that particular item are listed in the data sheets in **BOLD CAPITALS**. The default for the item will be assumed by the vendor unless an alternate selection is identified. There are two data sheets provided. One uses U.S. Customary units, and the other uses Metric units. The two systems will lead to similar but not always identical requirements.

Where a round bullet (•) is positioned at the beginning of a paragraph, a decision or further information is required, and there will be a place in the data sheet for this required information.

These data sheets are available from API in a user friendly, electronic spreadsheet (Excel) based format. To facilitate the functionality of these data sheets, bullets can be filled in by hitting the appropriate letter key. For example when filling in a bullet for a purchaser required item, hitting the "m" key leaves the bullet blank while hitting the "l" key fills it in, meaning that bullet applies. For user reference these Excel codes are noted at the top of each page: Line 5 of Page 1, and Line 1 of Pages 2 and 3. The second feature of the electronic version is that the input blanks may be reached through the "Tab" function. "TAB" for forward movement, and "SHIFT + TAB" for reverse. When the bottom of the page is reached, the cursor returns to the top of that page.

Items for which there are no alternatives (e.g., Stainless Steel nameplates) in the standard are not shown as options in the data sheets. If some other choice for these items is required, it should be listed in a line marked "Other".

Page 1

Line 2: Site Name/Location"—Indicates the name of the plant (e.g., Plant 18) or the equipment-train identification.

Line 3: "Supplier"—Manufacturer of the motor.

Line 3: "Supplier Project Number"—The vendor's internal project identification.

GENERAL INFORMATION

Line 4: "Applicable to: Proposal, Purchase, or As-built"—The originator of the request shall check "Proposal" when the data sheet is sent out for quotation. The purchaser of the equipment shall check, "Purchase" when an order is placed. This revision generally includes changes and modifications mutually agreed upon during coordination meetings and other communications. The equipment vendor shall check "As-built" to reflect the completed data sheet after all design details and changes during the manufacture of the motor have been completed.

Line 5: "Excel Code"—See electronic spreadsheet explanation under the General section.

Line 6: "Applicable Standards"—Indicate which standards apply, North American or International.

Line 7: "Nameplate Rating"—Horsepower or kilowatt output rating of the motor, where known. Add a note when this is to be determined by the driven-equipment vendor. A service factor of 1.0 is recommended. If output beyond the 1.0 service factor output rating is required, the next higher motor rating should be chosen. This is primarily done to assure adequate torque margin for the motor (accelerating, pull-up, and break-down torques). and to ensure long insulation life when applied to a Class F winding insulation system. Also, note that ISO standards for hazardous (classified) motors do not allow the employment of service factors above 1.0.

Line 7: "RPM (Synchronous)"—Corresponds to the no-load speed of the motor. Available speeds on 60 Hz power systems include 3600, 1800, 1200, 900, and 720 RPM. Lower speeds are available but seldom used for induction motor application. Synchronous speed is calculated using the formula: Speed in RPM = $120f/p$, where "f" is the electrical frequency and "p" is the number of poles in the motor (2, 4, 6, 8,...).

Line 8: "Volts, Phase, Hertz"—Normally specified utilization voltages for fixed speed North American applications are 2300 V, 4000 V, 6600 V or 13200 V supplied by 60 Hz, three-phase power systems of 2400 V, 4160 V, 6900 V, and 13800 V, respectively. Outside North America, 3000 V, 6000 V and 10000 V, 50 Hz are common, while 3300 V, 6600 V and 11000 V, 50 Hz are often used in British applications. Occasionally, a motor voltage of 460 V or 575 V might be specified for a motor of "form-wound" winding construction supplied by a 480 V or 600 V power system. Motors for use on adjustable speed drives sometimes have non standard voltages and frequencies, as required by the drive and the application. API Std 541 is more often used for ASD applications, and requires further data on the loads and the ASD, but when this standard is used, as a minimum list the drive output frequency range intended, and the speed versus torque requirements.

Line 9: "Motor Power Source"—This data sheet covers induction motors generally rated 2300 V and above and rated 500 hp and larger. If the motor is to be used on ASD power, details are required to be listed on Page 2 of the data sheet.

SITE DATA

Line 11: "Ambient Temperature"—Minimum and maximum ambient air temperature. Significant if below –25°C (–13°F) or above 40°C (104°F). Minimum temperature may determine the need for bearing-housing oil heaters or special steels with increased cold temperature toughness. Maximum temperature may determine a derating factor for the motor design (typically, a 1°C reduction in allowed temperature rise for every 1°C by which the ambient exceeds 40°C) or may dictate a special oil cooling system.

Line 11: "Site Elevation"—Significant if over 3300 ft (1000 m) above sea level. Machines must be derated by approximately 1% per 330 ft (100 m) for higher elevations due to the decreased air density. The manufacturer should be consulted for elevations above 6600 ft (2000 m) as other factors may affect this estimation. For new equipment, the manufacturer can take the elevation into consideration during the design stage and offer a machine fully rated for the conditions without derating. In this case, an indication of design-for-elevation should be made on the main rating nameplate.

Line 12: "Indoors, Outdoors"—Affects the selection of weatherproofing.

Line 13: "Dust, Chemicals, Corrosive Agents"—Other special site data which may affect motor operation or material selection is recorded here. Examples include abrasive dust, adhering dust, salt spray, corrosive agents, hose down, special mounting positions, etc.

Line 14: "Mounting"—Horizontal is the default. Foot mounted is the more common horizontal arrangement.

Line 16: "Area Classification"—Use the Class, Group, and Division, alternatively Class, Group and Zone as defined in Chapter 5 of the *National Electrical Code*. Areas are normally defined for existing plants, or projects. For Division or Zone 1 use, the Class, Group and Division identifiers are included in the area definition. For electric motors in Division 2 or Zone 2 locations, the Class and Division identifiers are included in the area definition. The most commonly specified area classification is Class I, Division 2 (Cl. I, Div. 2), for process areas. "Class I" means a flammable gas or liquid, "Division 2" or "Zone 2" is where the gas or vapor is present only during abnormal conditions. Almost all areas are "Division 2" or "Zone 2." A "Division 1" area means the gas or vapor is **often** present and special enclosures or provisions for ventilation must be used. A "Zone 1" area is one where the gas or vapor is likely to exist under normal conditions or that is adjacent to a "Zone 0" area. A "Zone 0" area is one where the gas or vapor is present continuously. In the Zone system Group IIA is similar to Group D in the Division system, Group IIB is similar to Group C and Group IIC is similar to Groups A and B in the Division system. However, not all chemicals retain this relationship: some materials change group designations depending upon the evaluating authority.

Line 16: "Autoignition Temp."—See Table C-1 for guidance.

The table that follows is a list of selected flammable gases and vapors of liquids having an auto ignition temperature (AIT) of less than 250°C.

Note: This table is NOT applicable to gasses and vapors tested to European standards. There are a few, but significant differences between the two reporting systems.

Line 18: "Connection to Load"—Direct coupled is the default.

Line 19: "Sound Pressure Level"—The normal value is 85 dBA at a distance of 3 ft. This is consistent with OSHA rules so that hearing protection is not required while the motor is in operation. Remote, unattended equipment may not require 85 dBA. Certain rare installations near noise sensitive areas, such as residential dwellings, may require reduced noise levels of 80 dBA or 75 dBA. Noise level of the train is affected by each individual machine's contribution to the total sound level, and other external effects such as nearby equipment, walls or other reflective surfaces. Motor noise levels are based upon a free-field measurement at no-load conditions when tested at the manufacture's facility, and may be different under loaded or installed conditions. Consider the alternative of accepting manufacturer-standard noise levels and enclosing the entire drive train in a sound enclosure that does not affect cooling air flow. Consult a local safety engineer for more guidance.

ENCLOSURE

Line 20: "Totally Enclosed Fan Cooled (TEFC)" (also designated IP44 or IP54 with IC411 cooling)—A construction where free exchange of air is prevented between the inside and outside of the motor. The motor is cooled by a shaft-mounted fan external to the main frame or enclosure which forces air past the outside of the frame. This design is typically characterized by external fins that act as a heat exchanger. Recommended for severe environments.

Line 21: "Weather Protected (WP)" (also designated IP23 or IP24W with IC01 cooling)—Air from outside the motor is passed through its interior for cooling active parts. Use the Weather-protected Type II (WP II) for most outdoor applications. The WP II machine is constructed so that high-velocity air and dirt blown into the motor by wind can be discharged without entering the internal air passages to the electric parts of the motor. Use the Weather-protected Type I (WP I) for sheltered locations which may be subject to some weather intrusion or water spray. WP I and WP II enclosures often incorporate cleanable filters to reduce dirt ingress. The WP II and WP I enclosures may not be an appropriate choice where adhering

Table C-1—List of Liquids with an Autoignition Temperature (AIT) of Less Than 250°C, Requiring Space Heaters with Heater Element Surface Temperature Less Than 200° (Extracted from NFPA 497-2004)

Material	Group	AIT °C	80% AIT°C
Acetaldehyde	C	175	140
Acrolein (inhibited)	B(C)	235	188
Allyl Glycidyl Ether	B(C)	57	45
n-Butyraldehyde	C	218	174
Carbon Disulfide	—	90	72
Crotonaldehyde	C	232	185
Cyclohexane	D	245	196
Cyclohexene	D	244	195
Cyclohexanone *	D	245	196
Decene *	D	235	188
Diethyl Ether (Ethyl Ether)	C	160	128
Diethylene Glycol Monobutyl Ether **	C	228	182
Diethylene Glycol Monomethyl Ether **	C	241	192
Dimethyl Sulfate **	D	188	150
1,4-Dioxane	C	180	144
Dipentene *	D	237	189
Ethylene Glycol Monobutyl Ether **	C	238	190
Ethylene Glycol Monoethyl Ether *	C	235	188
2-Ethylhexaldehyde *	C	191	152
Fuel Oil *	D	210	168
n-Heptane	D	204	163
n-Heptene	D	204	163
n-Hexane	D	225	180
Hexene	D	245	196
Hydrazine *	C	23	—
Isobutyraldehyde	C	196	156
Isoprene	D	220	176
Iso-octyl Aldehyde *	C	197	157
Kerosene *	D	210	168
Methyl Formal	C	238	190
2-Methyloctane	—	220	176
Methylal	C	237	189
2-Methyl-1-Propanol	D	223	178
2-Methyloctane	D	220	176
3-Methyloctane	D	220	176
4-Methyloctane	D	225	180
Monomethyl Hydrazine	C	194	155
n-Nonane	D	205	164
n-Octane	D	206	164
Octene	D	230	184
n-Pentane	D	243	194
Propionaldehyde	C	207	165
n-Propyl Ether	C	215	172
Propyl Nitrate	B	175	140
Triethylamine	C	249	199
Unsymmetrical Dimethyl Hydrazine	C	249	199
Valeraldehyde	C	222	177

Note: * Flash point of these materials is between 100°F (37.8°C) and 140°F (60°C). Special electrical equipment is required only if these materials are stored or handled above their flash points.
** Flash point of these materials is between 140°F (60°C) and 200°F (93.3°C). Special electrical equipment is required only if these materials are stored or handled above their flash points.

dust is present, on higher voltage (6 kV and above) machines, or if the area does not have free air exchange. The hot air discharged from the motor can cause a closed-in area to become unbearably hot.

Line 21: "Air Filters"—Filter provisions (mounting hardware) are provided as standard on WP II enclosures. Keep in mind that either an air-filter differential-pressure switch, winding temperature detectors or both must be wired to alarm operators when the filters become dirty. When filters are specified, order a set of spares so they can be exchanged from the motor and cleaned.

BEARINGS

Line 22: "Bearing Type"—Most horizontal motors purchased to this standard should be "hydrodynamic" type due to their extremely long life. In some cases, hydrodynamic bearings may be selected by the manufacturer due to the size of the shaft or speed-diameter considerations. Various sub types of hydrodynamic bearings (sleeve, tilt pad, four lobe, etc.) are used, depending on the application. Cylindrical sleeve journal bearings are most common on smaller applications. Many vertical motors will have "antifriction" bearings such as ball bearings. If antifriction bearings are selected, API Std 547 specifies the requirements.

Line 23: "Main Terminal Box"—The minimum sized box specified meets the requirements of NEMA MG 1 Type II and is large enough for most connection purposes, but not necessarily for accessories or some stress cones.

Line 24: "Box Location"—Indicate top, bottom, or side (left or right, facing a designated end of the motor).

Box to include:

Line 24: "Feeder Cable: Conductor Size/Type"—Indicate conductor size, number per phase, and whether the cable is shielded or unshielded, type MC (metal-clad) cable, type TC (tray-cable) cable, or type MV (medium-voltage) cable. Coordinate the choice with the project or responsible electrical engineer.

Line 24: "Cable Entry"—Indicate the position of the main power conductor entry. This depends on the physical configuration of the cable/conduit system.

Line 25: "Space Heaters"—Due to typical low power requirement, usually specified as 120 V or 240 V single phase. If required, these space heaters should always be energized when the motor is not in operation.

The default selection is suitability for Temperature Code T3C. Some gases or vapors may require lower T Code ratings, which shall be indicated in the blank provided.

Other Terminal Box requirements are not always required on less critical smaller motors such as specified by API Std 547, but if required can be described on Line 29 "Additional Information." The features are described below.

Line 26: "Motor Starting"—The starting requirements must be specified to help the motor designer; also the load torque versus speed characteristics are required by the designer.

Line 27: "Loaded, Unloaded, Partially Loaded _____%"—For driven equipment, indicate whether the start is loaded, unloaded or partially loaded (i.e., with valves, dampers or guide vanes closed). Reference should be made to speed vs. torque curves for the applicable conditions from the driven equipment supplier.

Line 28: "Other"—Full voltage applies in most cases. This is where the motor starter or circuit breaker is closed to start the motor with nominal voltage drop between the starter and motor or nothing intentionally inserted in the circuit to reduce the voltage to the motor, i.e., full voltage is applied to start the motor. Other starting methods used to reduce starting voltage drop and improve torque may include captive-transformer (a single transformer feeding only the motor), adjustable-frequency or adjustable-voltage starters, shunt-capacitor (switched during starting), or series-reactor/shunt-capacitor starting methods.

Line 28: "Reduced-voltage"—Where the starting voltage is intentionally reduced by use of an autotransformer, reactor, or resistor. In some instances, excessive voltage drop may be experienced on soft power systems. Indicate the value of reduced voltage which is provided by the starting method. For example, the voltage would typically be reduced to either 80% or 65% with an autotransformer starter.

Line 29: "Additional Information" (If Required)

"Space for Stress Cones"—A stress cone is used to terminate shielded cable. Historically, this was achieved by a large number layers of electrical tape suited for the purpose. A cross section of the finished connection would show a high thickness of tape covering the conductor, and tapering down to one layer over a distance of several ft. This style of installation requires a large space for access and installation, and can be time consuming. Presently, there are heat shrink and self shrink types available requiring less terminal box volume. If shielded conductors are used, specify the length of the cable termination.

"Differential Protection Current Transformers"—Recommended for all motors rated 2500 hp and larger.

There are two current differential protection schemes for motors: Conventional phase differential and self-balancing differential protection.

Conventional phase differential protection uses six identical current transformers, one pair for each phase. Three of the current transformers are located at the starter or motor switchgear and the other three in the three phases at the motor winding neutral. This method also requires reliable instrumentation wire interconnections between the monitoring unit and each set of CTs. Self-balancing differential protection uses three zero-sequence, window-type, current transformers installed at the motor terminal box. One current transformer per phase is used with the motor line and neutral leads of one phase passed through it such that the two currents normally cancel each other.

The self-balancing scheme is more commonly applied to motors. It usually has a lower primary pickup in amperes and provides motor stator winding phase and ground protection. This scheme does not detect cable faults. The conventional differential scheme has the advantage of protecting both the motor stator winding and the motor feeder cables in the differential protection zone. However, this arrangement can be prone to mis-balancing of signals and nuisance tripping due to instrument wire failure.

Appropriate protective relays must be provided in the motor starter or switchgear. Core-balance, or window type, current transformers are the most common. Either specify the specific type (e.g., type BYZ) or the current transformer accuracy class. A "C 10" accuracy class is usually adequate, but "C 20" may be required depending on the protective relay type. Recommend a "C 10 accuracy class" for "type" and a ratio of 50 to 5 (50:5) for self-balancing. Since conventional phase differential current transformers carry load current, they must have primary current ratings chosen accordingly. Bar-type current transformers are only applied for very high continuous current ratings, and are specified with appropriately high ratios and accuracy classes to match a set of three current transformers in the supply switchgear. For either the core-balance or bar-type current transformers specified, indicate whether they will be supplied by you (or the switchgear vendor) or if the motor manufacturer is to supply them.

"Surge Capacitors"—Are connected between each phase and ground to decrease the slope of the wavefront of lightning surge voltages and switching surge voltages. Recommended for critical motors, those connected through one transformer or directly to a bare overhead line, or those which have switched capacitors on the same voltage level. Under these conditions, recommended for each motor individually. Specify 0.5 microfarad for motor voltage ratings through 4160 V and 0.25 microfarad for ratings 6600 V and above. Surge capacitors may or may not be used in conjunction with surge (lightning) arresters.

"Surge Arresters"—Are installed one per phase connected between the phase and ground, to limit the voltage to ground impressed upon the motor stator winding due to lightning surges. Recommended for the same conditions given for surge capacitors. For those motors connected to a bare overhead line through at least one transformer (protected on its primary with arresters), one set of surge arresters applied on the main switchgear to protect a group of motors is usually adequate. Specify 2.7 kV rated arresters for 2.3 kV rated motors, 4.5 kV for 4.0 kV motors, 7.5 kV for 6.6 kV motors, and 15.0 kV for 13.2 kV motors. The arrester voltage ratings are usually adequate if a ground fault will be cleared in one second, that is, low resistance grounded systems. However, for high resistance grounded systems where fault clearing is not immediate, the arrester MCOV rating must be greater than the system line to line voltage. This would mean 3 kV arresters for 2.3 kV motors and 5.1 kV or 6 kV arresters for 4 kV motors.

"Provision for Purging"—Purging is required by the *National Electrical Code* for terminal boxes having surge arresters mounted within the terminal box when the motor is installed in a Class I, Division 1 or Zone 1 area. Specify for this condition. Additional requirements of NFPA 496 may be imposed for the consideration of monitoring instrumentation, protective controls, and purge times necessary prior to equipment startup.

"Other Terminal Box Requirements"—Specify any other terminal box features (location, oversize) here.

ACCESSORIES

Line 31: "Space Heaters"—All motors should include space heaters. Normally, the "manufacturer's standard" bar type heater sheath material is acceptable, but stainless steel or other material could be specified. Flexible belt type space heaters should be avoided, and any type of heater that contacts the surface of the motor winding is not acceptable. Specify 120 V or 240 V, single-phase or 208 V or 480 V, three-phase power, depending on what power source would be available with the motor shut down. Three-phase power for the space heaters is usually only needed for motors over approximately 4000 hp.

"Temperature Code" is defined by the maximum temperature permitted at the surface of the heater element, which could be a source of ignition in an explosive atmosphere if the element is too hot. The default selection is suitability for Temperature Code T3C. Some gases or vapors may require lower T Code ratings, which shall be indicated in the blank provided.

Line 32: "Winding Temperature Detectors"—These detectors are installed in intimate contact with the winding insulation and give an accurate measurement of the operating temperature of the winding. They provide better protection for the motor than current-sensitive overload relays. They also improve protection against clogged air filters which can cause high winding temperatures in weather-protected (WP I and WP II) enclosures. Required on all motors covered by this standard. Two detectors should be specified for each phase of the motor winding. Temperature detector type should be specified, depending on the monitoring system design. Typical Resistance Temperature Detectors (RTDs) are 100Ω at 0°C, Platinum, 3 wire, with a Temperature Coefficient of Resistance (TCR, Ω/Ω°C) of 0.00385 per DIN IEC 751, Class B, or 0.00392 commonly applied within North America.

Line 35: "Hydrodynamic Bearing Temperature Detectors" —These detectors should be applied consistent with the entire equipment train. They are usually applicable to large (1000 hp and greater) and special-purpose equipment trains. They can provide early warning of lube-oil loss or impending bearing failure. API Std 670 outlines requirements which will assure accurate bearing-metal temperature measurement. When radial temperature detectors are used for shutdown systems, either RTDs (types noted above) or thermocouples (e.g., iron-constantan) can be specified. Separate terminal heads are sometimes specified with an external conduit run to each head. An alternative is a terminal box, either separate or in combination with the winding RTDs.

Line 36: "Bearing Temperature Sensor Wire Termination"—The bearing temperature sensor terminations may be terminated in individual conduit heads at each sensor location, or brought out commonly to a separate terminal box on the side of the machine, or share space in the stator RTD terminal box. The choice is influenced by overall equipment design and site needs.

VIBRATION DETECTORS

Line 38: "Vibration Probes"—Specify to be consistent with the equipment train. Recommended for critical motors with synchronous speeds 1000 rpm or faster with sleeve or tilting-pad bearings. Frequently, a phase-indicating probe is also specified whenever probes are installed. This provides a phase reference for filtered vibration and speed measurements. Two externally adjustable probes per bearing are normal (90 degrees apart), but four probes per bearing may be desired if the probes are not accessible during the motor operation and vibration monitoring is considered important (usually only two oscillator/demodulators are supplied for each bearing, since the probe wires can be exchanged during operation).

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Line 1: "Excel Code"—See electronic spreadsheet explanation under the "General" section.

MISCELLANEOUS

Line 2: "Auxiliary Nameplate with Purchaser's Information"—If an auxiliary nameplate is needed for identifying the equipment number or other information, detail the requirements here.

Line 6: Adjustable Speed Drive Operation

Adjustable speed drives accelerate the motor by increasing the supply frequency, so the motor design may be different if it is only required to operate on an ASD. Specify the starting method.

The thermal performance of a motor on an ASD may be different than on a utility supply, depending on the load's torque versus speed characteristic. Specify the torque and speed ranges, and describe the type of drive.

DRIVEN EQUIPMENT INFORMATION

Lines 13 and 14: "Driven Equipment"—Loads for this document are assumed to be centrifugal in nature, i.e., where the load torque varies as the square of the speed. Tell the vendor if the load is a compressor, pump or fan. Positive displacement type loads may require additional information. For reciprocating compressors, provide data on the variation of load torque with crank angle (The Crank-Effort data) as this will affect shaft and rotor design, flywheel requirements, power system current pulsation, and machine efficiency.

Line 15: "Total Driven—Equipment Wk^2"—List the load inertia including all parts such as couplings, gears, and driven-equipment rotors. These are usually referenced to the motor speed. If this is to be completed by the driven-equipment vendor, add a note to that effect.

Line 15: "Load Speed-torque Curve"—Fill in the load curve details of the driven equipment including as a minimum the load torque during acceleration at zero, half and full speed. List or check off what type of equipment it will be driving. For driven equipment, indicate whether the start is loaded or unloaded (i.e, with valves, dampers, or guide vanes closed).

Line 16: "Rotation"—Indicate the direction of rotation as viewed from the opposite-drive end (the "outboard" or non coupling end) of the motor. Indicate clockwise (CW) or counterclockwise (CCW). If this information is to be supplied by the driven equipment vendor, indicate here. Note that the direction of rotation of some units must be designed and manufactured accordingly, and cannot be changed in the field without major consequences.

Line 17: "Coupling"—Indicate the type or model of coupling, e.g., a flexible-diaphragm type or a gear-type. If it is to be supplied by the driven-equipment supplier, indicate here, and also indicate who is to supply the coupling. Also, indicate whether the coupling is for a parallel or a tapered shaft, as this makes a difference in cost to the manufacturer.

Line 20: "Other"—List any other load data such as gearbox ratio.

ANALYSIS, SHOP INSPECTION AND TESTS

List whether the tests are to be performed, and also whether they are to be "witnessed" (a hold is put on production until the owner or his representative has witnessed the tests; this adds to the schedule time, and often requires a pretest by the vendor) or "observed" (the owner is notified of the time of test, but the schedule is not put on hold). Alternatively, the test may be performed without an owner representative present and results only submitted.

Certain "routine" tests are required by default and are marked as "Required" on the data sheet.

Line 30: "Stator Surge Test"—This is recommended. The risk of not doing the test is that marginal turn-to-turn insulation in the winding may not fail during the running tests but may fail in operation when subjected to mild power system surges. The test voltage should be agreed upon with the vendor, as too high a test voltage may induce premature failure.

Line 31: "Special Tests"— API Std 541 lists various extra tests which can be performed on motors, but may not be needed for the less critical applications for which API Std 547 is intended. The more likely tests are listed and described below. For other tests, check the testing section of API Std 541.

Line 32: "Complete Test"—Imposes the API Std 541 "Complete Test" requirements, which are common for large or critical service machines and two-pole units. Specify this when the efficiency and temperature rise is to be determined. This test should be specified for at least one (generally the first) of each motor rating when multiple units are ordered at the same time. It should also be specified where the evaluation factor justifies the test cost to prove the efficiency.

Line 33: "Unbalance Response Test"—Recommended for all two-pole motors 1000 hp and larger and all four-pole motors 5000 hp and larger to verify the motor's performance operating through its first resonant speed, or to verify the location of its resonant speed above operating speed. May be especially useful for motors intended for variable speed operation or those that will see frequent starting operations.

Line 34: "Rated Rotor Temperature Vibration Test"—Specify this if the motor is not going to have a complete API test but it is still important to know that it is thermally stable.

Line 35: "Sealed Winding Conformance"—This test involves submersing the motor winding or spraying it with a wetting solution to verify the seal of the insulation system. This test may be applied to motors whose windings will be exposed to weather or wash-down conditions and when purchasing from an unfamiliar supplier. This test should be as a "witness," because corrective measures, in the event of a failure, require purchaser involvement.

Line 36: "Other"—Most of the tests normally required for a motor covered by this specification are listed here. Other tests may be specified for particular situations, and are described in more detail in API Std 541.

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MOTOR DATA

This page is generally to be completed by the motor vendor. One possible exception is Line 8 "Test Method." IEEE and IEC have various methods of deriving the efficiency and power factor of electric motors, and each method gives results which may differ by up to 0.5%. If part of the selection process involves comparison of efficiencies, then the different vendors must be evaluated using the same criteria. This means that the test methods (e.g., IEEE 112 Method B [Input-output with loss segregation]; Method E [Segregated Losses]; Method E [Equivalent Circuit] or one of the IEC 60034-2 methods) used must be the same for all vendors.

Line 1: "Excel Code"—See electronic spreadsheet explanation under the "General" section.

Line 7: "Load Point, Other"—List loads above motor nameplate where efficiency, power factor, and current values are required.

Line 12: "Other"—List voltage levels other than motor full nameplate voltage, where locked-rotor current, cold locked-rotor withstand time and locked-rotor withstand time at rated temperature values are required.

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