

Petrochemical AC Induction Motor Standards A Comparison Between IEEE 841, API 541 And API 547

This material is posted here with permission of the IEEE. Such permission of the IEEE does not in any way imply IEEE endorsement of any of Baldor Electric Company's products or services. Internal or personal use of this material is permitted. However, permission to reprint/republish this material for advertising or promotional purposes or for creating new collective works for resale or redistribution must be obtained from the IEEE by writing to pubs-permissions@ieee.org. By choosing to view this document, you agree to all provisions of the copyright laws protecting it.

Copyright Material IEEE
Paper No. PCIC-2004-SF1

John Malinowski
IEEE Senior Member
Baldor Electric Company
PO Box 2400
Fort Smith, AR 72902
USA

Gabe D'Alleva
IEEE Member
ExxonMobil Corporation
3225 Gallows Road
Fairfax, VA 22037
USA

Mark M. Hodowanec
IEEE Senior Member
Siemens Energy & Automation
4620 Forest Avenue
Norwood, OH 45212
USA

Abstract - Many motor users may be confused when it comes to calling out the appropriate standard or specification for their applications. Some standards are better suited to certain applications than others. By thoroughly understanding what each specification was developed for, the most appropriate standard can be chosen. This paper discusses the IEEE 841-2001, API 541 4th edition, and API 547 standards, and provides guidance as to the applicability of each.

Index Terms: API, IEEE, electric motor, motor, induction

I. INTRODUCTION - HISTORY

IEEE 841, API 541 and API 547 are all AC induction motor standards developed by the petrochemical industry. Nonetheless, they have been adopted by other process industries that also require motors with high levels of reliability. A working group consisting of motor end-users, consultants and suppliers initially developed API 541 approximately 20 years ago. The standard is meant to provide an AC induction motor with increased reliability and value.

Throughout 541's life, each revision has added changes to promote increased reliability, safety and ease of use. API 541 has just finished its fourth revision as of fall 2003 and is scheduled for release in 2004.

IEEE 841 was completed September 1985 with a similar working group as the API standard. Initially the requirement for 841 was to produce a recommended practice (RP) so motor manufacturers could build a low voltage (460 or 575 volt) totally enclosed fan-cooled (TEFC) AC induction motor that could be made available from stock for easy procurement. In 1990, the RP was revised and made into a standard. The standard's latest version is IEEE 841-2001, which has been widely adopted into many other process industries, but most heartily endorsed by the pulp and paper industry.

During the ballot process for the 4th revision of API 541, great efforts were made to simplify the standard. In the process of doing this, the standard defaults were made to reflect appropriate choices for the largest, most critical machines. During the balloting process it was realized that a standard now did not exist for general purpose, non-critical service machines in the 250 hp through 3000 hp ranges. These machines are commonly found in the petrochemical industry. A working group was chartered to address the needs of these machines, and the standard number for this was API 547. This standard covers medium horsepower motors (250 – 3000 hp) that span between IEEE 841 and API 541. Motors of this size are likely to be of a more standard construction and might be made available for delivery from a manufacturer or distributor's inventory. API 547 is under development and scheduled for balloting in 2004.

Obviously there is much overlap between the three standards. That is the unfortunate outcome when various choices/options exist for a machine that goes into a particular application. With appropriate exceptions taken, as well as options selected, it is possible to make any one of the specifications 'valid'. However, one specification may be more appropriate than another. This paper will help identify which of the three standards are most appropriate for a particular application.

II. KEY REQUIREMENTS

This section highlights some of the key requirements for each standard:

IEEE 841 motors

- Severe duty for petroleum and chemical industry

- Enclosure limited to Totally Enclosed Fan Cooled (TEFC) and Totally Enclosed Non Ventilated (TENV) construction
- NEMA Frame size 143T and larger, up through 500 hp rating
- Voltages to 4000 V
- Horizontal and vertical motors
- Anti-Friction bearing only
- Assures bearing reliability by specifying temperature & vibration limits as well as bearing life requirements
- IP details of protection: IP54/IP55
- Sound limit: 90 dBA sound power
- Corrosion-resistant, tested per ASTM B117 97
- Minimum efficiency specified for all ratings covered by specification
- Routine factory tests identified
- Test information to be supplied with motor (i.e. each motor has a 'birth certificate' attached to it).
- Standardized design, data sheet not as important
- Intended to be a standard product that can be stocked

The IEEE 841 motor is intended to be a standardized product, which is available from stock (from motor manufacturers and motor distributors) and is produced by several manufacturers. The purpose of having such a specification is to establish a recognized baseline standard for petroleum and chemical industry severe duty motors. Prior to this standard being in place, manufacturers had total latitude on what they deemed to be sufficient for a 'severe duty' motor. IEEE 841 put all manufacturers on an even playing field and simplified procurement activities from the end-user side.

API 541

- Covers "minimum requirements for form wound squirrel-cage induction motors 500 Horsepower and larger for use in petroleum industry"
- Used for 'critical service' machines
- Enclosure not specified (WP11, open, TEWAC, etc. all are acceptable)
- Horizontal and vertical motors
- IP level of protection: IP55 (bearings only)
- Sleeve bearing machines are standard, but anti-friction bearings are available as an option
- Assures bearing reliability by specifying temperature & vibration limits as well as bearing life requirements

- Corrosion-resistant components specified but their testing method is not
- Minimum design and construction guidelines are defined for manufacturer
- Sound pressure limit of 85 dBA
- Comprehensive routine and special (optional) factory tests identified
- Data sheets must be filled out to properly specify the motor

API 541 is the premier large induction motor standard. It has rigorous specifications, but requires much motor knowledge from the user to be used successfully. There are many decisions (i.e. specification of options) within the specification that must be made. Proper utilization of this specification requires that the data sheets be correctly filled out. Regrettably, the data sheets are oftentimes incomplete and/or inaccurate. Unfortunately, many users and Original Equipment Manufacturers (OEMs) fail to recognize the importance of the data sheets.

API 547

- Covers "requirements for form-wound squirrel-cage induction motors for general use in petroleum, chemical and other industrial severe duty applications"
- Intended to cover motors from 250 hp to 3000 hp.
- Enclosures limited to WP11 and TEFC
- Horizontal motors only
- IP level of protection: IP55 (bearings only)
- Sleeve bearing machines are standard, but anti-friction bearings are available as an option
- Assures bearing reliability by specifying temperature & vibration limits as well as bearing life requirements
- Corrosion-resistant components specified but their testing method is not
- Minimum design and construction guidelines are defined for manufacturer
- Sound pressure limit of 85 dBA
- Routine and special (optional) factory tests identified
- Data sheets are optional but should be filled out to specify the motor but are not as detailed as the data sheets in API 541

API 547 is a simpler version of API 541 but it will not have significantly relaxed performance requirements. If any exceptions to API 547 are taken, the user is encouraged to use API 541 for more detailed technical guidance. In this regard, API 547 is similar to IEEE 841: the motor is standardized to a high enough degree such

that it can be available from stock. This is not possible with API 541 because of its highly customized nature.

All three standards target increased reliability, although they accomplish it in different ways. Obviously the scope of these standards can be extended, but care must be taken to avoid unintentional exceptions or incompatible requirements.

III. DATA SHEETS

IEEE 841 provides an optional one-page data sheet to be used if the end-user is specifying a motor for unusual service conditions. Manufacturers rarely see these used. Most IEEE 841 sales come from motors available from inventory made to comply with the standard's specifications with few differentiators from manufacturer-to-manufacturer. These differentiators are items not specified clearly in the standard, but often expected by end-users such as shaft labyrinth seals on each end, terminal lead lugs and NEMA Premium® efficiency levels. Some companies specify IEEE 841 on motors larger than 500 hp to obtain a robust severe duty motor design with less complexity and cost than API 541.

An API 541 motor cannot be built without a data sheet. The entire concept of the standard is for the manufacturer to design and build a special motor to meet the exact requirements of the end-user as defined by the 6-pages of data sheets. When the end-user or OEM does not fill out data sheets, then the motor manufacturer must make some assumptions as to what is required. Discussion over construction, requirements and final configuration is common during commercial negotiations. Because of the critical nature of many API 541 motors, particularly in higher outputs, witness tests at the manufacturer's test laboratory are common.

API 547 is a more standard motor design for general-purpose applications. A data sheet is provided for special conditions, however it is not required to build the motor.

Motors are often supplied with equipment to end-users. When OEMs work with manufacturers on motors for their equipment, they request that the motors be constructed per IEEE 841 or API 541. Data sheets are often not supplied by OEMs. If the end-user requires a motor built to API 541, he or she will need to work with the OEM and help complete the data sheet. IEEE 841 motors are much more standard, and can be supplied when the data sheet is not filled out, as long as basic information (speed, voltage, rating, etc.) is available.

IV. USE WITH ADJUSTABLE SPEED DRIVES

IEEE 841-2001 allows for the motor to be operated from an adjustable speed drive (ASD) as an unusual service condition. The user is instructed to contact the motor manufacturer to determine suitability for the required speed range. NEMA MG 1, Part 30 is referenced. Concerns specified in part 5.3 of the standard deal with heating issues, insufficient acceleration torque, noise, torque pulsations, winding failures due to high amplitude voltage spikes (dv/dt) from the drive's output voltage.

Additionally the user is cautioned regarding operation of the motor above allowable temperatures for Division 2 hazardous (classified) areas. IEEE 1349-2001 Guide for the Application of Electric Motors in Class I, Division 2 Hazardous (Classified) Locations should be consulted for application guidelines.

Most manufacturers building IEEE 841 motors provide a motor with an insulation system that will allow operation on an ASD. Constant torque speed range may be limited depending on the motor rating. Variable torque applications are generally not a problem. Voltage spikes are often addressed by referring the user to limit the spikes to levels defined by NEMA MG 1, Part 31.4.4.2 withstand peak voltage capability.

In API 541, each item dealing with an ASD is identified with a diamond symbol in the margin. Unlike IEEE 841, API 541 requires the motor to operate below an 80°C temperature rise at any speed with a variable torque load. Also with these larger motors, critical speeds must be evaluated when used with an ASD as some larger motors may have a flexible shaft. A flexible shaft machine is a machine that has its first lateral critical speed below the nominal operating speed. Continuous operation at a critical speed must be avoided. Because API 541 relies heavily on a complete set of data sheets, the user can document complete drive and application details. This allows the manufacturer to design and build a motor that will produce desired performance.

V. USE OF STANDARDS BY APPLICATION

Despite being developed by two separate organizations, American Petroleum Institute (API) and IEEE Petroleum and Chemical Industry Committee (PCIC), all three standards were developed by end-users in the petroleum and chemical industry. IEEE 841 has found wide use in other process industries where a reliable and well-protected NEMA-size motor is required, such as pulp and paper.

Table 1 provides basic features and some guidance on the use of each standard. Table 2 provides typical applications for each standard. The end-user is responsible for determining which of the three standards is most appropriate for his specific application.

TABLE 1
FEATURES OF EACH STANDARD

| IEEE 841 | API 547 | API 541 |
|---|--|--|
| <ul style="list-style-type: none"> •Petroleum and chemical industry | <ul style="list-style-type: none"> •Petroleum and chemical industry | <ul style="list-style-type: none"> •Petroleum and chemical industry |
| <ul style="list-style-type: none"> •Severe duty | <ul style="list-style-type: none"> •Severe duty | <ul style="list-style-type: none"> •Critical duty |
| <ul style="list-style-type: none"> •General purpose service (spared) | <ul style="list-style-type: none"> •General purpose service (spared) | <ul style="list-style-type: none"> •Special purpose service (unspared) |
| <ul style="list-style-type: none"> •Severely corrosive atmospheres | | <ul style="list-style-type: none"> •Induction generators •High inertia loads |
| <ul style="list-style-type: none"> •Anti-Friction bearings | <ul style="list-style-type: none"> •Sleeve bearings | <ul style="list-style-type: none"> •Adjustable speed drives •Sleeve bearings |
| <ul style="list-style-type: none"> •Totally Enclosed Fan-Cooled (TEFC) | <ul style="list-style-type: none"> •Totally Enclosed Fan-Cooled (TEFC) and WPIL | <ul style="list-style-type: none"> •All enclosures |
| <ul style="list-style-type: none"> •Horizontal & Vertical | <ul style="list-style-type: none"> •Horizontal | <ul style="list-style-type: none"> •Horizontal & Vertical |

TABLE 2
APPLICATION GUIDELINES FOR EACH STANDARD

| Application | IEEE 841 | API 547 | API 541 |
|---------------------------|----------|---------|---------|
| Coupled loads | Y | Y | Y |
| Belted loads | Y | N | N |
| Axial Thrust Loads | Y | N | Y |
| Centrifugal compressors | Y | Y | Y |
| Reciprocating compressors | U | U | Y |
| Centrifugal pumps | Y | Y | Y |
| Vertical turbine pumps | Y | N | Y |
| Fans & blowers | Y | Y | Y |
| Induction generator | N | N | Y |
| Division 2 (Zone 2) | U | U | Y |
| Adjustable speed (ASD) | U | U | Y |

Y=Suitable for application
N=Not suitable for application
U=Unusual condition – specify on data sheet

VI. CERTIFICATION TO STANDARD

Each manufacturer is responsible to design and manufacture their motor to each applicable standard (IEEE 841, API 547 or API 541). No outside agency is required to certify the compliance of these motors to the standard. The way the standards are interpreted, features offered may vary slightly from manufacturer-to-manufacturer.

API plans to offer a Monogram Program to certify motors that are made in compliance to their standard and further, that the plant producing them has adequate quality processes in place. In order to meet the requirements of the API Monogram Program, a facility licensed under API/IP Standards must not only meet the on-site audit requirements of API Spec Q1, but must also demonstrate through a series of qualification tests audited by an API auditor-witness, that the product meets all the performance criteria specified by the standard.

VII. CONCLUSION

All three standards provide specific and verifiable requirements that enable a user to purchase AC induction motors for most applications that will yield increased reliability over standard or severe duty motors. Where these standards are used to specify larger motors suited to specific applications, additional application data must be shared between the end-user and manufacturer. IEEE 841 provides the means to specify a very high quality motor, usually available off the shelf. API 541 motors are often applied to critical applications that would have a large cost impact or shut down a facility if they were to fail. API 547 completes the spectrum between these two widely accepted standards. See Appendix A for a detailed comparison between the three standards.

VIII. REFERENCES

- [1] NEMA MG 1-1998 and 1-2003, Motors and Generators, NEMA Standards Publication: Global Engineering Documents.
- [2] IEEE STD 841-2001, IEEE Standard for Petroleum and Chemical Industry – Severe Duty Totally Enclosed Fan-Cooled (TEFC) Squirrel Cage Induction Motors – Up to and including 370 kW (500 hp), Piscataway, NJ IEEE.
- [3] ANSI/API STD 541, Form-Wound Squirrel Cage Induction Motors – Larger than 500 Horsepower, Fourth Edition, Washington, DC: API.
- [4] ANSI/ API STD 547, General-Purpose Squirrel Cage Induction Motors – 250 Horsepower and Larger, Draft December 2003, Washington, DC: API.
- [5] NFPA 70-2002, National Electrical Code, Quincy, MA: NFPA.
- [6] IEEE 1349-2001, IEEE Guide for the Application of Electric Motors in Class I, Division 2 Hazardous (Classified) Locations, Piscataway, NJ: IEEE.
- [7] Richard L. Doughty and Austin H. Bonnett, "Introduction to IEEE 841-2001, IEEE Standard for Petroleum and Chemical Industry – Severe Duty Totally Enclosed Fan-Cooled (TEFC) Squirrel Cage Induction Motors – Up to and Including 370 kW (500 HP)" in IEEE PCIC Conference Record, 2001, pp 45-52

- [8] Mark Hodowanec, Michael Costello, Bill Lockley, John Rama and Travis Griffith, "Introduction to API Standard 541, 4th Edition – Form-Wound Squirrel Cage Induction Motors – Larger than 500 Horsepower" in IEEE PCIC Conference Record, pp 311-319
- [9] Lorraine K. Padden, Rick Bried and James Dymond, "IEEE 1349-2001 Guide for the Application of Electric Motors in Class 1 Division 2 Hazardous (Classified) Locations", IEEE PCIC Conference Record, 2003, pp 59-69

IX. VITA

Gabe F. D’Alleva graduated from Manhattan College, with a Bachelor of Electrical Engineering degree in 1974, and later graduated from the University of Missouri at Rolla with a Masters of Science in Engineering Management in 1983. Mr. D’Alleva is presently employed by ExxonMobil Research and Engineering in Fairfax VA as an Advanced Engineering Associate. He is a member of the IEEE, Industry Applications Society and participates in the IEEE 841, IEEE 303, API 541 and API 547 working groups.

Mark M. Hodowanec received a B.S. and M.S. degree in mechanical engineering from the University of Akron, Akron, OH, and an MBA from Xavier University, Cincinnati, OH. Responsibilities for Siemens Energy & Automation, Inc. included being the

Engineering Manager for the NEMA induction motor product line out of Little Rock, AR and Manager of Mechanical Engineering for the Above NEMA induction motor product line out of Norwood, OH. For the past ten years he has worked in a variety of engineering positions including design, product development, order processing, shop testing, and field support. He is a Senior Member of IEEE, and is currently active on various NEMA, IEEE, IEC and API working groups and Sub-committees. In addition to his NEMA and Above-NEMA motor experience, Mr. Hodowanec has worked on a wide assortment of specialty induction motors such as hermetic, submersible and MSHA motors. He has made numerous technical presentations and published over twenty papers on electrical machine design, construction, trouble-shooting, and failure analysis.

John Malinowski is the Product Marketing Manager for AC & DC Motors at Baldor Electric Company in Fort Smith, AR. He is a Senior Member of IEEE, Industrial Applications Society, Standards Association and serves on several IEEE and API working groups including IEEE 303, IEEE 841 and API 547. Mr. Malinowski is active on the Drives and Control Systems Sub-committee of IEEE Pulp and Paper Committee and active with IEEE PCIC Sub-committees. He is Baldor’s representative to NEMA Premium®, Motor Decisions Matter and Energy Star programs. Mr. Malinowski has published numerous papers and magazine articles and presented papers at IEEE and other conferences.

X. APPENDIX

Appendix A-1

DETAILED COMPARISON OF IEEE 841, API 541 AND API 547

| Standard | IEEE 841-2001 | | API 547 | | API 541 rev 4 | |
|---------------------------------|---|--|---|----------------------------------|---|-------------------------------|
| Title | IEEE Standard for Petroleum and Chemical Industry - Severe Duty Totally-Enclosed Fan-Cooled (TEFC) Squirrel Cage Induction Motors – Up to and Including 370 kW (500 hp) | | General Purpose Form-Wound Squirrel Cage Induction Motors – 250 Horsepower and Larger | | Form-Wound Squirrel Cage Induction Motors – 500 Horsepower and Larger | |
| Induction Generator Application | No | | No | | Yes | |
| Design Standards | ANSI, NEMA, IEEE | | ANSI, NEMA, IEEE, IEC, ISO | | ANSI, NEMA, IEEE, IEC, ISO | |
| Power Range | 0.75 – 370 kW (1 – 500 hp) | | 2P TEFC | 185-600 kW (250-800 hp) | 370 kW – up (500 hp - up) | |
| | | | 2P – WP II | 185-930 kW (1250 hp) | | |
| | | | 4-6-8 pole TEFC or WP II | 185 – 1500 kW (250 – 3000 hp) | | |
| Rating | <ul style="list-style-type: none"> • Continuous duty • Size for 1.0 SF, with 1.15 SF on nameplate | | <ul style="list-style-type: none"> • Continuous duty • Size for 1.0 SF | | <ul style="list-style-type: none"> • Continuous duty • Size for 1.0 SF | |
| Voltage Ratings | 50 Hz | 60 Hz | 50 Hz | 60 Hz | 50 Hz | 60 Hz |
| | Not specified | 200 230 460 575 2300 4000 | 3000 3300 6000 6600 | 2300 4000 | 4000 3300 6000 6600 10000 11000 | 2300 4000 6600 13200 |
| Speed (poles) | 2, 4, 6 & 8 pole | | 2, 4, 6 & 8 pole | | All poles | |
| Efficiency | <ul style="list-style-type: none"> • EPC + 1 NEMA range (most manufacturers build to NEMA Premium' efficiency) | | <ul style="list-style-type: none"> • Manufacturer's standard • Specified on data sheet | | <ul style="list-style-type: none"> • Manufacturer's standard • Specified on data sheet | |
| Rotor Cage Material | <ul style="list-style-type: none"> • Copper, aluminum or respective alloys (Typically die cast aluminum) | | <ul style="list-style-type: none"> • Copper or aluminum >1000 hp fabricated-bar • ≤ 1000 hp fabricated or die cast cage | | <ul style="list-style-type: none"> • Fabricated copper-bar • Optional – cast or fabricated aluminum cage | |
| Winding Type | <ul style="list-style-type: none"> • Random wound • Form wound | | <ul style="list-style-type: none"> • Form wound | | <ul style="list-style-type: none"> • Form wound | |
| Winding Insulation | <ul style="list-style-type: none"> • Minimum Class F • Random wound • Coils to have phase insulation in addition to varnish for each group of random windings • Form wound VPI for 2300/4000 volt designs • Sealed system capable of withstanding immersion test | | <ul style="list-style-type: none"> • Minimum Class F • Form wound • Epoxy base VPI • Corona suppressant materials for windings operating at 6000 volt or greater • Stator windings to have sealed system capable of NEMA MG 1-20 sealed winding conformance test | | <ul style="list-style-type: none"> • Minimum Class F • Form wound • Epoxy base VPI • Corona suppressant materials for windings operating at 6000 volt or greater • Stator windings to have sealed system capable of NEMA MG 1-20 sealed winding conformance test | |

Appendix A-2

DETAILED COMPARISON OF IEEE 841, API 541 AND API 547

| Standard | IEEE 841-2001 | | API 547 | | API 541 rev 4 | |
|--|---|---|---|--------------------------------|---|--|
| | NEMA | IP | NEMA | IP | NEMA | IP |
| Enclosure Type or IEC Details of Protection | TEFC TENV | IP54 < NEMA 320 frame IP55 ≥ 320 frame | WP II TEFC | IPW24 IC01 IP44-54 IC411 | DGP WP I WP II TEFC TEPV TEWAC TEAAC | IP22 IC01 IP23 IC01 IPW24 IC01 IP44-54 IC411 IP44 IC31/37 IP44-54 IC81W IP44-54 IC611/IC616 |
| Frame Sizes | Per NEMA MG 1-1998, Part 13 | | Manufacturer's standard | | Manufacturer's standard | |
| Frame and Endplate Material | Cast iron | | Cast iron or fabricated steel | | Cast iron or fabricated steel | |
| Terminal Box | ≤ 600V and ≤ 445T frame | Cast iron | Cast iron, nodular iron, cast steel, cast aluminum, steel plate, aluminum plate | | Cast iron, nodular iron, cast steel, cast aluminum, steel plate, aluminum plate | |
| | > 600V and > 445T frame | Cast iron, cast steel or steel plate | | | | |
| Bearings | • Anti-friction | | • Hydrodynamic (i.e. sleeve and tilting pad) standard • Anti-friction optional | | • Hydrodynamic (i.e. sleeve and tilting pad) standard • Anti-friction optional | |
| Power Supply Variation | Not exceeding: • ±10% voltage with rated frequency • ±5% frequency with rated voltage • Combination of voltage and frequency of 10% provided frequency ≤ 5% • ≤ 1% voltage imbalance | | Not exceeding: • ±10% voltage with rated frequency • ±5% frequency with rated voltage • Combination of voltage and frequency of 10% provided frequency ≤ 5% • ≤ 1% voltage imbalance | | Not exceeding: • ±10% voltage with rated frequency • ±5% frequency with rated voltage • Combination of voltage and frequency of 10% • ≤ 1% voltage imbalance | |
| Design and Starting | <ul style="list-style-type: none"> • Design B • Torque/current and starting per NEMA MG 1-1998, Part 12 or Part 20 with 90% of rated voltage • Two consecutive starts with the first start at ambient temperature • One start with motor at operating temperature | | <ul style="list-style-type: none"> • Design B • Torque/current and starting per NEMA MG 1-1998, Part 12 or Part 20 with 80% of rated voltage • Two consecutive starts with the first start at ambient temperature • One start with motor at operating temperature | | <ul style="list-style-type: none"> • All designs (A, B, C & D) • Torque/current and starting per NEMA MG 1-1998, Part 20 or IEC 60034-1 with 80% of rated voltage • Two consecutive starts with first start at ambient temperature with motor coasting to rest • Three consecutive starts with motor coasting to rest and idle for 20 minutes • Three evenly spaced starts over first hour | |
| Design Minimum Number of Full-voltage Starts | Not specified | | Minimum 5000 | | Minimum 5000 | |
| Safe Stall Time | NEMA MG 1, not less than 12 seconds total | | NEMA MG 1, not less than 12 seconds total | | 150% of, or 5 seconds more than, time required to accelerate the load | |

Appendix A-3

DETAILED COMPARISON OF IEEE 841, API 541 AND API 547

| Standard | IEEE 841-2001 | API 547 | API 541 rev 4 |
|----------------------------------|--|---|---|
| Vibration Levels | <ul style="list-style-type: none"> • Radial - Unfiltered 2.03 mm/s peak for 2,4,6 pole; 1.52 mm/s for 8 pole • Axial - Unfiltered 1.52 mm/s • Filtered - 1.27 mm/s peak at 2n (twice speed) or 2f (twice frequency) | <ul style="list-style-type: none"> • 0.10 in/s (filtered and unfiltered) | <ul style="list-style-type: none"> • 2 / 4 / 6 pole 0.10 in/s 8 pole 0.08 in/s, 10 pole 0.06 in/s, 12 pole 0.05 in/s, 14 pole 0.043 in/s, etc (unfiltered) • Shaft vibration 1.5 mils (unfiltered) displacement for 2 and higher pole motors |
| Airborne Sound | ≤ 90 dBA sound power | ≤ 85 dBA sound pressure | ≤ 85 dBA sound pressure |
| Temperature Rise | ≤80°C by winding resistance | Not to exceed Class B insulation listed temperatures | Not to exceed Class B insulation listed temperatures |
| Routine Factory Tests | <ul style="list-style-type: none"> a. No load current, power, and speed b. High-potential c. Winding resistance d. Mechanical vibration | <ul style="list-style-type: none"> a. No load current measurement b. Determination of locked-rotor current c. High-potential tests of stator windings, space heaters and RTDs d. Insulation resistance (IR) test by megohmmeter and polarization index (PI) per IEEE 43 e. Measurement of stator resistance f. Measurement of vibration g. Test of bearing insulation h. Test of bearing temperature rise i. Surge comparison test | <ul style="list-style-type: none"> a. No load current measurement b. Determination by calculation of locked-rotor current c. High-potential tests of stator windings, space heaters and RTDs d. Insulation resistance (IR) test by megohmmeter and polarization index (PI) per IEEE 43 e. Measurement of stator resistance f. Measurement of vibration g. Test of bearing insulation h. Test of bearing temperature rise i. Inspection of bearing and oil supply j. Measurement of rotor air gap k. Measurement of shaft voltage and current l. Surge comparison test |
| Special (Optional) Factory Tests | None specified | <ul style="list-style-type: none"> a. Complete test b. Unbalanced response c. Rated rotor temperature vibration test d. Sealed winding conformance | <ul style="list-style-type: none"> a. Complete test b. Unbalanced response c. Rated rotor temperature vibration test d. Sealed winding conformance e. Stator core test f. Surge test of sample motor coil g. Power factor tip-up h. Bearing housing natural frequency test |
| Winding Temperature Detectors | None identified | Stator RTDs required | Stator RTDs required |
| Space Heaters | Optional | Required | Optional |

Appendix A-4

DETAILED COMPARISON OF IEEE 841, API 541 AND API 547

| Standard | IEEE 841-2001 | API 547 | API 541 rev 4 |
|----------------------------|---|---|---|
| Service Conditions | <ul style="list-style-type: none"> • Full voltage across-the-line starting • Temp range -25°C to +40°C • Altitude \leq 1000 m above sea level • Indoor or outdoor • Severe duty <ul style="list-style-type: none"> - Humid - Chemical (corrosive) - Salty atmospheres • Minimum L-10 bearing life specified as 26,280 hours • Bearing temperature rise (coupled) \leq45° C (50°C for 2 pole) | <ul style="list-style-type: none"> • Full voltage across-the-line starting • Temp range -25°C to +40°C • Altitude \leq 1000 m above sea level • Indoor or outdoor • Severe duty <ul style="list-style-type: none"> - Humid - Chemical (corrosive) - Salty atmospheres • Horizontal mounting • Sinusoidal input power • Sleeve bearing temperature \leq93° C • Class 1, Div. 2 or Zone 2 location | <ul style="list-style-type: none"> • User specified on data sheet • Sleeve bearing temperature \leq93° C • 20 year service life • 3 year uninterrupted service |
| Unusual Service Conditions | <p>Exposure to:</p> <ul style="list-style-type: none"> • Flammable or explosive gasses • Combustible, explosive, abrasive, conductive dust • Lint or dirty atmospheres that interfere with ventilation • Nuclear radiation • Abnormal external shock, vibrations, or mechanical loads • Altitudes > 1000 m • Temperatures outside of -25° C to + 40° C • Abnormal axial or side thrust on shaft • AC supply outside of NEMA MG 1 limits • Supply voltage unbalance > 1% • Operating speeds other than rated • Operation from solid-state device for adjustable speed application • Load inertia greater than NEMA MG 1-1998, Section 12.55 | <p>Exposure to:</p> <ul style="list-style-type: none"> • Combustible, explosive, abrasive, conductive dust • Dirty operating conditions where accumulation of dirt will interfere with normal ventilation • Nuclear radiation • Abnormal external shock, vibrations, or mechanical loads • Altitudes > 1000 m • Temperatures outside of -25° C to + 40° C • Abnormal axial or side thrust on shaft • AC supply outside of NEMA MG 1 limits • Supply voltage unbalance > 1% • Operating speeds other than rated • Operation from solid-state device for adjustable speed application • Load inertia greater than NEMA MG 1-1998, Section 12.55 (Note: 2 pole motors \leq NEMA MG 1 inertia) • Reciprocating or positive displacement loads | <ul style="list-style-type: none"> • User specified on data sheet |
| Motor Data Sheet | <ul style="list-style-type: none"> • 1 page • Completion by user is optional | <ul style="list-style-type: none"> • 3 pages • Completion by user is optional (but recommended) | <ul style="list-style-type: none"> • 6 pages • Completion by user is required |
| Certification to Standard | <ul style="list-style-type: none"> • Self-certification | <ul style="list-style-type: none"> • Self-certification • API Monogram Program certification (optional) | <ul style="list-style-type: none"> • Self-certification |
| Availability | <ul style="list-style-type: none"> • Commonly stocked as 1 - 250 hp 2, 4 & 6p 460v and 575v | <ul style="list-style-type: none"> • Built to order (Expect common ratings will be stocked) | <ul style="list-style-type: none"> • Built to order |

BALDOR
MOTORS • DRIVES • GENERATORS

**5711 R.S. Boreham Jr. Street
Fort Smith, AR 72901 • 479-646-4711 • Fax: 479-648-5792**

**For additional White Papers and Technical Information, please visit our
web site at www.BaldorProSpec.com**