NISTHB 150-10-2020

NVLAP Efficiency of Electric Motors

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National Voluntary Laboratory Accreditation Program
Standards Coordination Office
Laboratory Programs

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April 2020

U.S. Department of Commerce
Wilbur L. Ross, Jr., Secretary

National Institute of Standards and Technology
Walter G. Copan, Under Secretary of Commerce for Standards and Technology and Director

National Institute of Standards and Technology Handbook 150-10-2020
Natl. Inst. Stand. Technol. Handbook 150-10-2020, 26 pages (April 2020)

This publication is available free of charge from:
https://doi.org/10.6028/NIST.HB.150-10-2020

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Contents

Foreword

The NIST Handbook 150 publication series sets forth the procedures, requirements, and guidance for the accreditation of testing and calibration laboratories by the National Voluntary Laboratory Accreditation Program (NVLAP). The series is comprised of the following publications:

- NIST Handbook 150, *NVLAP Procedures and General Requirements*, which contains the general procedures and requirements under which NVLAP operates as an unbiased third-party accreditation body;

- NIST Handbook 150-xx program-specific handbooks, which supplement NIST Handbook 150 by providing additional requirements, guidance, and interpretive information applicable to specific NVLAP laboratory accreditation programs (LAPs).

The program-specific handbooks are not stand-alone documents, but rather are companion documents to NIST Handbook 150 and the referenced ISO/IEC 17025 requirements. They tailor the general criteria found referenced in NIST Handbook 150 and ISO/IEC 17025 to the specific tests, calibrations, or types of tests or calibrations covered by a LAP.

NIST Handbook 150-10, *NVLAP Efficiency of Electric Motors*, presents the technical requirements and guidance for the accreditation of laboratories under the NVLAP Efficiency of Electric Motors LAP. The 2020 edition incorporates changes resulting from the release of the 2017 edition of ISO/IEC 17025, *General requirements for the competence of testing and calibration laboratories*, and NIST Handbook 150, as well as editorial improvements. The 2020 edition of NIST Handbook 150-10 supersedes and replaces the 2013 edition.

The handbook was revised with the participation of technical experts in the field of efficiency of electric motors testing and was approved by NVLAP. The following main changes have been made to this handbook with respect to the previous edition:

- all references to applicable international guides and standards have been updated;

- clause numbers 4 & 5 are now clauses 4 through 8 to align with the 2017 edition of ISO/IEC 17025 (hereafter referred to as ISO/IEC 17025);

- redundant requirements for specific equipment, certifications, records, etc. found in the various standards for test methods used in the program were removed.

This handbook is also available on the NVLAP website.

Questions or comments concerning this handbook should be submitted to NVLAP, National Institute of Standards and Technology, 100 Bureau Drive, Stop 2140, Gaithersburg, MD, 20899-2140; phone: 301-975-4016; fax: 301-926-2884; e-mail: nvlap@nist.gov.

Introduction

As part of broader energy conservation issues, the Energy Policy and Conservation Act (Public Law 94-163) was passed in 1975 in response to the oil crisis of the early 1970s. It has been amended several times, most notably in 1992 by the Energy Policy Act (EPAct) (Public Law 102-486). The *Energy Conservation Program for Consumer Products other than Automobiles* was added and includes energy efficiency test procedures and standards for various industrial equipment and, in particular, certain electric motors. The Energy Policy and Conservation Act (EPCA), as amended by EPAct, establishes definitions, test procedures, labeling provisions, energy efficiency standards, and compliance certification requirements for electric motors.

Section 345(c) of EPCA (42 U.S.C. 6316(c)) requires electric motor "manufacturers to certify, through an independent testing or certification program nationally recognized in the United States, that such motor meets the applicable [nominal full-load efficiency standard]."

Section 431.36(a) of Title 10, Code of Federal Regulations (CFR) Part 431 (10 CFR Part 431), provides two equivalent ways to fulfill the compliance certification requirements under section 345(c) of EPCA:

(1) A manufacturer may certify, through an independent, accredited testing laboratory, that a covered motor meets the standard; or

(2) A manufacturer may certify, through an independent certification program nationally recognized in the United States, that a covered motor meets the standard.

The procedures by which a manufacturer may certify the energy efficiency of its electric motors, either through a certification program or an accredited testing program, are set forth in section 431.17 of 10 CFR Part 431, and subsections 431.17(a)(5) and (b).

The Efficiency of Electric Motors (EEM) LAP was originally developed at the request of the National Electrical Manufacturers Association (NEMA) to assist the electric motor industry in complying with the statutory requirements for electric motors. NVLAP coordinated the development of the EEM program with NEMA and the Department of Energy (DOE).

Accreditation under NVLAP for the efficiency of electric motors fulfills the applicable requirements of 10 CFR Part 431 for accreditation as an independent testing program nationally recognized in the United States. (See section 431.18 of 10 CFR Part 431.) The names and contact information for NVLAP-accredited laboratories are published on the NVLAP website.

The author gratefully acknowledges the important contributions of the following: past regulatory and technical input and review by Jim Raba of DOE; past technical input and review by Vern Nielsen of Nielsen Engineering, Inc.; current input and technical review by Juan Carlos Balda of the University of Arkansas; and editing by Bethany Hackett of NVLAP.

1 General information

1.1 Scope

1.1.1 NIST Handbook 150-10 specifies the technical requirements and provides guidance for the accreditation of laboratories under the NVLAP Efficiency of Electric Motors (EEM) LAP. It supplements NVLAP procedures and the general requirements found in ISO/IEC 17025, by tailoring the general criteria found in NIST Handbook 150 to the specific tests and types of tests covered by the EEM LAP.

1.1.2 ISO/IEC 17025, NIST Handbook 150, this handbook, and test methods indicated on the (proposed) scope of accreditation constitute the collective body of requirements that must be met by a laboratory seeking NVLAP accreditation for the EEM LAP.

1.1.3 This handbook is intended for information and use by accredited EEM laboratories, assessors conducting onsite assessments, laboratories seeking accreditation, other laboratory accreditation systems, users of laboratory services, and others needing information on the requirements for accreditation under the EEM LAP.

1.2 Organization of handbook

The numbering and titles of clauses four through eight of this handbook mirror those of ISO/IEC 17025:2017. The primary subclauses in clauses 4 through 8 (e.g., 4.1, 4.2, etc.) are also numbered and titled to correspond with those of ISO/IEC 17025, even when there are no additional requirements.

1.3 Program description

1.3.1 Statutory and regulatory requirements

Before the enactment of the Energy Independence and Security Act of 2007 (EISA 2007), section 340(13)(A) of EPCA defined *electric motor* as any motor that is "general purpose T-frame, single speed, foot-mounting, polyphase squirrel-cage induction of the National Electrical Manufacturers Association (NEMA) Designs A and B, continuous-rated, operating on 230/460 volts and constant 60 hertz line power, as defined in NEMA Standards Publication MG1-1987." Section 342(b)(1) of EPCA then prescribes efficiency standards for electric motors that are 0.75 kW (1 hp) to 150 kW (200 hp) and manufactured (alone or as a component of another piece of equipment), except for definite purpose motors, special purpose motors, and those motors exempted by the Secretary of Energy. Further, section 343(a)(5)(A) of EPCA required that the testing procedures for motor efficiency shall be the test procedures specified in NEMA Standards Publication MG1-1987, and the Institute of Electrical and Electronics Engineers, Inc. (IEEE) Standard 112, Test Method B for motor efficiency, as in effect on October 24, 1992.

The Energy Policy Act of 1992 authorizes the Secretary of Energy to amend both the procedures used for the determination of efficiency and the performance standards that apply to regulated electric motors. An energy conservation standard may be amended by the Secretary of Energy by publishing the rule in the *Federal Register*. The most notable amendments follow the enactment of EISA 2007 and include extending the range of electric motor sizes and types covered by regulation from the original 0.75 kW

(1 hp) to 150 kW (200 hp) up to 375 kW (500 hp) and updating the test standards used in the determination of electric motor efficiency.

Pursuant to EISA 2007, DOE adopted new definitions in place of the original EPCA *general purpose motor*. The term *general purpose electric motor (subtype I)* covers motors subject to minimum efficiency standards since 1999. DOE also adopted a definition of *general purpose electric motor (subtype II)* as one that incorporates the design elements of a subtype I motor, but is configured as one of the following:

1. a U-frame motor
2. a design C motor
3. a close-coupled pump motor
4. a footless motor
5. a vertical solid shaft normal thrust motor (as tested in a horizontal configuration)
6. an 8-pole motor
7. a polyphase motor with rated voltage of not more than 600 volts (other than 230 volts or 460 volts).

The minimum efficiency standard for general purpose motors of subtype II is slightly lower than the minimum standards for motors of subtype I.

EPACT also requires DOE to prescribe energy conservation standards for those "small electric motors" for which DOE has determined that standards would be technologically feasible and economically justified and would result in significant energy savings and for which there are prescribed test procedures. On March 9, 2010, DOE published a final rule in the *Federal Register*, "Energy Conservation Standards for Small Electric Motors; Final Rule" (10 CFR Part 431). This rule, together with the subsequent DOE ruling published in the *Federal Register* on May 4, 2012, "Energy Conservation Program: Test Procedures for Electric Motors and Small Electric Motors; Final Rule" (10 CFR Part 431) updates all the prescribed test methods for determination of efficiency for both motor types (see references in 1.4). These rules also specify performance standards and define the terms *electric motor* and *small electric motor.*

1.3.2 Scope of Efficiency of Electric Motors LAP

1.3.2.1 The NVLAP EEM LAP provides for laboratory accreditation to ensure that a testing laboratory is competent to test a motor for energy efficiency and, in particular, for a motor that is covered under 10 CFR Part 431.25. It also provides adequate assurance of compliance with EPCA and EISA 2007 energy efficiency requirements. (The EEM LAP is not restricted only to motors that are covered under Federal regulations.)

1.3.2.2 For purposes of accreditation the test and calculation procedures used to determine the efficiency of a small electric motor or a polyphase electric motor shall be the test standards specified in *Federal Register*, Vol. 77, No. 87 (May 4, 2012).

1.3.2.3 The power range for testing polyphase electric motors in accordance with IEEE 112-2004, Method B or CSA C390-10, Test Method (1) or small electric motors with standards IEEE 114-2010 or CSA C747-09 is not limited to the 0.18 kW (0.25 hp) to 375 kW (500 hp) range provision of EPCA and EISA. Some laboratories seeking NVLAP accreditation consistent with the applicable provisions in 10 CFR Part 431 may have the capability to test a motor rated above 375 kW (500 hp). Consequently, the scope of the EEM program covers the entire range of motors that can be tested competently within the limits of IEEE 112-2004, Test Method A and B and CSA C390-10, Test Method (1) or IEEE 114-2010 and CSA C747-09. Also, added just prior to this addition, IEC 60034-2-1 Edition 2 2014-06.

1.3.2.4 Testing for safety performance of an electric motor is outside the scope of the accreditation program.

1.4 References

The following documents are referenced in this handbook. If no date is given in the reference, then the latest edition applies within one year of publication or within another time limit specified by regulations or other requirement documents.

— CSA International Standard C390-10, *Test methods, marking requirements, and energy efficiency levels for three-phase induction motors*

— ISO/IEC 17025, *General requirement for the competence of testing and calibration laboratories*

— CSA International Standard C747-09, *Energy Efficiency Test Methods for Small Motors*

— "Energy Conservation Program: Test Procedures for Electric Motors and Small Electric Motors; Final Rule," *Federal Register* 77:87 (4 May 2012), pp. 26608-26640 (to be codified at 10 CFR Part 431)

— "Energy Conservation Standards for Small Electric Motors; Final Rule," *Federal Register* 75:45 (9 March 2010), pp. 10874-10948 (codified at 10 CFR Part 431)

— IEEE Standard 112-2004, *Test Procedure for Polyphase Induction Motors and Generators*

— IEEE Standard 114-2010, *Test Procedure for Single-Phase Induction Motors*

— National Electrical Manufacturers Association, NEMA Standards Publication MG1-2011, *Motors and Generators*

— NIST Handbook 150, *NVLAP Procedures and General Requirements*

1.5 Terms and definitions

For the purposes of this handbook, the terms and definitions given in NIST Handbook 150 and section 431.12 of 10 CFR Part 431 apply.

1.5.1 polyphase electric motor

The term *polyphase electric motor* refers to polyphase induction motors with rated output of 1 hp to 500 hp for which test standards IEEE 112-2004 method B and CSA C390-10 method 1 may be used to determine efficiency.[1]

[1] It is NIST policy to employ the International System of Units (metric units) in its publications. However, in the North American electric motor industry, certain non-SI units are used, therefore measurement values using customary units are reported in this publication to avoid confusion.

1.5.2 small electric motor

The term *small electric motor* refers to single-phase induction motors and polyphase induction motors 1 hp or less. Efficiency of these motor types may be determined using IEEE 114-2010, CSA C747-09, or IEEE 112-2004 method A (for small polyphase motors with output 0.75 kW [1 hp] or less).

1.6 Program documentation

1.6.1 General

Assessors use NVLAP checklists to ensure that each laboratory receives an assessment comparable to that received by others and to assure completeness, uniformity, and objectivity. Checklists assist assessors in documenting the assessment to the NVLAP requirements found in NIST Handbook 150 and this handbook. Checklists contain definitive statements or questions about all aspects of the NVLAP requirements for accreditation, and form part of the Onsite Assessment Report (see NIST Handbook 150).

1.6.2 NVLAP General Criteria Checklist

All NVLAP programs use the NVLAP General Criteria Checklist (ISO/IEC 17025:2017) (formerly called the NIST Handbook 150 Checklist), which contains the requirements published in ISO/IEC 17025 and NIST Handbook 150. The checklist items are numbered to correspond to clauses 4 through 8 of ISO/IEC 17025 and annexes A, B, and E of NIST Handbook 150.

1.6.3 NIST Handbook 150-10 Checklist

The NIST Handbook 150-10 Checklist (also referred to as the EEM Program-Specific Checklist) addresses requirements specific to efficiency of electric motors testing.

1.6.4 Test Method Review Summary

The assessor uses the Test Method Review Summary to review the laboratory's ability to perform the EEM test method(s) listed on the (proposed) scope of accreditation. The review of the test method(s) by the assessor ranges from observing tests to having laboratory staff describe the test procedures. The assessor notes on the Test Method Review Summary the depth to which each part of the test method was reviewed (Observed Test, Walked/Talked Through Test, Listened to Description of Procedures, Examined Apparatus). Since the EEM LAP is limited to efficiency testing of polyphase electric motors and small electric motors, the test method review is in depth.

1.6.5 NVLAP lab bulletins

NVLAP lab bulletins are issued to laboratories and assessors, when needed, to clarify program-specific requirements and to provide information about the most current program additions and changes. Lab bulletins providing additions or changes to the current program will supersede the requirements of the current published handbook until the additions or changes are published in a revision of the handbook. Lab bulletins are posted on the program-specific handbooks page of the NVLAP website.

2 LAP establishment, development, and implementation

This clause contains no information additional to that provided in NIST Handbook 150, clause 2.

3 Accreditation process

3.1 General

An overview of the laboratory accreditation process is provided in NIST Handbook 150, clause 3, and includes information pertaining to application for accreditation; onsite assessment; proficiency testing; accreditation decision; granting accreditation; renewal of accreditation; changes to scope of accreditation; monitoring visits; and suspension, denial, revocation, and voluntary termination of accreditation.

3.2 Management system review

Prior to the onsite assessment, the assigned assessor will review all relevant management system documentation against NVLAP requirements. During this review, the assessor may request additional management system documents and/or records, which will be returned upon request.

3.3 Onsite assessment

3.3.1 General information

3.3.1.1 The purpose of the onsite assessment is to determine the laboratory's compliance with ISO/IEC 17025, NIST Handbook 150, this handbook, and its own management system and to assess the capability and competence of the testing activities for which accreditation is being requested.

3.3.1.2 Testing performed at locations other than the primary facility covered under the accreditation will be reviewed on a case-by-case basis to determine the extent of onsite review necessary at the other locations.

3.3.1.3 Prior to the onsite assessment, the NVLAP assessor will provide a preliminary agenda. The laboratory may not be granted accreditation or renewal if not prepared to conduct test demonstrations, have equipment in good working order, and/or ready for examination according to the requirements identified in ISO/IEC 17025, this handbook, and NIST Handbook 150.

3.3.1.4 The laboratory shall make available all supporting technical information. All relevant documentation shall be provided to NVLAP and its assessor(s) in English.

3.3.1.5 In addition to the checklists, to help assure the completeness, objectivity, and uniformity of the onsite assessment, the assessor uses the NVLAP Test Method Review Summary form to review the capability of laboratory personnel to perform testing for which accreditation is sought. The test method review ranges from observing tests to having laboratory staff describe the test procedures. The assessor notes the depth to which each part of the test method was reviewed and records the results of the review.

3.3.2 Typical onsite assessment

3.3.2.1 Assessment activities

The NVLAP assessor performs the following activities during a typical onsite assessment:

a) Conducts an opening meeting with the laboratory to explain the purpose of the onsite visit and to discuss the schedule for the day(s). At the discretion of the laboratory manager, other staff may attend the meeting.

b) Reviews laboratory documentation not provided for review prior to the assessment, including the management system records, equipment and maintenance records, record-keeping procedures, testing procedures, laboratory test records and reports, personnel competency records, personnel training plans and records, and safeguards for the protection of sensitive and proprietary information.

   At least one laboratory staff member shall be available to answer questions; however, the assessor may request to review the documents and records alone.

c) Examines equipment and facilities, observes the demonstration of selected procedures by the appropriate personnel assigned to conduct the tests, and interviews those personnel. The demonstrations requested may be selective or all-inclusive and shall include use of sample test devices, preparation of test device, establishment of test conditions, the setup/use of major equipment. The assessor will also review the test data and examine the hardware/software for functionality and appropriateness.

d) Completes an Onsite Assessment Report, which contains the NVLAP Onsite Assessment Signature Sheet with Narrative Summary, NVLAP General Criteria Checklist (ISO/IEC 17025:2017), NIST Handbook 150-10 Checklist, and the Test Method Review Summary. The assessor will also enter any nonconformities and/or comments into the NVLAP interactive website (NIWS).

e) Conducts a closing meeting with the laboratory to explain the findings of the visit. At the closing meeting, the report shall be signed by the assessor and the laboratory's authorized representative to acknowledge the discussion of the outcome of the onsite assessment. The authorized representative's signature does not necessarily indicate agreement, merely receipt, and challenges may be made through NVLAP. The process for resolving nonconformities identified during the onsite is documented in NIST Handbook 150.

3.4 Proficiency testing

General information regarding proficiency testing (PT) may be found in section 3.4 of NIST Handbook 150. PT requirements specific to this program may be found in section 7.7 of this handbook.

4 General Requirements

4.1 Impartiality

There are no requirements additional to those set forth in ISO/IEC 17025.

4.2 Confidentiality

There are no requirements additional to those set forth in ISO/IEC 17025.

5 Structural Requirements

There are no requirements additional to those set forth in ISO/IEC 17025.

6 Resource Requirements

6.1 General

There are no requirements additional to those set forth in ISO/IEC 17025.

6.2 Personnel

6.2.1 The laboratory's technical director (or an appropriate supervisor) shall be experienced in efficiency of electric motors testing and shall have the technical competence and the supervisory capability to direct the work of professionals and technicians in efficiency of electric motors testing.

6.2.2 Staff responsible for conducting the testing shall have technical competence in the following areas as a minimum:

a) general requirements of the electric motor test methods;
b) testing laboratory system capabilities (electrical, mechanical, and environmental);
c) electric motor specimen preparation and/or mounting techniques;
d) connection and operation of the test equipment;
e) electric motor pre-test temperature procedures;
f) techniques for measuring ambient thermal conditions;
g) use of equipment for measuring:
    1) temperature,
    2) resistance,
    3) torque,
    4) power,
    5) speed (rpm) and slip,
    6) voltage,
    7) current,
    8) frequency of input supply;
h) equipment calibration techniques, when applicable, for labs that perform in-house calibrations;
i) data collection, calculation, and analysis.

6.2.3 For each staff member, the staff member's immediate supervisor, or a designee appointed by the laboratory director, shall conduct annually an assessment and an observation of performance competency.

6.2.4 These reviews shall be planned to cover all authorized testing procedures over a defined period. This period is not necessarily one year and may vary depending upon the experience and previous performance of the staff member.

6.2.5 These annual performance competency reviews shall be documented, dated, signed by the supervisor and the employee, retained in the personnel file, and be available for review by the assessor.

6.3 Facilities and environmental conditions

6.3.1 Specific environmental requirements for laboratories are the following:

a) For testing of polyphase electric motors (1 hp to 500 hp using IEEE 112 method B or CSA C390 method 1) or three-phase small electric motors (under 1 hp using IEEE 112 method A), the laboratory shall be able to control the ambient air temperature within the temperature range of 10 °C to 40 °C.

b) For testing of single-phase small electric motors (using standards IEEE 114 or CSA C747), the laboratory shall be able to control the ambient air temperature within the temperature range of 20 °C to 30 °C.

c) The motor shall be protected from movement of the air resulting from sources other than the motor. Drafts and air currents shall be minimized to achieve required stable temperature rise during testing.

d) There shall be sufficient open space around the motor during testing so as not to restrict the normal air flow around or through the motor during testing.

e) The ambient temperature shall be relatively stable during the test.

f) The method for securing the motor to restrict movement during testing shall not interfere with the cooling of the motor.

6.4 Equipment

6.4.1 Provisions shall be available to properly ground the motor and test equipment as may be necessary during testing.

6.4.2 Power supply:

a) The power supply shall be at rated voltage for the motor being tested. If the motor being tested is a small electric motor rated for dual voltage service or service over a range of voltages, it shall be tested at the voltage specified by the motor manufacturer.

b) Polyphase motors shall be tested using a power source with balanced voltages.

c) The line voltages shall be balanced within 0.5 %.

d) The voltages should be sinusoidal and shall not have a total harmonic distortion (THD) exceeding 5 %.

e) The average frequency shall be within ± 0.1 % of the specified test value.

f) The frequency variation during the tests shall not exceed 0.33 % of the average frequency.

g) Any deviation of frequency from the rated frequency shall be taken into consideration when calculating slip.

6.4.3 Other equipment requirements:

a) Test instrumentation shall be properly selected and installed to minimize errors introduced by:

- loading of the signal source;
- lead calibration;
- range, condition, and calibration of the instrument;
- inductive or electrostatic coupling of signal leads to power systems
- common impedance coupling or ground loops;
- inadequate common mode rejection;
- conducted interference from the power line.

b) The loading device, such as a dynamometer, shall be appropriate for the size of the motor. The coupling, friction, and windage loss of the dynamometer measured at rated speed should not be greater than 15 % of the rated output of the motor being tested.

c) The motor shall be aligned correctly with the loading device (dynamometer).

d) When determining the cold winding resistance, a double bridge shall be used, or other means of equivalent accuracy, and checked by a second instrument, if possible.

Note: This requirement does not apply to efficiency testing of small electric motors unless temperature is being determined by the rise of resistance.

e) If thermocouples are used to monitor temperature, they shall be installed correctly.

f) Multiple thermocouples shall be cross-checked at ambient temperature for accuracy and agreement.

6.4.4 Accuracy of the test equipment

a) Instrumentation for measuring voltage, current, and power shall have an accuracy of ± 0.2 % of reading.

b) Instrument transformers shall have an accuracy of ± 0.3 %.

c) When the above instrumentation is calibrated as a system, the accuracy shall be ± 0.2 % of reading.

d) Instrumentation used to measure speed shall have an accuracy within ± 1 rpm.

e) Instrumentation used to measure the output torque of the motor shall have an accuracy of

± 0.2 % of reading. Dynamometers used for testing of small electric motors shall be sensitive to a change in torque of 0.1 % of the rated torque of the motor under test.

f) The range of each instrument chosen shall be as low as practical for the motor being tested such that readings are in the upper region of the scale.

6.5 Metrological traceability

The laboratory shall maintain calibration intervals in accordance with Annex A.

6.6 Externally provided products and services

There are no requirements additional to those set forth in ISO/IEC 17025.

7 Process Requirements

7.1 Review of requests, tenders and contracts

There are no requirements additional to those set forth in ISO/IEC 17025.

7.2 Selection, verification and validation of methods

7.2.1 DOE Requirements

a) For compliance with the DOE requirements (also see Introduction) in the NVLAP EEM LAP, laboratories shall use the test procedures described under "Energy Conservation Program: Test Procedures for Electric Motors and Small Electric Motors, Final Rule," *Federal Register* 77: 87 (4 May 2012), pp. 26608-26640 (to be codified at 10 CFR Part 431).

b) For testing of polyphase electric motors (1 hp to 500 hp) in compliance with U.S. DOE requirements in the NVLAP EEM LAP, the laboratories shall determine efficiency and losses in accordance with NEMA MG1-2011 paragraph 12.58.1 and the test procedures described in IEEE Standard 112-2004 Method B or CSA International Standard C390-10 Test Method (1).

c) For testing of single-phase small electric motors in compliance with U.S. DOE requirements in the NVLAP EEM LAP, the laboratories shall use the test procedures described in IEEE Standard 114-2010, or CSA International Standard C747-09.

d) Polyphase small electric motors (power output less than 1 horsepower) shall be tested using IEEE Standard 112-2004 Method A or CSA International Standard C747-09.

7.2.2 Requirements related to testing equipment

7.2.2.1 Heat run

a) For polyphase electric motors (1 hp to 500 hp) the initial winding resistance measurement shall be taken after the motor is exposed to the ambient temperature for a sufficient time for the windings to reach a stable reference temperature.

b) For small electric motors the initial winding resistance may be measured as above if temperature is to be determined using rise of resistance.

c) For small electric motors the ambient temperature in the test lab shall be not less than 20 °C or greater than 30 °C unless temperature correction of motor losses is calculated as described in IEEE 114-2010.

d) If a heat run is to be performed, it shall be performed first in the test sequence.

e) The heat run shall be performed at rated voltage, rated frequency, and rated load (1.0 service factor).

f) If the motor being tested is a small electric motor rated for dual voltage service or service over a range of voltages, it shall be tested at the voltage specified by the motor manufacturer.

g) If the motor is overloaded at the start of the test to shorten the total test time, the overload shall be kept under 150 % of rated load.

h) The motor shall be operated at rated load, voltage, and frequency for a sufficient period of time for the temperatures to stabilize with not more than a 1 °C change in temperature rise between two successive readings taken at thirty-minute intervals.

i) For polyphase electric motors (1 hp to 500 hp) at the conclusion of the test, the resistance between two lines shall be measured:

- Within 30 seconds of shutdown for motors rated 50 hp or less,
- Within 90 seconds of shutdown for motors rated 51 hp to 200 hp, or
- Within 120 seconds of shutdown for motors rated above 200 hp.

j) If the time limits above are exceeded, then resistance shall be measured as a function of time after shutdown, and the results plotted and extrapolated back to the appropriate time delay to determine the resistance at shutdown.

k) For small electric motors the final winding resistance may be measured as above if temperature is to be determined using rise of resistance.

7.2.2.2 Load performance test

a) The load test shall be performed following a heat run. If performed at another time, the motor temperature shall be adjusted by operating the motor at rated load or some overload condition.

b) The temperature of the stator winding shall be within 10 °C of the hottest thermosensor temperature reading during the heat run at rated operating conditions on a machine under test or on a duplicate machine for the rated full load operating temperature prior to beginning the test.

c) The temperature shall be stable at the start of a test. The test should be performed as quickly as possible to minimize temperature changes in the motor during the test.

d) The motor shall be loaded in decreasing order from the highest to the lowest load.

e) The load readings shall be taken at two points suitably chosen above 100 % but not exceeding 150 % of rated load, and at four points including 100 % of rated load and approximately equally spaced between 100 % and 25 % of rated load.

f) The load shall be steady during the time the data at each load are recorded.

g) The dynamometer correction test shall be performed properly in accordance with the applicable procedure in the test standard used.

h) The dynamometer correction test shall be performed after the load test is completed.

7.2.2.3 No-load test

a) The motor shall be operated at no-load until the input power at rated voltage and frequency does not vary by more than 3 % between two successive readings over a half hour time interval before starting the test.

   This test is not required for the determination of efficiency of a small electric motor.

b) The test shall begin at the highest voltage level and the voltage reduced in steps from that level to the lowest test value.

   This test is not required for the determination of efficiency of a small electric motor.

c) The readings shall be taken at voltages from approximately 125 % of rated voltage down to the point where further voltage reduction increases the current or the motor becomes unstable.

   This test is not required for the determination of efficiency of a small electric motor.

7.3 Sampling

There are no requirements additional to those set forth in ISO/IEC 17025.

7.4 Handling of test or calibration items

There are no requirements additional to those set forth in ISO/IEC 17025.

7.5 Technical records

There are no requirements additional to those set forth in ISO/IEC 17025.

7.6 Evaluation of measurement uncertainty

The uncertainty shall be determined and reported when required by the test method, the regulator, or the customer.

7.7 Ensuring the validity of results

7.7.1 The laboratory shall have satisfactorily participated in all required proficiency testing (PT) during its previous accreditation period or prior to accreditation if initial accreditation.

Note: Required PT will be identified on the program page on the NVLAP website.

7.7.2 If the laboratory performs unsatisfactorily in any proficiency test, the laboratory shall take corrective action to investigate and resolve nonconformities in a timely manner, according to the requirements of ISO/IEC 17025 for the control of nonconforming work.

7.8 Reporting of results

7.8.1 The correlation factor for smoothing stray-load loss shall be equal to or greater than the minimum value prescribed by the applicable standard with no more than one of the six points omitted from the analysis.

For efficiency testing using IEEE 112-2004 Method B, the minimum value is 0.90.

For efficiency testing using CSA C390-10 Method 1, the minimum value is 0.95.

Note: This requirement does not apply to efficiency testing of small electric motors.

7.8.2 When necessary to repeat the test to obtain a correlation factor equal to or greater than the minimum values listed above, the source of error shall be investigated and corrected prior to rerunning the test.

Note: This requirement does not apply to efficiency testing of small electric motors.

7.8.3 Data analysis and report generation

7.8.3.1 In some cases, raw data collected electronically are collated, reduced, analyzed, or otherwise treated for direct incorporation in the test report. Such treatment involving transmission of the data, writing, and generation of the test report is generally performed at the laboratory or at an area close to the facility and under the control of laboratory personnel. In such cases, the laboratory personnel responsible for the report writing and generation shall be available during the laboratory's onsite assessment to be interviewed by the assessor for evaluation of the laboratory's compliance with the NVLAP criteria for test reports. The assessor shall perform an independent calculation of the efficiency based on laboratory test results and compare the independently-calculated efficiency with that calculated by the laboratory.

7.8.3.2 At times, the final report may be written and generated at an offsite facility that is located some distance from the testing laboratory such that the assessor cannot interview the off-site personnel. In such a case, the laboratory shall have in place for assessor review appropriate written descriptions in its management system documentation of procedures and documentation for assuring the accuracy and validity of the data transmission, the incorporation and accurate analysis of the data in the test report, and the compliance of the test report with NVLAP criteria. Depending on the onsite laboratory evaluations of these written descriptions, a visit to the off-site facility may be required. When warranted, an assessor will visit the off-site facility at additional cost to the laboratory before accreditation is granted or renewed.

7.8.3.3 When a test report is written at an offsite facility such that the assessor cannot interview the off-site personnel, the report shall include the names and addresses of both those responsible for conducting the laboratory tests and for writing and generating the test report. Copies of typical reports written at an offsite facility shall be available at the laboratory at the time of the on-site assessment and these typical reports shall be reviewed by the assessor for compliance with NVLAP requirements. The assessor shall perform an independent calculation of efficiency and compare it to that calculated at the offsite facility as required in 5.10.2.1.

7.9 Complaints

There are no requirements additional to those set forth in ISO/IEC 17025.

7.10 Nonconforming work

There are no requirements additional to those set forth in ISO/IEC 17025.

7.11 Control of data and information management

There are no requirements additional to those set forth in ISO/IEC 17025.

8 Management system requirements

8.1 Options

There are no requirements additional to those set forth in ISO/IEC 17025.

8.2 Management system documentation (Option A)

There are no requirements additional to those set forth in ISO/IEC 17025.

8.3 Control of management system documents (Option A)

There are no requirements additional to those set forth in ISO/IEC 17025.

8.4 Control of records (Option A)

To allow for objective evidence during NVLAP assessments, the laboratory shall maintain all records at least three (3) years.

8.5 Actions to address risks and opportunities (Option A)

There are no requirements additional to those set forth in ISO/IEC 17025.

8.6 Improvement (Option A)

There are no requirements additional to those set forth in ISO/IEC 17025.

8.7 Corrective actions (Option A)

There are no requirements additional to those set forth in ISO/IEC 17025.

8.8 Internal audits (Option A)

8.8.1 An applicant laboratory shall conduct at least one complete internal audit prior to the first onsite assessment. The records will be reviewed by the NVLAP assessor before or during the onsite assessment.

8.8.2 Internal audits are separate and distinct from both management reviews (see 8.9) and NVLAP onsite assessments.

8.9 Management reviews (Option A)

An applicant laboratory shall perform at least one complete management review prior to the first onsite assessment. The records will be reviewed by the NVLAP assessor before or during the onsite assessment.

Annex A
(Normative)

To account for the effects on traceability of the calibration of measurement and test equipment, the laboratory shall determine equipment calibration, verification, and maintenance intervals based on the equipment's frequency of use and the environment in which it is used, and also in accordance with standard test methods, manufacturer's recommendations, or as specified in the following table, whichever results in a shorter time between calibrations.

Extension of the time interval between calibrations is acceptable if the laboratory can provide justification for increasing the interval.

Apparatus/Instrumentation	***Calibration or Verification Frequency***
ammeters, voltmeters and wattmeters	Annually
current transformers (CTs)	Every 5 years
potential transformers (PTs)	Every 5 years
shunts	Every 2 years
data acquisition systems	Annually
electronic transducers	Annually
frequency meters	Annually
resistance measurement equipment	Annually
speed sensors	Annually
temperature measuring equipment	Annually
torque measuring equipment	Annually or more frequently.* See note below for requirements for the calibration interval for torque measurement equipment.
calibration weights and torque arm	1 to 3 years *

* With regard to torque measurement, the frequency of recalibration of torque transducers, masses (weights) and arm length needs to be determined by the laboratory.
Torque transducers may need to be recalibrated more often if laboratory calibration records show that the instrument is subject to drifting out of tolerance with time. It is the responsibility of the lab to ensure that torque transducers always meet NVLAP accuracy requirements even if this means more frequent calibrations.

Depending on how often the masses and torque arm are used, their care and storage, and records that the laboratory develops and maintains to see if any change has occurred, the laboratory may determine that the masses and arm length need to be recalibrated relatively infrequently; that is with sufficient documentation for masses and arm length, the laboratory may determine to extend the calibration frequency interval of one year to an interval not exceeding three years.