[6450-01-P]

DEPARTMENT OF ENERGY

10 CFR Part 431

[EERE-2017-BT-TP-0055]

RIN 1904-AB39

Energy Conservation Program: Test Procedure for Distribution Transformers

AGENCY: Office of Energy Efficiency and Renewable Energy, Department of Energy.

ACTION: Notice of proposed rulemaking and request for comment.

SUMMARY: The U.S. Department of Energy ("DOE") proposes clarifying amendments to the test procedure for distribution transformers to revise and add definitions of certain terms, to incorporate revisions based on the latest versions of relevant Institute of Electrical and Electronics Engineers (IEEE) industry standards, and to specify the basis for voluntary representations at additional per-unit loads (PULs) and additional reference temperatures. The proposals in this NOPR are minor revisions that do not significantly change the test procedure. Therefore, none of the revisions would pose undue burden on manufacturers. DOE is seeking comment from interested parties on the proposal.

DATES: DOE will accept comments, data, and information regarding this notice of proposed rulemaking (NOPR) no later than [**INSERT DATE 60 DAYS AFTER DATE OF**

PUBLICATION IN THE *FEDERAL REGISTER*]. See section V, "Public Participation," for details.

ADDRESSES: Any comments submitted must identify the Test Procedure NOPR for Distribution Transformers and provide docket number EERE-2017-BT-TP-0055 and/or regulatory information number (RIN) 1904-AB39. Comments may be submitted using any of the following methods:

1) *Federal eRulemaking Portal*: *http://www.regulations.gov*. Follow the instructions for submitting comments.
2) *E-mail: DistributionTransformers2017TP0055@EE.DOE.Gov*. Include the docket number and/or RIN in the subject line of the message.
3) *Postal Mail*: Appliance and Equipment Standards Program, U.S. Department of Energy, Building Technologies Program, Mailstop EE–5B, 1000 Independence Avenue, SW., Washington, DC 20585-0121. Telephone: (202) 287-1445. If possible, please submit all items on a compact disc ("CD"), in which case it is not necessary to include printed copies.
4) *Hand Delivery/Courier:* Appliance and Equipment Standards Program, U.S. Department of Energy, Building Technologies Program, 950 L'Enfant Plaza, SW, Suite 600, Washington, DC 20024. Phone: (202) 287-1445. If possible, please submit all items on a CD, in which case it is not necessary to include printed copies.

No telefacsimilies (faxes) will be accepted. For detailed instructions on submitting written comments and additional information on the rulemaking process, see section V of this document (Public Participation).

Docket: The docket, which includes *Federal Register* notices, public meeting attendee lists and transcripts, comments, and other supporting documents/materials, is available for review at *http://www.regulations.gov*. All documents in the docket are listed in the *http://www.regulations.gov* index. However, some documents listed in the index, such as those containing information that is exempt from public disclosure, may not be publicly available.

The docket web page can be found at *https://www.regulations.gov/docket?D=EERE-2017-BT-TP-0055*. The docket web page will contain simple instructions on how to access all documents, including public comments, in the docket. See section V for information on how to submit comments through *http://www.regulations.gov*.

FOR FURTHER INFORMATION CONTACT:

Mr. Jeremy Dommu, U.S. Department of Energy, Office of Energy Efficiency and Renewable Energy, Building Technologies Program, EE–5B, 1000 Independence Avenue SW, Washington, DC 20585-0121. Telephone: (202) 586-9870. E-mail: *ApplianceStandardsQuestions@ee.doe.gov*.

Ms. Sarah Butler, U.S. Department of Energy, Office of the General Counsel, GC-33, 1000 Independence Avenue SW, Washington, DC 20585-0121. Telephone: (202) 586-1777. E-mail: *sarah.butler@hq.doe.gov*.

For further information on how to submit a comment or review other public comments and the docket, contact the Appliance and Equipment Standards Program staff at (202) 287-1445 or by e-mail: *ApplianceStandardsQuestions@ee.doe.gov*.

SUPPLEMENTARY INFORMATION:

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I. Authority and Background

DOE is authorized to establish and amend energy conservation standards and test procedures for certain industrial equipment, including distribution transformers. (42 U.S.C. 6317(a)) The current DOE test procedures for distribution transformers appear at title 10 of the Code of Federal Regulations ("CFR") 431.193 and appendix A to subpart K of 10 CFR part 431 (herein referenced as "appendix A"). The following sections discuss DOE's authority to establish

and amend test procedures for distribution transformers, as well as relevant background information regarding DOE's consideration of test procedures for this equipment.

A. Authority

The Energy Policy and Conservation Act of 1975, as amended ("EPCA")[1] among other things, authorizes DOE to regulate the energy efficiency of a number of consumer products and industrial equipment. (42 U.S.C. 6291–6317) Title III, Part C[2] of EPCA, added by Public Law 95-619, Title IV, §441(a), established the Energy Conservation Program for Certain Industrial Equipment, which sets forth a variety of provisions designed to improve energy efficiency. This equipment includes distribution transformers, the subject of this NOPR. (42 U.S.C. 6317(a))

Under EPCA, DOE's energy conservation program consists of four parts: (1) testing, (2) labeling, (3) Federal energy conservation standards, and (4) certification and enforcement procedures. Relevant provisions of EPCA for distribution transformers include definitions (42 U.S.C. 6291; 42 U.S.C. 6311), energy conservation standards (42 U.S.C. 6295; 42 U.S.C. 6317), test procedures (42 U.S.C. 6293; 42 U.S.C. 6314), labeling provisions (42 U.S.C. 6294; 42 U.S.C. 6315), and the authority to require information and reports from manufacturers (42 U.S.C. 6316).

[1] All references to EPCA refer to the statute as amended through America's Water Infrastructure Act of 2018, Public Law 115-270 (October 23, 2018).
[2] For editorial purposes, upon codification into the U.S. Code, Part C was redesignated as Part A-1.

Federal energy efficiency requirements for covered equipment established under EPCA generally supersede State laws and regulations concerning energy conservation testing, labeling, and standards. (42 U.S.C. 6316)

The Federal testing requirements consist of test procedures that manufacturers of covered equipment must use as the basis for (1) certifying to DOE that their products comply with the applicable energy conservation standards adopted under EPCA (42 U.S.C. 6316(a); 42 U.S.C. 6296), and (2) making representations about the efficiency of those products (42 U.S.C. 6314(d)). Similarly, DOE must use these test procedures to determine whether the products comply with any relevant standards promulgated under EPCA. (42 U.S.C. 6316(a); 42 U.S.C. 6295(s))

Under 42 U.S.C. 6314, EPCA sets forth the criteria and procedures DOE must follow when prescribing or amending test procedures for covered equipment. EPCA provides in relevant part that any test procedures prescribed or amended under this section must be reasonably designed to produce test results which measure energy efficiency, energy use and estimated annual operating cost of a covered equipment during a representative average use cycle or period of use and not be unduly burdensome to conduct. (42 U.S.C. 6314(a)(2))

In addition, if DOE determines that a test procedure amendment is warranted, it must publish proposed test procedures and offer the public an opportunity to present oral and written comments on them. (42 U.S.C. 6314(b)) EPCA also requires that, at least once every 7 years, DOE evaluate test procedures for each type of covered equipment, including distribution

transformers, to determine whether amended test procedures would more accurately or fully comply with the requirements for the test procedures to not be unduly burdensome to conduct and to be reasonably designed to produce test results that reflect energy efficiency, energy use, and estimated operating costs during a representative average use cycle. (42 U.S.C. 6314(a)(1)). If the Secretary determines that a test procedure amendment is warranted, the Secretary must publish proposed test procedures in the *Federal Register*, and afford interested persons an opportunity (of not less than 45 days' duration) to present oral and written data, views, and arguments on the proposed test procedures. (42 U.S.C. 6314(b)) DOE is publishing this NOPR to satisfy the 7-year review requirement specified in EPCA. (42 U.S.C. 6314(a)(1)(A))

With respect to distribution transformers, EPCA states that the test procedures for distribution transformers shall be based on the "Standard Test Method for Measuring the Energy Consumption of Distribution Transformers" prescribed by the National Electrical Manufacturers Association (NEMA TP 2-1998). (42 U.S.C. 6293(b)(10)(A)) Further, DOE may review and revise the DOE test procedure. (42 U.S.C. 6293(b)(10)(B))

B. Background

DOE's existing test procedure for distribution transformers appears at 10 CFR 431.193 and appendix A. EPCA directed DOE to prescribe testing procedures for those "distribution transformers" for which DOE determines that energy conservation standards "would be technologically feasible and economically justified, and would result in significant energy savings." (42 U.S.C. 6317(a)(1)) EPCA states that the testing procedures for distribution transformers shall be based on the "Standard Test Method for Measuring the Energy

Consumption of Distribution Transformers" prescribed by the National Electrical Manufacturers Association (NEMA TP 2-1998). (42 U.S.C. 6293(b)(10)(A)) Upon establishment of the required test procedures, EPCA required DOE to establish standards for those distribution transformers for which test procedures were prescribed. (42 U.S.C. 6317(a)(2)) DOE has established standards for distribution transformers at 10 CFR 431.196. 70 FR 60407 (October 18, 2005); 78 FR 23336 (Apr. 18, 2013).

Accordingly, DOE prescribed the test procedure for distribution transformers on April 27, 2006 (hereafter "April 2006 TP final rule"). 71 FR 24972. In an April 2013 final rule amending the standards for distribution transformers (hereafter "April 2013 ECS final rule"), DOE determined that the test procedures did not require amendment at that time, concluding that the test procedure as established in the April 2006 TP final rule was reasonably designed to produce test results that reflect energy efficiency and energy use, as required by 42 U.S.C. 6314(a)(2). 78 FR 23336, 23347-48 (April 18, 2013).

On September 22, 2017, DOE published a request for information (RFI) to collect data and information to inform its decision in satisfaction with the 7-year review requirement specified in EPCA (hereafter "September 2017 TP RFI"). 82 FR 44347. In response to the September 2017 TP RFI, National Electrical Manufacturers Association (NEMA) requested an extension of the comment period. (NEMA, No. 4 at p. 1) DOE published a notice on October 31, 2017, reopening the public comment period until November 6, 2017. 82 FR 50324.

In this document, DOE is proposing amendments to the test procedure for distribution transformers. DOE also addresses the comments received in response to the September 2017 TP RFI.

II. Synopsis of the Notice of Proposed Rulemaking

In this NOPR, DOE proposes to update 10 CFR 429.47, 431.192, 431.193, 431.196 and appendix A as follows:

1) Explicitly specify that the test procedure is applicable only to distribution transformers that are subject to energy conservation standards,
2) Include new definitions for "per-unit load," "terminal" and "auxiliary device," and updated definitions for "low-voltage dry-type distribution transformer" and "reference temperature,"
3) Reflect certain revisions from the latest version[3] of the IEEE standards on which the DOE test procedure is based,
4) Incorporate other clarifying revisions based on review of the DOE test procedure,
5) Require manufacturers to use the DOE test procedure to make voluntary (optional) representations at additional PULs and reference temperatures,[4]and

[3] 42 U.S.C. 6314(d) generally requires that 180 days after a test procedure rule applicable to any covered equipment is prescribed under this section, a manufacturer who makes a representation of energy consumption of such equipment must test in accordance with the applicable test procedure. Any voluntary (optional) representations at additional PULs and/or temperatures would be required to fairly disclose the results of such testing.
[4] The existing test procedure already includes equations for producing representations at additional PULs and reference temperatures.

6) Centralize the per-unit load and reference temperature specifications for certification to energy conservation standards and for voluntary representations.

Table II.1 summarizes the proposed test procedure amendments compared to the current test procedure, as well as the reason for the change.

Table II.1 Synopsis of the Proposed Test Procedure

Current DOE TP	Proposed TP	Attribution
Current test procedure does not specify scope.	States explicitly that the scope of the test procedure is limited to the scope of the energy conservation standards (10 CFR 431.196). DTs not subject to ECSs are not subject to the TP.	Clarification added by DOE
Per-unit load (PUL) is referred to in the DOE TP as "percent load," "percent of nameplate-rated load," "percent of the rated load," or "per unit load level"	Adds new definition for "per-unit load" (PUL) and consolidates all the terms in subpart K of 10 CFR part 431 to only "per-unit load."	Improves consistency and readability of test procedure
Does not define "Per-unit load," "Terminal" and "Auxiliary device," which are used in the current TP	Adds new definitions for "Per-unit load," "Terminal" and "Auxiliary device" based on industry IEEE standards and other research. (10 CFR 431.192)	Reflects industry standard definition (terminal) and clarification added by DOE (PUL and auxiliary device)
Follows four IEEE industry standards, which contain general electric and mechanical requirements and methods for performing tests: (1) C57.12.00-*2000* (2) C57.12.01-*1998* (3) C57.12.90-*1999* (4) C57.12.91-*2001*	Proposes amendments that reflect the <u>latest version</u> of the four IEEE industry standards: (1) C57.12.00-*2015* (2) C57.12.01-*2015* (3) C57.12.90-*2015* (4) C57.12.91-*2011* (Throughout appendix A to subpart K of part 431)	Reflects industry standard updates
Requires reporting performance at the rated frequency; however, the rated frequency is not explicitly stated	States explicitly that all testing under the DOE test procedure is to occur only at 60 Hz, consistent with the frequency used by the US electric transmission and distribution system. (Appendix A, sections 3.1(c), 4.1)	Update to reflect industry standards
Requires determining winding resistance but does not specify whether the polarity of the core magnetization should be kept constant as measurements are made.	Specifies that the polarity of the core magnetization be kept constant during all resistance readings, consistent with industry test method. (Appendix A, section 3.4.1(f))	Update to reflect industry standards
Requires the measurement of load and no-load loss, without explicitly specifying the connection locations for measurements	Specifies explicitly that load and no-load loss measurements are required to be taken only at the transformer terminals. (Appendix A, section 3.4.1(g)-(i))	Update to reflect industry standards
Testing with a sinusoidal waveform explicitly specified only for transformers designed for harmonic currents.	Specifies that <u>all</u> transformers must be tested using a sinusoidal waveform (not just those designed for harmonic current). (Appendix A, section 4.1)	Update to reflect industry practice

Current DOE TP	Proposed TP	Attribution
Requires that efficiency must be determined at a single test per-unit load (PUL) of 50 percent for both liquid-immersed and MVDT distribution transformers, and at a single test PUL of 35 percent for LVDT distribution transformers.	Permits *voluntary* representations of efficiency, load loss and no-load loss at additional PULs and/or reference temperature, using the DOE TP. Does not require certification to DOE of any voluntary representations. (Appendix A, new section 7)	Response to industry comment
Specifies PUL and reference temperature specifications for certification to energy conservation standards in multiple locations throughout appendix A.	Centralizes the PUL and reference temperature specifications, both for the certification to energy conservation standards and for use with a voluntary representation. (Appendix A, new sections 2.1 and 2.2)	Improves readability of test procedure.

DOE has tentatively determined that the proposed updates would not change measured values used for certifying compliance with existing energy conservation standards for distribution transformers or pose undue test burden. DOE's proposed actions are addressed in detail in section III of this document.

III. Discussion

The following sections focus on certain aspects of DOE's test procedure, including rulemaking process, scope and definitions, revisions based on industry standards, per-unit load (PUL) testing requirements, purchasing decision, load growth, temperature correction, multiple voltage capabilities, other test procedure issues and updates, sampling, representations and alternate efficiency determination method (AEDM), test procedure costs and harmonization, and compliance date and waivers. The proposals in this NOPR are minor revisions that do not significantly change the test procedure. Therefore, none of the revisions would increase burden on manufacturers. Relevant comments received in response to the September 2017 TP RFI are addressed in the appropriate sections in the following discussion. Table III.1 includes the list of stakeholders that submitted comments.

Table III.1 List of Stakeholders that Submitted Comments*

Stakeholder Group	Stakeholder Listing (and Abbreviation Used in this NOPR)
Efficiency Advocates	American Council for an Energy-Efficiency Economy and Appliance Standards Awareness Program (ACEEE & ASAP)
Manufacturers	Howard Industries, NEMA, Powersmiths International Corp. (Powersmiths), Prolec-GE.
Utilities	American Public Power Association (APPA), Edison Electric Institute (EEI), National Rural Electric Cooperative Association (NRECA), Pacific Gas and Electric Company, Southern California Gas Company, Southern California Edison and San Diego Gas & Electric Company (hereafter called California Investor Owner Utilities, or CA IOUs).
Steel Producers	AK Steel, Metglas
Others	HVOLT Inc., Babanna Suresh (Suresh), Mikro-Kod Consulting (MKC).

* DOE received other comments from anonymous submitters that were unrelated to the Distribution Transformer Test Procedure and are therefore not addressed in this NOPR but are available for review on the docket. The docket web page can be found at *https://www.regulations.gov/docket?D=EERE-2017-BT-TP-0055.*

A. Rulemaking Process

In response to the September 2017 TP RFI, DOE received several comments regarding the rulemaking process.

EEI and APPA stated that DOE should complete work on the test procedure before issuing any advanced notice of proposed rulemaking (ANOPR) or "no new standard" determination for the energy conservation standards. (EEI, No. 16 at p. 2; APPA, No. 24 at p. 1) DOE notes that for rulemakings related to covered equipment, it generally seeks to follow the process outlined in 10 CFR part 430 subpart C appendix A, *Procedures, Interpretations and Policies for Consideration of New or Revised Energy Conservation Standards for Consumer Products* (hereafter the "Process Improvement Rule"). The Process Improvement Rule provides that, when appropriate and otherwise permissible, any necessary modifications to a test

procedure will be proposed before issuance of an ANOPR in the standards development process, and a final test procedure modifying test procedures as necessary will be issued prior to a NOPR on proposed standards. See section 7(a) and (b). This document is part of the rulemaking for the test procedure for distribution transformers. DOE has not initiated a rulemaking regarding amended standards for distribution transformers, and to the extent DOE does propose amended standards for distribution transformers, such a proposal will be addressed in a separate rulemaking.

NEMA commented that it believes there is no need for significant revisions to test procedures for distribution transformers. (NEMA, No. 14 at p. 2). NRECA and APPA commented that further action to issue new standards or new test procedures to support new standards is not necessary for this product category. (NRECA, No. 22 at p. 1; APPA, No. 24 at p. 2) Per EPCA (as discussed in section I.A of this document), DOE must evaluate test procedures for each type of covered equipment at least once every 7 years. 42 U.S.C. 6314(a)(1). Consistent with NEMA's comments, based on DOE's evaluation, the proposals in this NOPR are minor revisions that do not make significant changes to the test procedure. Therefore, the proposed amendments would have no impact to measured values.

CA IOUs urged DOE to work with Institute of Electrical and Electronics Engineers (IEEE) and the Distribution Transformers subcommittee to gather the necessary data and information requested in the RFI. (CA IOUs, No. 18 at p. 1) In response to the September 2017 TP RFI, DOE received relevant information and data from multiple stakeholders to inform the test procedure rulemaking. The proposals presented in this document reflect DOE's

consideration of all the information received in response to the RFI. Through this NOPR, DOE is providing further opportunity for the public to provide comments, information, and data on proposed amendments to the test procedure for distribution transformers.

B. Scope

The applicability of the test procedure is provided in 10 CFR 431.193, which states that "the test procedures for measuring the energy efficiency of distribution transformers for purposes of EPCA are specified in appendix A to this subpart." DOE has established energy conservation standards for low-voltage dry-type (LVDT) distribution transformers, liquid-immersed distribution transformers, and medium-voltage dry type (MVDT) distribution transformers at 10 CFR 431.196. In this NOPR, DOE proposes to state explicitly that the scope of the test procedure is limited to the scope of the distribution transformers that are subject to energy conservation standards. DOE proposes to modify text in 10 CFR 431.193 accordingly.

C. Definitions

This notice proposes clarifying amendments to the test procedure for distribution transformers. A "transformer" is a device consisting of 2 or more coils of insulated wire that transfers alternating current by electromagnetic induction from 1 coil to another to change the original voltage or current value. 10 CFR 431.192. A "distribution transformer" is a transformer that: (1) has an input voltage of 34.5 kV or less; (2) has an output voltage of 600 V or less; (3) is rated for operation at a frequency of 60 Hz; and (4) has a capacity of 10 kVA to 2500 kVA for liquid-immersed units and 15 kVA to 2500 kVA for dry-type units. *Id*. The term "distribution transformer" does not include a transformer that is an autotransformer; drive (isolation)

transformer; grounding transformer; machine-tool (control) transformer; nonventilated transformer; rectifier transformer; regulating transformer; sealed transformer; special-impedance transformer; testing transformer; transformer with tap range of 20 percent or more; uninterruptible power supply transformer; or welding transformer. *Id*.

A "liquid-immersed distribution transformer" is a distribution transformer in which the core and coil assembly is immersed in an insulating liquid. *Id*. A "low-voltage dry-type distribution transformer" is a distribution transformer that has an input voltage of 600 volts or less; is air-cooled; and does not use oil as a coolant. *Id*. A "medium-voltage dry-type distribution transformer" means a distribution transformer in which the core and coil assembly is immersed in a gaseous or dry-compound insulating medium, and which has a rated primary voltage between 601 V and 34.5 kV. *Id*.

In this NOPR, DOE proposes additional specification to the test procedure scope and instructions. As part of that objective, DOE is proposing new definitions for two terms: "terminal" and "auxiliary device." Details are provided in sections III.C.2.b and III.C.2.c of this document. In addition, DOE is proposing minor editorial updates to the following definitions: "low-voltage dry-type distribution transformer" and "reference temperature." Details are provided in section III.C.3 of this NOPR.

1. Rectifier Transformers

Rectifier transformers are defined in the CFR to operate at the fundamental frequency of an alternating-current system and are designed to have one or more output windings connected to

a rectifier. 10 CFR 431.192. Rectifier transformers are among the exclusions to the term "distribution transformer" at 10 CFR 431.192. Because rectifier transformers are not classified as distribution transformers, they are not subject to the energy conservation standards at 10 CFR 431.196.

Drive transformers are defined in the CFR to isolate electric motors from the line, accommodate the added loads of drive-created harmonics, and are designed to withstand the mechanical stresses resulting from both alternating- and direct-current motors drives. 10 CFR 431.192. Drive transformers are among the exclusions to the term "distribution transformer" at 10 CFR 431.192. Although drive and rectifier transformers are defined differently, they would share many features. First, both are isolation (*i.e.* not auto-) transformers. Second, both are typically exposed to (and must tolerate) significant drive-/power supply-created harmonic current. Finally, both are likely to include design features enabling them to bear mechanical stress resulting from rapid current changes that may arise from operation of motors and other industrial equipment.

Suresh commented that many distribution transformers supply loads that may have greater harmonic current due to the ubiquity of electronics, which typically include rectifiers and which tend to produce harmonic current. Suresh stated that, as a result, it could be argued that most distribution-type transformers meet the present definition of the terms "rectifier transformer" or "drive transformer." Suresh suggested that those terms be removed from the list of exclusions to the term "distribution transformer." (Suresh, No. 8 at p. 1) Suresh also suggested

that the definition of "rectifier transformer" be limited to transformers that supply loads that are composed of at least 75 percent power electronics. (Suresh, No. 9 at p. 1)

The definition of "rectifier transformer" should not be interpreted as broadly as the commenter suggests it could be; *i.e.*, this term is not intended to describe a large number of transformers intended for general power distribution service. Linking a definition of "rectifier transformer" to supply of loads composed of greater than 75 percent power electronics would not be sufficient to designate a distribution transformer, as it may not be possible for a manufacturer to know in advance what fraction of the distribution transformer's load will include power electronics.

DOE reviewed industry standards[5] and internet-published manufacturer literature[6] to identify physical attributes that could be used to distinguish transformers requiring design modification to serve large rectifiers and drives from transformers designed for general-purpose use. In that review, DOE did not observe feature combinations that could be used to reliably identify rectifier transformers. For example, DOE did not find a quantification of how much harmonic current a transformer would need to accommodate to become suitable for service as a rectifier transformer. Although DOE was not able to find a candidate replacement definition for "rectifier transformer" (or "drive transformer") in review of certain industry standards and

[5] DOE reviewed the following industry standards:
(1) IEEE C57.18.10-1998, "IEEE Standard Practices and Requirements for Semiconductor Power Rectifier Transformers"
(2) IEC 61378-1:2011, "Converter transformers – Part 1: Transformers for Industrial Applications"
(3) IEEE 100-2000, "The Authoritative Dictionary of IEEE Standards Terms; Seventh Edition"
(4) IEC 60050[5], "International Electrotechnical Vocabulary"
[6] Internet-published literature included product guides, brochures, manuals, and drawings.

internet-published literature, DOE is interested in receiving feedback on how such a definition may be identified.

DOE requests comment on: (1) whether the current definition of rectifier transformer is sufficiently specific, (2) if not, what modifications would make it sufficiently specific, and (3) whether partial output phase shift, harmonic current tolerance, or other electrical properties may be used to reliably identify rectifier transformers.

DOE requests comment on: (1) whether the current definition of drive transformer is sufficiently specific, (2) if not, what modifications would make it sufficiently specific, and (3) the level of technical similarity drive transformers bear to rectifier transformers.

2. New Definitions

In this NOPR, DOE proposes to include new definitions for "per-unit load," "terminal," and "auxiliary devices." Section 5.1 of Appendix A references "per-unit load" in reference to calculation of load-losses. Appendix A references "terminal" in several provisions regarding test set-up, including in sections 3.3.1.2(c), 3.3.2, and 4.4.2(a)(3). Section 4.4.1 of appendix A provides that measurement corrections are permitted but not required for losses from auxiliary devices. Neither "per-unit load," "terminal," nor "auxiliary device" is currently defined in the regulatory text. DOE's justification for proposing to add these terms is discussed further in the following sections.

a. Per-unit Load

A distribution transformer is regularly operated in-service at load levels less than the full rated load, based on distribution system design, and fluctuations in customer energy demand. Throughout the test procedures and energy conservation standards for distribution transformers, various terms are used to refer to a less-than-full rated load, including "percent load," "percent of nameplate-rated load," "percent of the rated load," or "per unit load level." 10 CFR 431.192, 10 CFR 431.196, and appendix A. DOE is proposing to define a single term, "per-unit load," to mean the fraction of rated load, and to consolidate the usage of these various terms to the new term "per-unit load" in all instances identified. Consolidating the terms would provide consistency throughout the DOE test procedure and would affirm that the different terms have the same meaning.

DOE requests comment on its proposed definition of "per-unit load" and its proposal to consolidate the usage of various terms referring to less-than-full rated load to the single term "per-unit load."

b. Terminal

DOE is proposing to define "terminal" to mean "a conducting element of a distribution transformer providing electrical connection to an external conductor that is not part of the transformer." This definition is based on the definition for "terminal" in IEEE C57.12.80-2010, "IEEE Standard Terminology for Power and Distribution Transformers." To clarify how losses should be measured, DOE is proposing to specify that load and no-load loss measurements are

required to be taken only at the transformer terminals, as discussed further in Section III.J.3 of this document.

DOE requests comment on its proposed definition of "terminal."

c. Auxiliary Device

Section 4.5.3.1.2 of appendix A specifies "during testing, measured losses attributable to auxiliary devices (e.g., circuit breakers, fuses, switches) installed in the transformer, if any, that are not part of the winding and core assembly, may be excluded from load losses measured during testing." DOE has received inquiries from manufacturers regarding whether certain other internal components of distribution transformers are required by DOE test procedures to be included in the loss calculation, or whether they are considered an auxiliary device. Beyond the listed examples of circuit breakers, fuses, and switches, the current test procedures do not specify which other components may be considered auxiliary devices. DOE is not aware of a prevailing industry definition for the term "auxiliary device," as applied to distribution transformers. The language at section 4.5.3.1.2 of appendix A provides example-based guidance regarding which components of a distribution transformer are regarded as auxiliary devices. In this NOPR, however, DOE is proposing to establish a definition of the term "auxiliary device" based on a specific list of all components and/or component functions that would be considered auxiliary devices and, therefore, be optionally excluded from measurement of load loss during testing.

The auxiliary device examples listed at section 4.5.3.1.2 of appendix A (circuit breakers, fuses, and switches) all provide protective function, but do not directly aid the transformer's core

function of supplying electrical power. Additionally, the term "device" may imply a localized nature, rather than a diffuse system or property of the transformer.

DOE researched commonly included components in distribution transformers and identified circuit breakers, fuses, switches, and surge/lightning arresters as devices which provide protective function and upon which the transformer does not rely to provide its primary function of supplying electrical power at a certain voltage. Accordingly, DOE is proposing to define "auxiliary device" to mean "a localized component of a distribution transformer that is a circuit breaker, switch, fuse, or surge/lightning arrester."

DOE requests comment on its proposed definition of "auxiliary device," and whether certain components should be added or removed from the listed auxiliary devices and why. DOE also requests comment on whether it is appropriate to include functional component designations as part of a definition of "auxiliary device" and, if so, which functions and why.

3. Updated Definitions

a. Low-voltage Dry-type Distribution Transformer

As described, the definition of "low-voltage dry-type distribution transformer" specifies that it does not use oil as a coolant, among other criteria. DOE is proposing to update the definition for "low-voltage dry-type distribution transformer" by replacing the term "oil" with "insulating liquid" within the definition, in conjunction with DOE's proposal to consolidate multiple terms to "insulating liquid," as described in section III.D.2 of this document. DOE is

proposing this update to reflect that the term is inclusive of all insulating liquids, including those identified in IEEE C57.12.90-2015.

DOE requests comment on its proposed updated definition of "low-voltage dry-type distribution transformer."

b. Reference Temperature

As currently defined at 10 CFR 431.192, "reference temperature" means 20 °C for no-load loss, 55 °C for load loss of liquid-immersed distribution transformers at 50 percent load, and 75 °C for load loss of both low-voltage and medium-voltage dry-type distribution transformers, at 35 percent load and 50 percent load, respectively. It is the temperature at which the transformer losses must be determined, and to which such losses must be corrected if testing is done at a different point.

DOE is proposing to update the definition for "reference temperature" by removing references to the numerical temperature values required for certification with energy conservation standards. DOE proposes to retain the conceptual definition of reference temperature and to instead rely on appendix A to specify the numerical temperature values. As proposed, "reference temperature" would mean the temperature at which the transformer losses are determined, and to which such losses must be corrected if testing is done at a different point. This proposal would allow use of the term reference temperature outside the context of conditions required for certification with energy conservation standards (*i.e.*, voluntary

representations at additional temperature values, as described in section III.E.4 of this document).

DOE requests comment on its proposed updated definition of "reference temperature."

D. Updates to Industry Testing Standards

The current DOE test procedure for distribution transformers is based on the following industry testing standards (*See* 71 FR 24972, 24982 (April 27, 2006)):

- NEMA TP 2-1998, "Standard Test Method for Measuring the Energy Consumption of Distribution Transformers" (NEMA TP 2-1998)
- IEEE C57.12.90-1999 "IEEE Standard Test Code for Liquid-Immersed Distribution, Power and Regulating Transformers and IEEE Guide for Short Circuit Testing of Distribution and Power Transformers"
- IEEE C57.12.91-2001, "IEEE Standard Test Code for Dry-Type Distribution and Power Transformers"
- IEEE C57.12.00-2000, "IEEE Standard General Requirements for Liquid-Immersed Distribution, Power and Regulating Transformers"
- IEEE C57.12.01-1998, "IEEE Standard General Requirements for Dry-Type Distribution and Power Transformers Including those with Solid Cast and/or Resin Encapsulated Windings"

In addition, the DOE test procedure also incorporates relevant parts of NEMA TP 2-2005, which also references the aforementioned IEEE industry standards. DOE determined that basing the procedure on multiple industry standards, as opposed to adopting an industry test

procedure (or procedures) without modification, was necessary to provide the detail and accuracy required for the Federal test procedure, with the additional benefit of providing manufacturers the Federal test procedure in a single reference. 71 FR 24972, 24982 (April 27, 2006).

In the September 2017 TP RFI, DOE requested comments on the benefits and burdens of adopting industry standards without modification. 82 FR 44347, 44351 (September 22, 2017). Without identifying specific benefits, NEMA stated generally that there is benefit to adopting an industry standard, but if doing so, DOE should limit the reference to the measurement of losses and retain DOE's existing calculation for efficiency. (NEMA, No. 14 at p. 9) As stated, DOE has already based the current test procedure on industry standards developed by NEMA and IEEE. Additionally, if DOE were to adopt an industry standard without modification, the resulting changes to the test procedure could require manufacturers to retest and recertify, because such an incorporation by reference (IBR) would require updating a majority of the current test procedure. At this time, DOE is not proposing to incorporate industry standards into its test procedures for distribution transformers.

1. Updates to NEMA TP 2

Since the April 2006 TP final rule, NEMA has rescinded NEMA TP 2-2005.[7] DOE received one comment regarding the withdrawal; Suresh commented that because NEMA TP 2 was rescinded, it should not be used as a reference for determining efficiency for distribution

[7] Standard Test Method for measuring the energy consumption of distribution transformers, available at: *https://www.nema.org/Standards/Pages/Standard-Test-Method-for-Measuring-the-Energy-Consumption-of-Distribution-Transformers.aspx.*

transformers. Suresh also stated that the current IEEE/ANSI C57.12.00, C57.12.90 and C57.12.91 are adequate for testing. (Suresh, No. 9 at p. 1)

EPCA requires that DOE base the test procedure on NEMA TP 2-1998. (42 U.S.C. 6293(b)(10)(A)) As discussed in the previous section, the DOE test procedure is based on NEMA TP 2-1998, NEMA TP 2-2005, as well as four widely used IEEE standards, *i.e.*, IEEE.C57.12.00, IEEE C57.12.01, IEEE C57.12.90 and IEEE C57.12.91. *See* 71 FR 24972, 24982 (April 27, 2006). In addition, these IEEE standards, are all referenced standards in NEMA TP 2-2005. Therefore, even though the DOE test procedure is based on NEMA TP 2-1998 and NEMA TP 2-2005, because the DOE test procedure also follows the appropriate IEEE standards, DOE finds that the current stand-alone test procedure is still appropriate.

2. Updates to IEEE Standards

As discussed previously in this section, the DOE test procedure mirrors four widely used IEEE industry standards.[8] . IEEE develops and maintains a large number of standards for a broad range of electrical, electronic, and communications equipment and protocols. Since the April 2006 TP final rule, all of the four IEEE standards have been updated. The latest versions of the IEEE standards include IEEE C57.12.90-2015, IEEE C57.12.91-2011, IEEE C57.12.00-2015, and IEEE C57.12.01-2015. Table III.2 provides a list of old and new versions of each of these IEEE standards.

[8] The distribution transformers industry refers to these documents as "standards" because they reflect standardized, consensus-based methods of designing, constructing, naming, rating, and measuring performance of distribution transformers. This use of the term "standards" contrasts with that of DOE's Appliance Standards Program use of the term "standards" to refer to a minimum energy efficiency (or maximum energy consumption) requirement. These IEEE standards do not contain minimal energy thresholds or requirements.

Table III.2 IEEE Industry Standards Versions and Summary

IEEE Standard	Old Version (Year)	New Version (Year)	Content
C57.12.00	2000	2015	General electrical and mechanical requirements for liquid-immersed distribution transformers.
C57.12.01	1998	2015	General electrical and mechanical requirements for dry-type distribution transformers.
C57.12.90	1999	2015	Methods for performing tests specified in C57.12.00 and others for liquid-immersed distribution transformers.
C57.12.91	2001	2011	Methods for performing tests specified in C57.12.01 and others for dry-type distribution transformers.

DOE reviewed the updated IEEE standards to determine whether any of the updates should be incorporated into the DOE test procedure. The four IEEE standards are not relevant to the DOE test procedure in their entirety, as they include specifications and test methods beyond those required to measure efficiency, such as test methods for polarity, phase-relation, dielectric, and audible sound-level. These industry standards do not contain minimum energy efficiency (or maximum energy consumption) requirements. DOE performed the review as follows: (1) DOE identified the sections of the IEEE industry standards that form the basis of the DOE test procedure, (2) DOE compared those sections between the old and new versions of the IEEE industry standards, and (3) DOE determined which of the changes were editorial versus which could be improvements to the DOE test procedure.

The IEEE C57.12.00 and IEEE C57.12.01 standards include general electrical and mechanical requirements and specify test methods for liquid-immersed and dry-type distribution transformers, by referring to the test methods in IEEE C57.12.90 and IEEE C57.12.91, respectively. Sections 5, 8, and 9 of IEEE C57.12.90-2015 and IEEE C57.12.91-2011 provide the resistance measurements, the no-load loss test, and the load loss test, respectively, which

provide the basis for the DOE test procedure. In general, DOE did not find major changes in sections 5, 8, and 9 between IEEE C57.12.90-2015 and IEEE C57.12.91-2011, and IEEE C57.12.90-1999 and IEEE C57.12.91-2001, respectively. DOE did identify certain updates that would provide supplemental detail to the current DOE test procedure and that reflect current industry practice in conducting the test procedure. Therefore, the adoption of these updates would further improve the DOE test procedure consistent with industry practice. Table III.3 summarizes the proposed updates.

Table III.3 Proposed Updates Based on IEEE Standards

Topic	Proposed Update Based on IEEE Standards
Consolidating the Terms "Oil," "Transformer Liquid," and "Insulating Liquid"	Replace the term "oil" and "transformer liquid" with "insulating liquid" in 10 CFR 431.192 and appendix A to reflect that the term is inclusive of all insulating liquids, including those identified in IEEE C57.12.90-2015.
Stability Requirement for Resistance Measurement	Specify, consistent with IEEE C57.12.90-2015, that resistance measurements are considered stable if the top insulating liquid temperature does not vary more than 2 ºC in a one-hour period. (Appendix A, section 3.2.1.2(b))
Automatic Recording of Data	Require automatic recording of data, as required in IEEE C57.12.90-2015 and IEEE C57.12.91-2011, using a digital data acquisition system. (Appendix A, section 4.4.2(b))
Temperature Test System Accuracy	Relax the temperature test system accuracy requirements to be within ±1.5 °C for liquid-immersed distribution transformers, and ±2.0 °C for MVDT and LVDT distribution transformers, as specified in IEEE C57.12.00-2015 and IEEE C57.12.01-2015, respectively. (Appendix A, section 2.0)
Limits for Voltmeter-Ammeter Method	Permit use of the voltmeter-ammeter method when the rated current of the winding is less than or equal to 1 A. Neither IEEE C57.12.90-2015 nor IEEE C57.12.90-2011 restrict usage of this method to certain current ranges. (Appendix A, section 3.3.2(a))
Number of Readings Required for Resistance Measurement	Include the requirement that a minimum of four readings for current and voltage must be used for each resistance measurement, as specified in IEEE C57.12.90-2015. (Appendix A, section 3.3.2(b))
Connection Locations for Resistance Measurements	Add resistance measurement specifications for single-phase windings, wye windings and delta windings, as provided in section 5.4.1 and 5.4.2 of IEEE C57.12.90-2015, and sections 5.6.1 through 5.6.3 of IEEE C57.12.91-2011. (Appendix A, section 3.4.1(g)-(i))
Test Frequency	Require that all testing under the DOE test procedure is to occur only at 60 Hz. (Appendix A, sections 3.1(c), 4.1)
Polarity of Core Magnetization	Require that the polarity of the core magnetization be kept constant during all resistance readings. (Appendix A, section 3.4.1(f))

The proposed updates listed in Table III.2 align with an industry-consensus standard, and therefore, would not increase testing burden because the industry-consensus standard reflects current testing practice. IEEE standards are voluntarily developed by industry with input from a range of stakeholders and are based on industry experience. The industry standards represent the industry's own position on what is the best approach to distribution transformer testing. Additionally, industry uses IEEE test procedures. For example, DOE found that municipal distribution transformer procurement contracts almost always require the transformer be tested in accordance with IEEE standards. Furthermore, several manufacturer catalogs also indicate that distribution transformers are tested in accordance with the pertinent IEEE standards.

The proposals listed in Table III.2 provide additional detail and direction to the current test procedures. The proposed updates requiring new or additional test requirements would not contradict the current DOE test requirements, were they to be made final. As discussed, these proposed clarifications reflecting the industry standards are already industry practice. As such, the proposals, if made final, would not change current measured values. Furthermore, providing additional specificity would improve the repeatability of the test procedure.

DOE requests comment on the proposed updates based on the latest version of the applicable IEEE standards for testing distribution transformers, and specifically regarding whether industry is already testing to the requirements of those IEEE standards.

DOE requests comment on the tentative determination that each of the proposals do not increase test cost or burden, and that they would not result in different measured values than the current test procedure.

E. Per-Unit Load Testing Requirements

Per-unit load (PUL) is the actual power supplied by a distribution transformer, divided by the distribution transformer's rated capacity. As discussed, it is also referred to as "percent load," "percent of nameplate-rated load," "percent of the rated load," or "per unit load level" in 10 CFR 431.192, 10 CFR 431.196, and appendix A. In this NOPR, all instances are referred to as per-unit load, or PUL.

The efficiency of a distribution transformer varies depending on the PUL at which it is operating. However, the measurements obtained by testing a distribution transformer at one PUL can be used to mathematically determine the efficiency of the transformer at other PULs. For certifying compliance with the energy conservation standards, the efficiency is determined at a PUL of 50 percent for liquid-immersed transformers and MVDT distribution transformers, and a PUL of 35 percent for LVDT distribution transformers. 10 CFR 431.196 and appendix A. The PUL at which the efficiency of a distribution transformer is evaluated for compliance with the applicable energy conservation standard is generally referred to as the "test PUL." The test procedure, however, does not require testing of the distribution transformer while operating at the test PUL. Section 5.1 of appendix A provides equations to calculate the efficiency of a distribution transformer at any PUL based on the testing of the distribution transformer at a single PUL. Current industry practice is to test at 100 percent PUL and mathematically determine the efficiency at the applicable test PUL.

The test PUL is intended to represent the typical PUL experienced by in-service distribution transformers. However, some complications exist, including: (1) a given customer may not operate the transformer at a single constant PUL, and (2) a transformer model may be used at different PULs by different customers. In the September 2017 TP RFI, DOE requested comments and sought information on whether the test PUL accurately represents in-service distribution transformer performance, and provides test results that reflect energy efficiency, energy use, and estimated operating costs during a representative average use cycle of an in-service transformer. 82 FR 44347, 44350 (September 22, 2017).

In addition, so that the test procedure could better reflect how distribution transformers operate in service, DOE stated in the September 2017 TP RFI that it may consider: (1) revising the single test PUL to a multiple-PUL weighted-average efficiency metric, (2) revising the single test PUL to an alternative single test PUL metric that better represents in-service PUL, or (3) maintaining current single test PUL specifications. DOE received several comments on this topic, in addition to potential other metrics for energy conservation standards. 82 FR 44347, 44350 (September 22, 2017)

DOE received a number of comments stating that in-service PUL is diverse. (HVOLT, No. 3 at p. 16, Powersmiths, No. 11 at p. 1, NRECA, No. 22 at p. 2, NEMA, No. 14 at p. 2, EEI, No. 16 at p. 2, Howard Industries, No. 24 at p. 1) HVOLT stated that transformers are generally purchased in bulk and largely placed in stock to be applied as needed, and therefore, the same transformer may be placed in a light loaded or heavy loaded application. (HVOLT, No. 3 at p. 21) AK Steel commented that transformers of the same design operate at many different PULs,

and when transformers are operated at higher PULs, the load loss will far exceed the no-load losses. (AK Steel, No. 6 at p. 1) NRECA commented that transformers have different efficiencies at different PULs, and PULs can change over the lifetime of a transformer. (NRECA, No. 22 at p. 2)

Several stakeholders also submitted information showing how observed in-service PULs are different than what was presented by DOE in the September 2017 TP RFI. 82 FR 44347, 44350 (September 22, 2017). Suresh supported re-assessing the current test PUL requirements to achieve the benefits of improved efficiency at optimum cost. (Suresh, No. 9 at p. 1) HVOLT commented that PUL data from loading studies show light average loads in rural settings and loads greater than 70 percent in some urban settings and for some commercial and industrial customers. (HVOLT, No. 3 at p. 16) Summary system load information provided by HVOLT, and referenced by EEI, of some of California's Pacific Gas and Electric (PG&E) regional commercial, industrial, and residential customers show diversity of annual and peak load factors as a function of what DOE assumes is system capacity. HVOLT also stated that American Electric Power (AEP) and PECO customer loads are also similarly diverse. (HVOLT, No. 3 at p. 16; EEI, No. 16 at p. 2) Metglas stated that PULs of 20 percent to 30 percent are typical of residential distribution transformers, as reported by APPA and NRECA in a February 2015 letter to the U.S. Environmental Protection Agency (EPA). (Metglas, No. 17 at p. 4) Howard Industries stated that it provides liquid-immersed units to rural electrical cooperatives with very light loading and heavy industrial customers with extremely high loading. (Howard Industries, No. 24 at p. 1)

Regarding the representativeness of the California data, EEI reasoned that it is likely that the annual load factors of transformers serving residential customers in California will be lower than the load factors of transformers serving homes in other parts of the United States due to the state's utility electric efficiency programs and building energy codes. EEI also indicated that the PG&E data is from 2006, and therefore does not account for the significant rise in the number of plug-in electric vehicles, which could further increase load factors. (EEI, No. 16 at pp. 2 − 3)

NEMA commented that it believes that the previous DOE distribution transformer rulemaking's investigations in typical field loading practices remain relevant and as accurate as is possible given the high variations in field conditions.[9,10,11] Additionally, NEMA mentioned certain IEEE studies that indicate that particular utilities practice very high loading levels, but that EPA's ENERGY STAR consideration for liquid-immersed distribution transformers showed several utilities lightly load their transformers, which happens mostly in rural electric markets. (NEMA, No. 14 at p. 2) APPA and NRECA stated that a "one-size-fits-all" energy conservation standard based on a single test PUL has restricted availability of the most cost-effective and energy efficient options. Further, APPA and NRECA stated that it is not possible to develop an energy conservation standard and test procedure that take into account the varied loading on a transformer (both from location to location, and on an hourly and seasonal basis). APPA and

[9] The result of DOE's distribution transformer load analysis for medium-voltage liquid-immersed distribution transformers are contained in the Life-cycle Cost and Payback Period spreadsheet tools for design lines (DL) 1 through 5 on the Forecast Cells tab. (available at: *https://www.regulations.gov/document?D=EERE-2010-BT-STD-0048-0767)*

[10] The result of DOE's transformer load analysis for LVDT distribution transformers are contained in the Life-cycle Cost and Payback Period spreadsheet tools for DLs 6 through 8 on the Forecast Cells tab. (available at: *https://www.regulations.gov/document?D=EERE-2011-BT-STD-0051-0085*)

[11] The result of DOE's transformer load analysis for MVDT distribution transformers are contained in the Life-cycle Cost and Payback Period spreadsheet tools for DL 9 through 13B on the Forecast Cells tab. (available at: *https://www.regulations.gov/document?D=EERE-2010-BT-STD-0048-0764*)

NRECA requested that DOE refrain from any future action with test procedures or energy conservation standards, stating that there would only be a burden (no benefit) associated with those changes. (APPA, No. 24 at p. 2; NRECA, No. 22 at p. 3)

DOE appreciates the data and information it received on the topic of in-service PULs. The data and comments received are consistent with DOE's understanding that the in-service PULs sustained by transformers are very diverse. This diversity of PUL is because the application of distribution transformers is itself diverse, ranging from light-loading to heavy-loading applications. DOE recognizes that the wide range of in-service conditions that transformers sustain means that the efficiency at the test PUL may not reflect the efficiency of any given transformer at its in-service PUL. The information supplied by stakeholders was either largely anecdotal, or limited utility customer meter data from which transformer loads may be inferred as a proxy. Both anecdotal and utility customer meter data are useful as they frame generally expected loading limits. Additionally, the customer load data contains detailed loading characteristics for small, specific populations. However, DOE notes that both are of limited representativeness. Given these factors, DOE finds the information available at this time for describing in-service PUL to be inconclusive, leaving DOE unable to demonstrate that an alternate test PUL is more representative than the existing test PUL.

1. Multiple-PUL Weighted-Average Efficiency Metric

In the September 2017 TP RFI, DOE stated it would consider a multiple-PUL efficiency metric because the use of a weighted-average efficiency metric comprised of efficiency at more than one test PUL may better reflect how distribution transformers operate in service, as

described in this document. As such, DOE requested data and information to inform a multiple-PUL metric. 82 FR 44347, 44350 (September 22, 2017).

The majority of stakeholders commented that including a multiple-PUL weighted-average efficiency metric would be overly burdensome on manufacturers. (HVOLT, No. 3 at p. 24; AK Steel, No. 6 at p. 2; Powersmiths, No. 11 at p. 2; Prolec-GE, No. 23 at p. 1-2; Howard Industries, No. 24 at p. 1) Specifically, Powersmiths commented that it would increase test burden, be difficult to agree on appropriate test PULs to include, present a consumer education challenge, and disadvantage small business manufacturers. (Powersmiths, No. 11 at p. 2) Prolec-GE stated that a multiple-PUL weighted-average efficiency metric would result in suboptimal, higher-cost designs. (Prolec-GE, No. 23 at p. 3) Howard Industries stated that no additional constraints or alternate metrics should be included because it will be too burdensome and costly. (Howard Industries, No. 24 at p. 2)

NEMA stated that physical testing at multiple PULs would result in significant technical challenges to keep winding temperatures managed under test conditions, adding significant complexity to the test procedures and introducing new sources for variation. NEMA stated that these conditions would be unavoidable and their impacts on testing would serve to further increase differences between test results and actual in-service conditions. Because of these challenges, NEMA asserted that testing at one load point is the most feasible method. (NEMA, No. 14 at p. 5) NEMA commented that currently, transformers are physically tested at 100 percent PUL and follow-on test points are calculated, and that this practice should be maintained. NEMA stated that the existing method is well-proven and well-understood by NEMA members

and other stakeholders in the transformer industry as the best system to evaluate transformer performance. (NEMA, No. 14 at p. 5) NEMA also stated that using weighted-average loading in the application of energy conservation standards without consideration of how it affects measured efficiency values could be misleading. Adding a weighted-average formula requirement could also deny a customer who is certain of their field loading level from buying the most efficient transformer for their application. NEMA further commented that the current test PUL requirements allow for sufficient flexibility in field purchasing decisions today. (NEMA, No. 14 at p. 5)

ACEEE & ASAP commented that DOE should consider the benefits of ratings based on a weighted average of multiple load points, where weightings are based on expected hours of operation within bands around each load point. ACEEE & ASAP provided as an example, ratings based on the average load point (about 40 percent), and the 25^{th} and 75^{th} percentile load points (about 30 percent and 50 percent respectively), which they stated may improve representativeness and foster improved efficiency in the field. ACEEE & ASAP commented that in no case should DOE base ratings on extreme load conditions rarely seen in the field. They also commented that they understand AEDMs to be technically capable of supplying ratings at any load point and, therefore, that manufacturers should be able to certify to weighted-average ratings at very low additional costs. (ACEEE & ASAP, No. 15 at p. 3)

DOE appreciates the comments received regarding the multiple-PUL weighted-average efficiency metric. Based on comments received, DOE has tentatively determined that the range of in-service PULs is large, and varies depending on the application and location of distribution

transformers. DOE recognizes that depending on the procedure for measuring and calculating the efficiency based on multiple test PULs, a change of metric may increase the current test burden, due to the need to re-test and re-certify performance to DOE.[12] In addition, consumers would need to be educated on how to interpret the new metric, which would not correspond to performance at any one test PUL, but would be based on multiple operating conditions. Lastly, available data describing this PUL variation is largely anecdotal and insufficient to show that a multiple-PUL weighted-average efficiency metric is more representative of in-service PUL than the existing metric. Specifically, a lack of information is available to determine which PULs would be appropriate as part of a multiple-PUL weighted efficiency metric, and how those PULs should be weighted. Given the drawbacks cited and the lack of evidence at this time to show a weighted-average metric is more representative than the existing metric, DOE is not proposing a multiple-PUL weighted-average efficiency metric.

2. Single-PUL Efficiency Metric

In the September 2017 TP RFI, DOE stated that for a single-PUL efficiency metric, it may consider either continuing to use the current single test PUL requirements, or revising the single test PUL to an alternate single test PUL, if it were to better reflect how distribution transformers operate in service. As such, DOE requested data and information to inform any changes to the metric. 82 FR 44347, 44350 (September 22, 2017).

A number of stakeholders commented in support of both a single-PUL efficiency metric and the existing test PUL requirements specified. (HVOLT, No. 3 at p. 21; Powersmiths, No. 11

[12] Per-unit testing costs could be identical for a multiple-PUL metric versus the existing metric, if performance at each PUL is calculated from a single measurement point (rather than physical measurements at each PUL).

at p. 3; NEMA, No. 14 at p. 2; NRECA, No. 22 at p. 3; Prolec-GE, No. 23 at p. 1; Howard Industries, No. 24 at p. 1) Specifically, Prolec-GE commented that it has not seen evidence warranting a change from the current 50 percent PUL requirement for liquid-immersed transformers. Prolec-GE stated that it is aware that some utilities assumed lower loads, as demonstrated by their Total Owning Cost (ToC)[13, 14] formulas and information presented during the development of the EPA ENERGY STAR program for liquid-filled distribution transformers; however, some are higher, though this is the exception. Prolec-GE stated that utilities do not know in advance where a transformer will be installed, and that they also plan for load growth. Therefore, Prolec-GE concluded that 50 percent PUL is reasonable. (Prolec-GE, No. 23 at p. 1) Howard Industries stated that no additional constraints or alternate metrics should be included because it would be too burdensome and costly. (Howard Industries, No. 24 at p. 2)

ACEEE & ASAP recommended 25 percent PUL for LVDT distribution transformers, 35 percent PUL for MVDT distribution transformers and 40 percent PUL for liquid-immersed distribution transformers, in addition to considering ratings based on a weighted-average PUL. ACEEE & ASAP stated that these values would be more representative, based on data provided in the RFI. (ACEEE & ASAP, No. 15 at p. 3) EEI recommended 75 percent PUL for liquid-immersed distribution transformers, if two single-PUL ratings are not proposed (as discussed in section III.E.1 of this NOPR). (EEI, No. 16 at p. 4) Powersmiths commented that the current

[13] The Total Owning Cost is the cost savings over the lifetime of the product, based on the utility's no-load and load loss evaluation factors. ToC takes into account not only the initial transformer cost, but also the cost to operate and maintain the transformer over its lifetime. The ToC formula is provided in the ENERGY STAR specification for distribution transformers that is currently under development: (*https://www.energystar.gov/products/spec/distribution_transformers_pd*).

[14] U.S. Department of Agriculture and Rural Development, Rural Utility Service (RUS), *Guide for Economic Evaluation of Distribution Transformers*, 2016, Bulletin 1724D-107, *https://www.rd.usda.gov/publications/regulationsguidelines/bulletins/electric*.

DOE test procedure at 35 percent PUL for LVDT distribution transformers does not reflect real world efficiency, and that field measurements showed most of the market either at less than 15 percent PUL or greater than 50 percent PUL. However, given the real-world variability in loading and harmonic content, Powersmiths stated that it would not be practical or economically viable to establish a revised test protocol that would capture all these scenarios, as it would be onerous for the whole industry to follow. (Powersmiths, No. 11 at p. 2)

With respect to test PUL requirements, DOE considered updating the test PUL requirements to an alternative single test PUL if it were to better reflect how distribution transformers operate in service. As discussed in sections III.E and III.E.1, however, DOE has tentatively determined that the range of in-service PULs is large, and that the available information describing in-service PUL is inconclusive, which leaves DOE unable at this time to show that an alternate single test PUL is more representative of in-service PUL than the existing single test PUL. DOE recognizes that a change of metric may increase the current test burden (depending on the procedure for measuring and calculating efficiency at the new test PUL), due to the need to re-test and re-certify performance to DOE. Therefore, given the limitations of the currently available data and lack of a strong indication that an alternate single test PUL would be more representative than the existing single test PUL, DOE is not proposing to amend the test PUL requirements. As such, DOE has tentatively determined to maintain the current single test PUL requirements in appendix A, which require that efficiency must be determined at a single test PUL of 50 percent for both liquid-immersed and MVDT distribution transformers, and that efficiency must be determined at a single test PUL of 35 percent for LVDT distribution transformers.

However, DOE agrees there is value in providing a basis for voluntary representations of additional performance information to foster better-informed decision-making by consumers. Additional performance information at other PULs would allow consumers to maximize transformer efficiency based on their needs. As such, in this NOPR, DOE is proposing a test procedure for voluntary representations at additional PULs and/or reference temperatures, which is discussed further in section III.E.4 of this document.

3. Other Efficiency Metric Recommendations

In addition to the potential use of alternate efficiency metrics on which DOE requested comment in the September 2017 TP RFI, DOE also received other recommendations from stakeholders to take under consideration. AK Steel recommended that DOE implement an efficiency requirement at 100 percent PUL, in addition to the current test requirement. (AK Steel, No. 6 at p. 2) EEI commented that based on factors that could both increase and decrease transformer load, it supported having two PUL tests for liquid-filled transformers: one at the current 50 percent PUL and a second at 75 percent PUL. (EEI, No. 16 at p. 4) Howard Industries stated that no additional constraints or alternate metrics should be included because it will be too burdensome and costly. (Howard Industries, No. 24 at p. 2)

Metglas recommended DOE use the approach considered by EPA's ENERGY STAR program, where EPA proposed to expand the number of PULs that would be optimized to four PULs (25, 35, 50, and 65 percent), in addition to the ToC process.[15] Metglas stated that better

[15] The EPA's ENERGY STAR specification for distribution transformers (version 1.0) is currently under development. The final draft specification was published on December 9, 2016 (*https://www.energystar.gov/products/spec/distribution_transformers_pd*). On September 27, 2017, EPA published

matching the purchased unit's actual operating PUL with optimized PULs for those units could result in significant energy savings. (Metglas, No. 17 at p. 2) Metglas commented that the addition of a 100 percent PUL only reduces the competitiveness of all transformers made with low core-loss material since, to meet the (infrequently observed) 100 percent PUL, all low core-loss material transformers become more expensive rather than being the best economic solution for many actual operating PULs. (Metglas, No. 17 at p. 5) NRECA advocated for the ToC process, similar to the EPA program, which allows individual utilities to select optimal designs for their systems and expected PUL. (NRECA, No. 22 at p. 3)

HVOLT stated that the advent of new low core-loss materials has created the opportunity for transformers with low no-load loss to carry greater load losses and remain compliant; the low core-loss distribution transformers may perform comparatively better than conventional-core distribution transformers at low PULs and comparatively worse at high PULs. (HVOLT, No. 3 at p. 22 − 23) HVOLT recommended that to limit the potential for large load losses in transformers built with low core-loss materials, a constraint on total losses at full load is warranted to ensure that highly loaded transformers remain efficient. *Id.* HVOLT suggested that total losses do not require any new measurements, but would simply be calculated. In addition, HVOLT recommended a limit which it characterized as an additional energy conservation standard, on full load total losses as "limit = $1+1/(0.9\times0.5^2)$ × watts" at 50 percent PUL for medium-voltage distribution transformers and "limit = $1+1/(0.82\times0.35^2)$ × watts" at 35 percent PUL for low-

guidance on buying energy efficient medium-voltage liquid-immersed transformers, which includes recommended energy efficiency criteria at 25 percent, 35 percent, 50 percent and 65 percent PULs, in addition to using the ToC equation: *https://www.energystar.gov/products/avoiding_distribution_transformer_energy_waste*.

voltage distribution transformers. HVOLT stated a generous tolerance could also be applied to that limit. (HVOLT, No. 3 at p. 22)

NEMA, on the other hand, stated that proposals encouraging the restriction of losses at high PULs are based on very simplistic assumptions that do not consider the real-life restrictions a design must meet. NEMA stated that assuming a design can be optimized to have the peak efficiency at the required PUL, and that the load losses can be indefinitely increased through greater use of low core-loss materials like amorphous metal, does not adequately consider other restrictions transformers have in real life; for example, the capacity of the cooling system. (NEMA, No. 14 at p. 5)

To summarize, the recommendations for additional metrics as provided by commenters are: (1) efficiency requirements at 100 percent PUL in addition to current DOE requirements, (2) efficiency requirements at 75 percent PUL in addition to current DOE requirements at 50 percent PUL for liquid-immersed transformers, (3) optimization at 25, 35, 50 and 65 percent PUL, in addition to the ToC process, similar to EPA's ENERGY STAR guidance, and (4) constraint on total losses, in addition to current DOE requirements. The above recommendations address issues beyond the test procedure, *i.e.*, they would result in multiple standards applicable to a single distribution transformer.

DOE also received comments from Powersmiths stating that customers incorrectly understand transformers to operate at the minimum efficiencies required by DOE even at operating conditions that are different than in the DOE test procedure. (Powersmiths, No. 11 at p.

2) Powersmiths commented that the current DOE test procedure should remain, but also require a disclaimer label or associated literature that the efficiency applies only under ideal linear load (*i.e.,* at the DOE test PUL), and that actual efficiency may be lower. (Powersmiths, No. 11 at p. 3) Powersmiths stated that, if manufacturers offer transformers optimized for other PULs, then they should be required to back up their performance claims by clearly defining whatever test protocols are used, supported by audit and by certification to a recognized testing body. (Powersmiths, No. 11 at p. 3)

As discussed in sections III.E.1 and III.E.2 of this document, any changes or additional metrics may increase the current test burden, due to the need to re-test and re-certify performance to DOE. Additionally, consumers would need to be educated on how to interpret any of the new metrics recommended in the comments above. Lastly, DOE lacks sufficient information on in-service PUL to support whether an alternate test PUL or metric would be more representative of field conditions, so as to justify requiring testing at that alternate test PUL. Therefore, DOE finds that proposing a new metric is not justified at this time.

However, to provide manufacturers the opportunity to inform end users of the performance of a distribution transformer at conditions other than those required to demonstrate compliance with the DOE efficiency standard, DOE is proposing to provide explicitly for voluntary representation at additional PULs and reference temperatures. Additional representations would allow customers to better predict how different distribution transformers would operate under the individualized conditions of that customer. Further discussion on this proposal is provided in section III.E.4.

4. Voluntary Representations of Efficiency at Additional PULs

DOE received one comment suggesting that public reporting of additional data would increase consumer information informing purchasing decisions. In response to the September 2017 TP RFI, MKC commented that rather than specify one test point, which is typically at rated voltage and 50 percent load, the test procedure should determine both no-load loss and load loss. MKC stated that the two values can determine the efficiency of the transformer under any loading condition, and that the no-load loss and load loss would be determined by Clause 8 and 9 from IEEE C57.12.90, or a similar test method. (MKC, No. 4 at p. 1)

42 USC 6314(d) prohibits manufacturers from making representations respecting the energy consumption of covered equipment or cost of energy consumed by such equipment, unless that equipment has been tested in accordance with the applicable DOE test procedure and such representations fairly disclose the results of that testing. As discussed, the current DOE test procedure requires that for both liquid-immersed and MVDT distribution transformers, efficiency is determined at a single test PUL of 50 percent, and that for LVDT distribution transformers, efficiency is determined at a single test PUL of 35 percent. Section 3.5 of appendix A. In addition, efficiency must be determined at the reference temperature of 20 °C for no-load loss for all distribution transformers; 55 °C for load loss for liquid-immersed distribution transformers at the required test PUL of 50 percent; 75 °C for load loss for MVDT distribution transformers at the required test PUL of 50 percent; and 75 °C for load loss for LVDT distribution transformers at the required test PUL of 35 percent. 10 CFR 431.192. The DOE test

procedure specifies reference temperature requirements only at the test PULs currently required to comply with the energy conservation standards.

In this NOPR, DOE is proposing amendments to the test procedure to permit manufacturers to make voluntary representations of additional performance information of distribution transformers when operated under conditions other than those required for compliance with the energy conservation standards for distribution transformers at 10 CFR 431.196. The proposal would help consumers make better purchasing decisions based on their specific installation conditions. Therefore, DOE proposes in a new section 7 of appendix A to allow manufacturers to represent efficiency, no-load loss, or load loss at additional PULs and/or reference temperatures, as long as the equipment is also represented in accordance with DOE's test procedure at the mandatory PUL and reference temperature. When making voluntary representations, best practice would be for the manufacturers also to provide the PUL and reference temperature corresponding to those voluntary representations.

Table III.4 provides a summary of the proposal for voluntary representations at any PUL.

Table III.4 Summary of Voluntary Representation Proposal

	Mandatory Certified Values*			Voluntary Representations (Proposed)		
	Metric	PUL (percent)	Reference Temperature for load loss (°C)	Metric	PUL (percent)	Reference Temperature (°C)
Liquid Immersed	Efficiency	50	55	Efficiency, load loss, no load loss	Any	Any
MVDT		50	75			
LVDT		35	75			

* Efficiency must be determined at a reference temperature of 20 °C for no-load loss for all distribution transformers.

DOE requests comment on the proposal to amend the DOE test procedure to permit manufacturers to make voluntary representations at any additional PUL and/or reference temperature, and whether this would assist consumers in making better purchasing decisions based on their specific installation conditions. DOE requests comment on whether the current DOE test procedure would be appropriate at non-mandatory PULs and reference temperatures.

F. Purchasing Decision

While a customer can specify that transformer efficiency be optimized to their in-service PUL, the transformer must also comply with the energy conservation standard at the test PUL. The lowest-cost transformer design would likely have an efficiency peak at or near the test PUL, and that the low-cost transformers would experience reduced efficiency when operated at PULs other than the test PUL. Therefore, considering there may be variation between the test PUL specified in the test procedure and actual in-service use, DOE requested comment on the extent to which efficiency is considered for transformer purchasing decisions.

DOE received several comments from stakeholders indicating that first cost is the primary driver for purchasing decisions. HVOLT commented that efficiency is only considered for simple verification that the transformer is DOE-compliant. Beyond that, HVOLT asserted, purchase decisions are mostly made on price, delivery and other user specifications. (HVOLT, No. 3 at p. 17) AK Steel stated that it has consistently seen that when purchasing transformers, first cost, including transformer cost plus installation, is the primary driver in purchasing decisions. (AK Steel, No. 6 at p. 2)

In addition, DOE received several comments stating that most manufacturers and customers ensure only that transformers are DOE compliant when considering efficiency. Specifically, AK Steel, which produces electrical steel used in distribution transformers, stated that performance exceeding the DOE energy conservation standard is not a consideration when AK Steel prices its electrical steel. (AK Steel, No. 6 at p. 2) AK Steel commented that transformer efficiency at current test PULs have little influence on transformer efficiency at higher PULs, which AK Steel states is especially apparent when lower-cost, less-efficient windings are used. AK Steel asserts that as a result, users will purchase DOE-compliant transformers that have significantly lower efficiency than more appropriately designed units for in-service PULs. (AK Steel, No. 6 at p. 1)

Metglas, which also produces electrical steel used in distribution transformers, suggests that by allowing those purchasing distribution transformers the opportunity to better match projected operating conditions with transformers better optimized for those conditions that significant energy saving could be realized. (Metglas, No. 17 at p. 2) Powersmiths recognized DOE's identification of the business opportunity for transformer manufacturers to produce application-specific optimization that can realize low transformer lifecycle cost to customers, but stated that this opportunity has been ignored by manufacturers. (Powersmiths, No. 11 at p. 2) NEMA stated that some utility customers who know their anticipated loading do seek information from their transformer supplier about whether a transformer can be designed to meet best efficiency at that PUL. (NEMA, No. 14 at p. 3)

However, Powersmiths stated that despite smaller manufacturers having more flexibility to provide application-specific models that deliver increased efficiency in each targeted application, these manufacturers do not typically offer additional choices beyond what is required by the DOE test procedure. Additionally, having a multitude of models optimized for different applications is not compatible with the low cost, high volume manufacturing and distribution model, which drives the fewest product configurations. (Powersmiths, No. 11 at pgs. 2−3) Powersmiths further commented that manufacturers design their transformers with peak efficiency at the single DOE test PUL to the detriment of all other operating conditions, such that they are the lowest cost supplier in the competitive market. (Powersmiths, No. 11 at p. 2) Prolec-GE similarly stated that it does not see benefit in representing efficiency at a level higher than the DOE minimum, because most customers only want assurance that the transformer is compliant. (Prolec-GE, No. 23 at p. 5) NEMA further stated that while a transformer can be designed to be optimized for PULs other that DOE's test PUL, it must also meet the current DOE efficiency standard, and the two are not necessarily the same, and in many cases, the two efficiency points cannot be reconciled in a feasible design and manageable cost. (NEMA, No. 14 at p. 3)

DOE also received several other comments regarding other ways customers evaluate their purchasing decisions. NEMA stated that members in liquid-filled product categories seek specifications from customers which include ToC as a way of addressing efficiency in the purchasing decision process. However, NEMA stated that ToC does not guarantee that the resulting design will exceed the current DOE efficiency levels by any appreciable margin. NEMA commented that the NEMA dry-type manufacturers rarely experience ToC requests.

NEMA stated that there is a niche market for high efficiency LVDT distribution transformers, but the size of the market is unknown to NEMA members. For MVDT distribution transformers, NEMA stated that efficiency does not appear to be a significant consideration; price and delivery remain top considerations. (NEMA, No. 14 at p. 3) Prolec-GE stated that 30 to 40 percent of its customers (mostly in rural utility service and rural electric cooperative markets) evaluate, and half end up buying the best ToC choice. (Prolec-GE, No. 23 at p. 2) Prolec-GE further stated meeting the DOE standard at 50 percent PUL and customer ToC formula can be challenging without pushing first cost too high. (Prolec-GE, No. 23 at p. 2) Howard Industries commented that approximately 50 percent of its utility customers are still using the ToC approach when purchasing liquid-immersed transformers. (Howard Industries, No. 24 at p. 1)

DOE acknowledges that many transformers are designed such that their efficiency peaks at the DOE test PULs, which will allow for the lowest costs. DOE also acknowledges that some transformers are optimized at PULs other than those required by DOE's test procedure. DOE also notes that customers use several different methods to determine the appropriate distribution transformers for their application, including the ToC method. DOE's requirements do not restrict the use of any of the purchasing decision methods, as long as both the test procedure and standards requirements are met.

As described previously in section III.E.4 of this NOPR, in an effort to provide manufacturers greater opportunity to describe equipment performance at additional PULs, DOE is proposing amendments to the DOE test procedure that would allow manufacturers to make voluntary representations at additional PULs and reference temperatures, using the DOE test

procedure. Manufacturers would still be required to comply with the current energy conservation standards requirements but would be allowed to voluntarily represent their equipment at a variety of PUL conditions. This information could be used by consumers to make better informed purchasing decisions based on their specific installation conditions.

G. Load Growth

In the September 2017 TP RFI, DOE discussed estimates for the load growth of distribution transformers used in the April 2013 ECS final rule. 82 FR 33437, 44349. These estimates contribute to the description of typical loading experienced by a distribution transformer in-service. DOE estimated a one percent annual increase over the life of the transformer to account for connected load growth for liquid-immersed transformers, and no load growth over the life of LVDT and MVDT distribution transformers. DOE requested comments regarding the load growth estimate over the life of distribution transformers currently being installed, and how that could inform test requirements in the DOE test procedure. *Id.*

DOE received several comments on this topic. HVOLT stated that it does not have any hard data on the load growth estimate over the life of the distribution transformer. HVOLT commented that utilities are generally focused on peak power demand, as non-peak loading does little to affect distribution system design needs, and that load growth normally results from new customers or loads being added to existing circuits. In addition, HVOLT stated that the expanded electrification of motor vehicles and new commercial and industrial processes are likely to increase the load on MVDT distribution transformers. On the other hand, HVOLT commented

that the loads on LVDT distribution transformers may be relatively constant. (HVOLT, No. 13 at p. 17)

ACEEE & ASAP commented that a 0.5 percent growth rate is consistent with the EIA's Annual Energy Outlook 2017 projected load growth of 0.56 percent per year in its reference case. (ACEEE & ASAP, No. 15 at p. 2) EEI commented that it believes the overall trends in load could be increasing over time given some of the significant changes occurring in the electricity industry. Specifically, the trends include the deployment of Smart Grid technologies, the increased variability of distributed and renewable energy sources at different times of day in renewable distributed generation systems, increased deployment of electric transportation options, and the increased electrification of industrial and other operations; and asks that any change in the test procedure account for these changes. (EEI, No. 16 at p. 3) NRECA stated that it is not possible to tell if load factors over the lifetime of transformers will decrease due to energy efficiency or greatly increase due to penetration of electric vehicles and other distributed energy resources. (NRECA, No. 22 at p. 2)

DOE appreciates the comments and opinions submitted on the topic of load growth sustained by in-service transformers. As commenters noted, a number of trends and factors may impact the load growth realized by distribution transformers and that some of these trends would have opposing impacts (*e.g.*, improvements in efficiencies versus the increased penetration of electric vehicles). At the present, DOE does not have sufficient data to propose changing the current test procedure to account for transformer load growth. However, DOE will continue to

examine trends in transformer load growth and may address the issue as necessary and feasible in any future rulemaking.

H. Temperature Correction

DOE's current test procedure specifies temperature correction of measured loss values, a process that calculates the losses of a transformer as though its internal temperature during testing were equal to a "reference" temperature. The reference temperature provides a common point of comparison, so that the effect of temperature on efficiency is diminished. If transformers in service do not reach the same internal temperature (under identical operating conditions, including ambient temperature and PUL), temperature correction may weaken the ability of the test procedure to predict relative in-service performance. In the September 2017 TP RFI, DOE requested comments, data and information on whether the current temperature correction is appropriate or whether alternative approaches should be considered. 82 FR 44347, 44350 (September 22, 2017) DOE received several comments on the September 2017 TP RFI regarding this topic. All supported maintaining the current requirements.

Several comments directly supported the current method of temperature correction. Howard Industries stated that the current method for temperature correction is appropriate and applicable. (Howard, No. 24 at p. 1) NEMA commented that the temperature conditions may vary greatly during operation, and that use of a common reference temperature allows the DOE test procedure to fairly compare different products. (NEMA, No. 14 at p. 4) Accordingly, NEMA suggested that the current test procedure requirements for temperature correction are adequate. NEMA also stated that internal temperature of a transformer is driven by both electrical losses

and cooling ability. Cooling ability changes as a function of ambient temperature, which may vary widely even for a single design. In addition, cooling ability is closely coupled with design features that also affect many other electrical and mechanical characteristics of the unit. NEMA stated that as a result, developing a characteristic relationship between operating temperature and PUL is quite difficult. NEMA stated that maintaining the 75 °C reference temperature provides consistency and is the best approach given the uncertainty [in true operating temperature]. (NEMA, No. 14 at p. 4) NEMA further commented that any change in requirements would cause performance data across current and future designs to become noncomparable. (NEMA, No. 14 at p. 4) NEMA also commented that modifications to the existing internal temperature correction methodology and test PUL requirement, which would require adjustment to temperature correction requirements, would cause manufacturers significant burden. (NEMA, No. 14 at p. 4)

Other comments concurred with the general concept of temperature correction. HVOLT stated that temperature generally rises with load current to the 1.6 power under steady state conditions. (HVOLT, No. 3 at p. 19) HVOLT further stated that temperature correction is not of significant concern, because even when it is performed, the true temperature of tested transformers is accurately measured and recorded. (HVOLT, No. 3 at p. 19) Howard Industries commented that temperature will rise with increasing PUL; winding rises are generally designed to meet 65 °C rise at full load. (Howard Industries, No. 24 at p. 1)

After further consideration, including the comments received, DOE is not proposing changes to the current temperature correction requirements. In response to NEMA's comment that transformer operating temperature is a function of heat buildup, ambient conditions, and

transformer cooling design, DOE observes that, while it is true that no single reference temperature could represent all operating conditions, it may be possible to develop a methodology that accounts for heat buildup and transformer cooling design. DOE may explore the possibility in a future notice.

I. Multiple Voltage Capability

Some distribution transformers have primary windings ("primaries") and secondary windings ("secondaries") that may each be reconfigured, for example either in series or in parallel, to accommodate multiple voltages. Some configurations may be more efficient than others. Such transformers are often purchased with the intent of upgrading the local power grid to a higher operating voltage and thereby reducing overall system losses.

Section 4.5.1(b) of appendix A requires that for a transformer that has a configuration of windings that allows for more than one nominal rated voltage, the load losses must be determined either in the winding configuration in which the highest losses occur, or in each winding configuration in which the transformer can operate. Similarly, section 5.0 of appendix A states that for a transformer that has a configuration of windings that allows for more than one nominal rated voltage, its efficiency must be determined either at the voltage at which the highest losses occur, or at each voltage at which the transformer is rated to operate. Under either testing and rating option (*i.e.,* testing only the highest loss configuration, or testing all configurations), the winding configuration that produces the highest losses must be tested and consequently must comply with the applicable energy conservation standard.

Whereas IEEE directs distribution transformers to be shipped with the windings in series,[16] a manufacturer physically testing for DOE compliance may need to disassemble the unit, reconfigure the windings to test the configuration that produces the highest losses, test the unit, then reassemble the unit in its original configuration, which adds time and expense.

NEMA stated that the majority of distribution transformers are used in service in the highest-voltage configuration and that some transformers will have slightly higher losses in the lowest-voltage configuration. NEMA stated that, based on its calculations, the difference in load loss between the as-shipped version as compared to the highest loss configuration is no more than two percent. NEMA further asserts that the difference in testing as-shipped versus highest-loss configuration has minimal impact in determining the numerical value of efficiency, and that the difference is smaller than the error introduced by the DOE formula for scaling load loss to the specified test PUL. (NEMA, No. 14 at p. 6) Prolec-GE commented that switching to as-shipped voltage configuration would improve reliability and reproducibility because it would facilitate more physical testing of transformers, and would improve representativeness because it would better align with performance experienced by users. (Prolec-GE, No. 23 at p. 4) Prolec-GE also stated that it uses an AEDM and supports its continued allowance because reconfiguring transformers from the as-shipped winding configuration would be quite costly. (Prolec-GE, No. 23 at p. 4) Both Prolec-GE and NEMA suggested that DOE should harmonize with industry

[16] Institute of Electrical and Electronics Engineers, Inc (IEEE); *IEEE Standard General Requirements for Liquid-Immersed Distribution, Power, and Regulating Transformers,* 2017, IEEE Standard C57.12.00-2015, *https://standards.ieee.org/findstds/standard/C57.12.00-2015.html*

standards and practices by permitting testing in the as-shipped winding configuration. (Prolec-GE, No. 23 at p. 6, NEMA, No. 14 at p. 6)

DOE recognizes that, for manufacturers physically testing their transformers, reporting losses in the same configuration in which the transformers are shipped, which IEEE instructs to be the in-series configuration, may be less burdensome than requiring testing in the configuration that produces the highest losses.[17] DOE notes, however, that neither Prolec-GE nor NEMA provided transformer design data to support their claim that the difference in losses would be minimal when comparing between transformers rated "as-shipped" versus the current requirement that transformers be rated in their highest loss configuration. Conversely, the losses of different winding positions can vary considerably and, as a result, no single winding configuration will always yield the greatest loss (or lowest efficiency) for all distribution transformers. Manufacturers may decide to test in multiple or all configurations to find the highest loss configuration. DOE remains concerned that there is no reliable way to predict in which winding configuration a transformer will be operated over the majority of its lifetime.

Furthermore, as an alternative to physical testing, DOE provides for certification using an AEDM, which is a mathematical model based on the transformer design. 10 CFR 429.47. The shipped configuration has no bearing on the AEDM calculation, and an AEDM can determine the highest-loss configuration instantly. The current requirement to test and certify based on the highest-loss configuration of the windings confers a consumer benefit by ensuring the consumer

[17] *Ibid.*

receives at least the tested level of performance. 71 FR 24972, 24985 (April 27, 2006). DOE notes that most transformers are currently certified using the AEDM.

Further, changing the requirement of testing in the configuration from producing the highest losses to "as-shipped", may increase the calculated efficiency, changing the basis upon which existing energy conservation standards were established. The losses between different winding configurations can be significant, and to avoid potential backsliding DOE would need to amend its energy conservation standard to account for testing in a different configuration.[18] This could also necessitate the need for manufacturers of transformers with multiple windings to re-test and re-certify their performance to DOE.

Based on these considerations, DOE is not proposing to amend the requirement relating to winding configuration.

DOE requests comment on secondary winding configurations. DOE also requests comment on the magnitude of the additional losses associated with the less efficient configurations as well as the relative period of operation in each winding configuration.

[18] EPCA contains what is known as an "anti-backsliding" provision, which prevents the Secretary from prescribing any amended standard that either increases the maximum allowable energy use or decreases the minimum required energy efficiency of a covered equipment. (42 U.S.C. 6295(o)(1); 42 U.S.C 6316(a))

J. Other Test Procedure Topics

In addition to the proposed updates to the DOE test procedure provided in the preceding sections, DOE also considered whether the existing test procedure would benefit from any further revisions and/or reorganizing. Additional issues are discussed in the following section.

1. Per-unit Load Specification

DOE proposes to centralize the PUL specifications, both for the certification to energy conservation standards and for use with a voluntary representation. Currently, the PUL for certification to energy conservation standards is specified in multiple locations, including 10 CFR 431.192 (definition of reference temperature), 10 CFR 431.196, section 3.5(a) of appendix A, and section 5.1 of appendix A. DOE proposes to consolidate the PUL specification into one location – a newly proposed section 2.1 of appendix A. Additionally, DOE proposes to provide in the proposed section 2.1 of appendix A that the PUL specification can be any value for purposes of voluntary representations. The consolidation would enhance readability of the test procedure and more clearly communicate DOE's PUL requirements with respect to certification to energy conservation standards and voluntary representations. The updates do not change existing test PUL requirements with respect to certification to energy conservation standards. Instead, the updates improve clarity with respect to selection of PUL for voluntary representations versus certification to energy conservation standards.

DOE also proposes editorial changes to section 5.1 of appendix A to support the consolidated approach to PUL specification. Section 5.1 contains equations used to calculate load-losses at any PUL. Section 5.1 of appendix A uses language that limits its applicability to

certification to energy conservation standards only. For example, it references the "specified energy efficiency load level" (*i.e.*, the PUL required for certification to energy conservation standards) specifically. DOE proposes to generalize the language in this section to reference the PUL selected in the proposed section 2.1.

2. Reference Temperature Specification

Similar to PUL, DOE proposes to consolidate the reference temperature specifications for certification to energy conservation standards and for the proposed voluntary representations. Currently, the reference temperature for certification to energy conservation standards is described in multiple locations, including 10 CFR 431.192 (definition of reference temperature), section 3.5(a) of appendix A, and section 4.4.3.3 of appendix A. DOE proposes to consolidate the reference temperature specification into one location – a newly proposed section 2.2 of appendix A. Additionally, DOE proposes to describe in the proposed section 2.2 of appendix A that the reference temperature specification can be any value for purposes of voluntary representations. Similar to PUL, this consolidation would enhance readability of the test procedure and more clearly communicate DOE's reference temperature requirements with respect to certification to energy conservation standards or voluntary representations. The updates do not change existing reference temperature requirements with respect to certification to energy conservation standards. Instead, the updates improve clarity with respect to selection of reference temperature for voluntary representations versus certification to energy conservation standards.

DOE also proposes editorial changes to section 3.5 and section 4.4.3.3 of appendix A to support the consolidated approach to reference temperature specification. Section 3.5 of

appendix A provides reference temperatures for certification to energy conservation standards. However, considering DOE has consolidated reference temperature specifications into one location (proposed section 2.2), DOE has removed the same specification in section 3.5 so that the section could be applicable to determine voluntary representations.

Section 4.4.3.3 of appendix A provides the specifications and equations used for correcting no-load loss to the reference temperature. Specifically, the section provides an option for no correction if the no-load measurements were made between 10 °C and 30 °C. This tolerance is only applicable for certification to energy conservation standards (it is a ±10 °C range around the 20 °C reference temperature). For simplicity, DOE proposes no such tolerance for voluntary representations at additional reference temperatures, so that all measured values would be adjusted using the reference temperature correction formula. Finally, DOE proposes to remove any reference to a reference temperature of 20 °C so that the section would be applicable to determine voluntary representations.

3. Measurement Location

DOE proposes to specify that load and no-load loss measurements are required to be taken only at the transformer terminals. Accordingly, in this NOPR, DOE has proposed a definition for "terminal," as described in section III.C.2.b. DOE notes that section 5.4 of IEEE.C57.12.90-2015 and section 5.6 of IEEE C57.12.91-2011 specify terminal-based load-loss measurements. In addition, section 8.2.4 of both IEEE.C57.12.90-2015 and IEEE C57.12.91-2011 provides the same for no-load loss measurement. These documents reflect current industry practices and manufacturers are already measuring losses at the transformer terminals. Therefore,

in this NOPR, DOE proposes to specify in section 4.3(c) of appendix A that both load loss and no-load loss measurements must be made from terminal to terminal.

4. Specification for Stabilization of Current and Voltage

Section 3.3.2 and 3.3.1 of appendix A describe a voltmeter-ammeter method and resistance bridge methods, respectively, for measuring resistance. Both methods require measurements to be stable before determining the resistance of the transformer winding being measured. Specifically, the voltmeter-ammeter method in section 3.3.2(b) of appendix A requires that current and voltage readings be stable before taking simultaneous readings of current and voltage to determine winding resistance. For the resistance bridge methods, section 3.3.1 of appendix A requires the bridge be balanced (*i.e.*, no voltage across it or current through it) before determining winding resistance. Both methods allow for a resistor to reduce the time constant of the circuit, but do not explicitly specify how to determine when measurements are stable. DOE notes that IEEE C57.12.90-2015, IEEE C57.12.91-2011, IEEE C57.12.00-2015, and IEEE C57.12.01-2015 do not specify how to determine that stabilization is reached. Section 3.4.2 of appendix A provides related guidelines for improving measurement accuracy of resistance by reducing the transformer's time constant. However, section 3.4.2 also does not explicitly provide for the period of time (such as a certain multiple of the time constant) necessary to achieve stability. In this NOPR, DOE is seeking further information on how industry currently determines that measurements have stabilized before determining winding resistance using both voltmeter-ammeter method and resistance bridge methods.

DOE requests comments regarding when, or at what number of time constants, stability is reached for the voltmeter-ammeter method and the resistance bridge method.

5. Ambient Temperature Tolerances

In response to the September 2017 TP RFI, DOE received one comment concerning potential burden arising from the requirement to maintain the temperatures of both the testing laboratory and the transformer within certain ranges. Specifically, NEMA recommended that DOE increase the temperature tolerances when testing dry-type transformers, which require maintaining the laboratory ambient temperature within a range of 3 °C for 3 hours before testing, and maintaining transformer internal temperature (if ventilated) or surface temperature (if sealed) within 2 °C of the laboratory ambient temperature.

NEMA stated that these temperature limits may be burdensome in laboratories that are not climate controlled, and that an alternate method to the temperature limits may be a development of a mathematical correction factor. NEMA acknowledged, however, that in the experience of its membership, the temperature requirements generally presented little challenge.

As stated, EPCA requires that DOE establish test procedures that are not unduly burdensome to conduct. Whereas widening tolerances of temperatures (or other measured parameters) may reduce testing cost, it may impact the reproducibility and repeatability of the test result. In the case of these particular temperature boundaries, that NEMA's membership is generally not experiencing difficulty in meeting them may suggest that they are appropriately sized. DOE does not have data regarding typical ranges of laboratory ambient temperature and,

as a result, cannot be certain that reduction in temperature tolerance would not harm reproducibility, repeatability, and accuracy and cause future test results to become incomparable to past data. For these reasons, DOE is not proposing amendments to the laboratory ambient temperature and transformer internal temperature requirements.

DOE seeks comment on its proposal to maintain the laboratory ambient and transformer internal temperature requirements with no changes.

6. Field Test Equipment

MKC commented regarding potential difficulties inherent in using conventional test equipment with deployed, operational distribution transformers. MKC described and recommended alternative test equipment. (MKC, No. 4 at pp. 1 - 2) DOE observes that manufacturers and other parties testing distribution transformers are free to use any variety of equipment that meets the requirements set forth in appendix A.

7. Harmonic current

Harmonic current refers to electrical power at alternating current frequencies greater than the fundamental frequency. In electrical power applications, harmonic current is typically regarded as undesirable; nonetheless, distribution transformers in service are commonly subject to (and must tolerate) harmonic current of a degree that varies by application. Test procedures for distribution transformers at sections 4.4.1(a) and 4.4.3.2(a) of appendix A direct use of a sinusoidal waveform when evaluating efficiency in distribution transformers.

Regarding test setup, Powersmiths commented that it would not be practical for the test procedure to address the harmonic content experienced in every customer's installation. (Powersmiths, No. 11 at p. 2) DOE recognizes that transformers in service are subject to a variety of harmonic conditions, and that the test procedure must provide a common basis for comparison. Currently, the test procedure states that transformers designed for harmonic currents must be tested with a sinusoidal waveform (*i.e.*, free of harmonic current), but does not do so for all other varieties of transformers. However, the intent of the test procedure is for all transformers to be tested with a sinusoidal waveform, as is implicit in section 4.4.1(a) of appendix A. To clarify this test setup requirement, DOE proposes to modify section 4.1 of appendix A to read "…Test all distribution transformers using a sinusoidal waveform (k=1)." This is consistent with industry practice and manufacturers are already testing all distribution transformers using a sinusoidal waveform.

DOE seeks comment on its proposal to modify section 4.1 of appendix A to read "…Test all distribution transformers using a sinusoidal waveform (k=1)."

8. Other Editorial Revisions

DOE proposes the following editorial updates to improve the readability of the test procedure and provide additional detail: (i) revising "shall" (and a single instance of "should" in the temperature condition requirements at section 3.2.2(b)(3)) to "must" in appendix A, (ii) clarifying the instructional language for recording the winding temperature for dry-type transformers (section 3.2.2 of appendix A), (iii) separating certain sentences into enumerated

clauses (section 3.2.2(a) of appendix A)[19], (iv) identifying the corresponding resistance measurement method sections (section 3.3 of appendix A), (v) replacing a reference to "uniform test method" with "this Appendix" (section 3.3 of appendix A), (vi) removing reference to guidelines under section 3.4.1, *Required actions*, of appendix A to clarify that section establishes requirements, (vii) specifying the maximum amount of time for the temperature of the transformer windings to stabilize (section 3.2.2(b)(4) of appendix A[20]), (viii) removing references to the test procedure in 10 CFR 431.196, and (ix) replacing any reference to accuracy requirements in "section 2.0" and/or "Table 2.0" to "section 2.3" and/or "Table 2.3," accordingly.

Section 3.2.2 of appendix A requires that, for testing of both ventilated and sealed units, the ambient temperature of the test area may be used to estimate the winding temperature (rather than direct measurement of the winding temperature), provided a number of conditions are met, including the condition that neither voltage nor current has been applied to the unit under test for 24 hours (provided in section 3.2.2(b)(4) of appendix A). The same section also allows for the initial 24 hours to be increased to up to a maximum of an additional 24 hours, so as to allow the temperature of the transformer windings to stabilize at the level of the ambient temperature. Based on the requirement, the total amount of time allowed would be a maximum of 48 hours. As such, in this NOPR, DOE proposes to specify explicitly that, for section 3.2.2(b)(4) of appendix A, the total maximum amount of time allowed is 48 hours.

[19] Under the changes proposed in this document, section 3.2.2(a) of appendix A would be split into section 3.2.2(a) and section 3.2.2(b).
[20] Under the changes proposed in this document, this section would become section 3.2.2(c)(4) of appendix A.

DOE is also proposing conforming amendments to the energy conservation standard provisions. 10 CFR 431.196 establishes energy conservation standards for certain distribution transformers. Immediately following each table of standards, a note specifies the applicable test PUL and DOE test procedure. For example, in 10 CFR 431.196(a) the note reads, "Note: All efficiency values are at 35 percent of nameplate-rated load, determined according to the DOE Test Method for Measuring the Energy Consumption of Distribution Transformers under Appendix A to Subpart K of 10 CFR part 431." Because 10 CFR 431.193 already requires that testing be in accordance with appendix A, DOE proposes to remove the references to the test procedure in 10 CFR 431.196. DOE proposes to maintain the portion of the note identifying the PUL corresponding to the efficiency values, for continuity and clarity.

As discussed in section III.J.1 and section III.J.2, DOE is proposing to clarify the PUL and reference temperature specifications for certification to energy conservation standards, and provide PUL and reference temperature specifications for voluntary representations, with a new section 2.1 for PUL requirements and section 2.2 for reference temperature requirements in appendix A. Accordingly, DOE proposes that the accuracy requirements previously provided in section 2.0 be moved to section 2.3 in appendix A. In addition, DOE proposes to re-number Table 2.1, Test System Accuracy Requirements For Each Measured Quantity, to Table 2.3. Lastly, DOE proposes to update cross-references in appendix A to the accuracy requirements in section 2.0 and/or table 2.1, to section 2.3 and/or table 2.3. The cross-references occur in section 3.1(b), section 3.3.3, section 3.4.2(a), section 4.3(a), section 6.0 and section 6.2 of appendix A.

K. Sampling, Representations, AEDMs

The certification and compliance requirements for distribution transformers are codified at 10 CFR part 429. DOE's sampling requirements are provided at 10 CFR 429.47. The sampling requirements, among other things, state that, (1) the provisions of 10 CFR 429.11, General sampling requirements for the selected units to be tested, apply, (2) a manufacturer must use a sample of at least five units if more than five units have been manufactured over a span of six months (10 CFR 429.47(a)(2)(i)(A)), and (3) efficiency of a basic model may be determined through testing, in accordance with appendix A, or through application of an AEDM under the requirements of 10 CFR 429.70. (10 CFR 429.47(a)(2)(i)(B))

DOE's requirements related to AEDMs are at 10 CFR 429.70. This section specifies under which circumstances an AEDM may be developed, validated, and applied to performance ratings for certain covered products and equipment.

In the September 2017 TP RFI, DOE requested feedback on the current sampling requirements; on whether manufacturers typically represent the minimum efficiency standard, the maximum efficiency allowable, or a different value; and regarding the usefulness of the AEDM provisions. 82 FR 44347, 44351 (September 22, 2017) DOE received several comments on the September 2017 TP RFI regarding these topics.

HVOLT commented that it believes the represented value calculations are useful in describing tolerance and objectives; large volumes of production have an easier means of achieving average performance than very small volumes of transformers. (HVOLT, No. 3 at p.

29) NEMA commented that the opportunity to use AEDM must be preserved, or burden will be raised for some manufacturers, and that DOE should maintain the status quo and afford manufacturers flexibility. (NEMA, No. 14 at p. 7) Howard Industries also commented that it uses the AEDM method to the fullest because it is too burdensome to physically test all units. (Howard Industries, No. 24 at p. 2) DOE appreciates stakeholders' comments and is not proposing changes to the AEDM provisions.

HVOLT stated that it believes all manufacturers test each transformer manufactured for losses, and that normally distribution transformers are overdesigned to minimize the possibility of non-compliant designs. (HVOLT, No. 3 at p. 28) Suresh stated that for units lower than 500 kVA, some manufacturers adopt bulk testing for a given rating at a time, and the average efficiency is determined, and that in some cases, manufacturers do not test all of their units because they test a statistically significant number of units to demonstrate the efficiency. (Suresh, No. 9 at p. 1) As discussed previously, DOE's sampling requirements require that for ratings developed using testing (rather than an AEDM) a manufacturer must use a sample of at least five units if more than five units have been manufactured over a span of six months (10 CFR 429.47(a)(2)(i)(B)), or as many as have been produced if five or fewer have been manufactured over a span of six months (10 CFR 429.47(a)(2)(i)(A)).

NEMA recommended that DOE consider providing software for manufacturers to help with reporting, and that this could be designed to contain all the raw data and the represented efficiency calculations. (NEMA, No. 14 at p. 8) DOE does provide product-specific templates for certifying basic models, which can be found on the following website:

https://www.regulations.doe.gov/ccms/templates. However, DOE does not provide software for certification reporting. It is the manufacturer's responsibility to certify its products (or equipment) as required by DOE under 10 CFR part 429. Further, the manufacturer must decide how to represent the efficiency of a transformer between the limits of the energy conservation standard and the maximum representation allowed by section 429.47(a)(2).

DOE received no other comments on the current sampling, representation and AEDM requirements. DOE is not proposing amendments to the sampling and AEDM requirements.

L. Test Procedure Costs, Harmonization, and Other Topics

1. Test Procedure Costs and Impact

EPCA requires that test procedures proposed by DOE not be unduly burdensome to conduct. In this NOPR, DOE proposes to amend the existing test procedure for distribution transformers by revising certain definitions, incorporating new definitions, incorporating revisions based on the latest versions of the IEEE industry standards, including provisions to allow manufacturers to use the DOE test procedure to make voluntary representations at additional PULs and/or reference temperatures, and reorganizing content among relevant sections of the CFR to improve readability. The proposed amendments would primarily provide updates and supplemental details for how to conduct the test procedure and do not add complexity to test conditions/setup or add test steps. In accordance with EPCA, DOE has tentatively determined that these proposed amendments would not be unduly burdensome for manufacturers to conduct. Further, DOE has tentatively determined that the proposal would not impact testing costs already experienced by manufacturers. DOE estimates based on a test quote from a laboratory that the cost for testing distribution transformers using the existing test

procedure is approximately $400 per unit tested and that this figure would not change in response to the changes in this proposed rule. In summary, the proposals reflect and codify current industry practice.

The proposed amendments would not impact the scope of the test procedure. The proposed amendments would not require the testing of distribution transformers not already subject to the test procedure at 10 CFR 431.193 (*i.e.*, the proposal would not require manufacturers to test autotransformers, drive (isolation) transformers, grounding transformers, machine-tool (control) transformers, nonventilated transformers, rectifier transformers, regulating transformers, sealed transformer; special-impedance transformer; testing transformer; transformer with tap range of 20 percent or more; uninterruptible power supply transformer; or welding transformer, which are presently not subject to testing). The proposed amendments would not alter the measured energy efficiency or energy use of the distribution transformers. Manufacturers would be able to rely on data generated under the current test procedure should the proposed amendments be finalized. Further, the amendments proposed in this document, if finalized, would not require the purchase of additional equipment for testing.

DOE is proposing to adopt definitions for "PUL," "terminal" and "auxiliary device." The proposed definitions are intended to provide additional specificity in the application of the test procedure. The proposed definitions match current industry application of the test procedure and, if finalized, would not impact the conduct of the test or testing costs experienced by manufacturers. DOE is also proposing to specify that both load loss and no-load loss measurements must be made from "terminal to terminal." Measuring losses at the transformer

terminals reflects current industry practices. In addition, the DOE test procedure already explicitly requires certain measurements at the terminals; specifically, the kelvin bridge method for determining resistance measurements in section 3.3.1.2(c), the voltmeter-ammeter method for determining resistance measurements in section 3.3.2(c), and the no-load loss test method in section 4.4.2(a)(3). Furthermore, taking other measurements (whose measurement locations are not explicit in the test procedure) at locations other than the terminal would yield results formed of mutually incongruous components, and would leave unclear what the test procedure was purporting to represent. Therefore, DOE initially concludes that the proposal to specify that both load loss and no-load loss measurements must be made from "terminal to terminal" reflects current practice and would not add any additional testing cost.

DOE is proposing a number of updates to its test procedures based on updates to the relevant IEEE standards. In addition to proposals that reflect non-substantive editorial updates to the IEEE standards (*i.e.*, consistent use of the term "insulating liquid"), DOE is proposing to specify parameters for determining stability when making resistance measurements, explicitly require the automatic recording of data, specify the number of readings required for resistance measurement, specify the connection locations for resistance measurements, explicitly state the required test frequency, and require the polarity of the core magnetization be kept constant during all resistance readings. These proposed revisions, which are based on updates to the IEEE standards, reflect industry consensus and current practice. As such, these proposed revisions, if made final, would not impact test costs.

DOE is proposing an amendment to the test procedures to permit manufacturers to make voluntary representations of the performance (*i.e.*, efficiency, load loss, no load loss) of distribution transformers at conditions other than those required for compliance testing (*i.e.*, at additional PULs and manufacturer selected reference temperature). Under DOE's proposal in this document, manufacturers would be permitted to make representations using the DOE test procedure regarding the performance of distribution transformers under a wider range of operating conditions. The additional representations would be voluntary.

DOE estimates that if a manufacturer chose to make such voluntary representations, no additional testing cost would be incurred because the voluntary representations could be determined mathematically, without any additional testing. As discussed previously, manufacturers typically test distribution transformers at 100 percent PUL; performance at other PULs (including the PULs required for compliance with the energy conservation standards) is calculated mathematically. Appendix A provides equations[21] that manufacturers can use to (1) calculate no-load and load losses at any reference temperature and (2) calculate load losses at any PUL. These equations are currently used to calculate performance at the DOE-required conditions, but these same equations can also be used to calculate performance at additional conditions (of PULs and reference temperatures) for any voluntary representations, without the need to conduct additional testing.

A manufacturer could choose to re-test rather than mathematically determine the values for voluntary representations at other PULs or reference temperatures. However, the proposed

[21] Equations are provided in section 5.1, section 4.4.3.3, and section 4.5.3.3 of appendix A.

provision regarding voluntary representations does not necessitate additional testing, were a manufacturer to choose to make voluntary representations. In addition, DOE is not requiring any certification or reporting of voluntary representations. For these reasons, no additional costs or test burden would be incurred for voluntary representations.

In addition, DOE is also proposing to centralize the PUL and reference temperature specifications in appendix A, both for the certification to energy conservation standards and for use with a voluntary representation. The updates are not substantive and do not change existing test PUL requirements with respect to certification to energy conservation standards. Rather, the consolidation would enhance readability of the test procedure and more clearly communicate DOE's PUL requirements with respect to certification to energy conservation standards and voluntary representations.

The other proposed amendments are mainly clerical or editorial in nature, and if finalized, they would not impact the measured test results or impact the test costs.

DOE requests comment on its understanding of the impact and associated costs of the proposed test procedure. To the extent commenters believe that manufacturers would not be able to rely on data generated under the current test procedure should the proposed amendments be finalized, DOE requests comment on the potential associated costs.

2. Harmonization with Industry Standards

As discussed in section III.D, the test procedure for distribution transformers at appendix A mirrors language contained in several industry standards: NEMA TP 2-1998; IEEE C57.12.90-1999; IEEE C57.12.91-2001; IEEE C57.12.00-2000; and IEEE C57.12.01-1998. DOE notes that when establishing the test procedure for distribution transformers, DOE determined that basing the procedure on multiple industry standards, as opposed to adopting an industry test procedure (or procedures) without modification, was necessary to provide the detail and accuracy required for the DOE test procedure, with the additional benefit of providing manufacturers the DOE test procedure in a single reference. As such, DOE relied heavily on the techniques and methods from NEMA TP 2-1998, NEMA TP 2-2005and the four IEEE standards in developing the DOE test procedure. Both versions of NEMA TP 2 reference the IEEE standards as part of that industry test procedure. Specifically, the IEEE standards provide the test system accuracy requirements, resistance measurement test methods, and load loss and no-load loss test methods for both NEMA TP 2-1998 and NEMA TP 2-2005. Although both versions of NEMA TP 2 were designed to be a standard that extracts and presents pertinent parts of the IEEE standards, DOE determined the standard is not sufficiently clear and detailed to adopt as the DOE test procedure. Therefore, the current DOE test procedure is a stand-alone test procedure based on the multiple industry standards.

DOE seeks comment on the degree to which the DOE test procedure should consider and be harmonized further with the most recent relevant industry standards for distribution transformers, and whether any changes to the Federal test method would provide additional

benefits to the public. DOE also requests comment on the benefits and burdens of adopting any industry/voluntary consensus-based or other appropriate test procedure, without modification.

3. Other Test Procedure Topics

In addition to the issues identified earlier in this document, DOE welcomes comment on any other aspect of the existing test procedure for distribution transformers not already addressed by the specific areas identified in this document. DOE particularly seeks information that would improve the representativeness of the test procedure, as well as information that would help DOE create a procedure that would limit manufacturer test burden. Comments regarding repeatability and reproducibility are also welcome.

DOE also requests information that would help DOE create procedures that would limit manufacturer test burden through streamlining or simplifying testing requirements. In particular, DOE notes that under Executive Order 13771, "Reducing Regulation and Controlling Regulatory Costs," Executive Branch agencies such as DOE must manage the costs associated with the imposition of expenditures required to comply with Federal regulations. See 82 FR 9339 (Feb. 3, 2017). Consistent with that Executive Order, DOE encourages the public to provide input on measures DOE could take to lower the cost of its regulations applicable to distribution transformers consistent with the requirements of EPCA.

M. Compliance Date

EPCA prescribes that all representations of energy efficiency and energy use, including those made on marketing materials and product labels, must be made in accordance with an amended test procedure, beginning 180 days after publication of such a test procedure final rule

in the *Federal Register*. (42 U.S.C. 6314(d)(1)) If DOE were to publish an amended test procedure, EPCA provides an allowance for individual manufacturers to petition DOE for an extension of the 180-day period if the manufacturer may experience undue hardship in meeting the deadline. (42 U.S.C. 6314(d)(2)) To receive such an extension, petitions must be filed with DOE no later than 60 days before the end of the 180-day period and must detail how the manufacturer will experience undue hardship. *Id.*

IV. Procedural Issues and Regulatory Review

A. Review Under Executive Order 12866

The Office of Management and Budget (OMB) has determined that test procedure rulemakings do not constitute "significant regulatory actions" under section 3(f) of Executive Order 12866, Regulatory Planning and Review, 58 FR 51735 (Oct. 4, 1993). Accordingly, this action was not subject to review under the Executive Order by the Office of Information and Regulatory Affairs (OIRA) in the OMB.

B. Review Under Executive Orders 13771 and 13777

On January 30, 2017, the President issued Executive Order 13771, "Reducing Regulation and Controlling Regulatory Costs." That Order stated the policy of the executive branch is to be prudent and financially responsible in the expenditure of funds, from both public and private sources. The Order stated it is essential to manage the costs associated with the governmental

imposition of private expenditures required to comply with Federal regulations. This rulemaking is expected to be an E.O. 13771 other action because the costs of this action is zero.

Additionally, on February 24, 2017, the President issued Executive Order 13777, "Enforcing the Regulatory Reform Agenda." The Order required the head of each agency designate an agency official as its Regulatory Reform Officer (RRO). Each RRO oversees the implementation of regulatory reform initiatives and policies to ensure that agencies effectively carry out regulatory reforms, consistent with applicable law. Further, E.O. 13777 requires the establishment of a regulatory task force at each agency. The regulatory task force is required to make recommendations to the agency head regarding the repeal, replacement, or modification of existing regulations, consistent with applicable law. At a minimum, each regulatory reform task force must attempt to identify regulations that:

(i) Eliminate jobs, or inhibit job creation;

(ii) Are outdated, unnecessary, or ineffective;

(iii) Impose costs that exceed benefits;

(iv) Create a serious inconsistency or otherwise interfere with regulatory reform initiatives and policies;

(v) Are inconsistent with the requirements of Information Quality Act, or the guidance issued pursuant to that Act, in particular those regulations that rely in whole or in part on data, information, or methods that are not publicly available or that are insufficiently transparent to meet the standard for reproducibility; or

(vi) Derive from or implement Executive Orders or other Presidential directives that have been subsequently rescinded or substantially modified.

DOE initially concludes that this rulemaking is consistent with the directives set forth in these executive orders. The proposed rule would not yield any costs or cost savings. Currently subject to test procedures, nor do they place additional requirements on distribution transformers currently subject to test procedures. In addition, the proposed amendments would not alter the measured energy efficiency/energy use of the distribution transformers. Manufacturers would be able to rely on data generated under the current test procedure should the proposed amendments be finalized. Therefore, no proposed revisions would increase burden on manufacturers.

However, in the NOPR, DOE is proposing to allow manufacturers to make voluntary representations of the performance of distribution transformers at conditions other than those required currently for compliance testing. DOE estimates that, if a manufacturer chose to make such representations, no additional testing cost would be incurred because the voluntary representations could be determined mathematically and without any additional testing required. Therefore, DOE concludes that no incremental testing cost and no additional testing burden would be incurred by manufacturers because of this proposed rule.

Given that the proposed test procedures would not increase burden on small manufacturers, DOE certifies that the proposed testing procedure amendments would not have a "significant economic impact on a substantial number of small entities," and the preparation of an IRFA is not warranted. DOE will submit a certification and supporting statement of factual basis to the Chief Counsel for Advocacy of the Small Business Administration for review under 5 U.S.C. 605(b).

DOE seeks comment on whether the proposed test procedure changes would place new and significant burdens on a substantial number of small entities.

C. Review Under the Paperwork Reduction Act of 1995

Manufacturers of distribution transformers must certify to DOE that their products comply with any applicable energy conservation standards. To certify compliance, manufacturers must first obtain test data for their products according to the DOE test procedures, including any amendments adopted for those test procedures. DOE has established regulations for the certification and recordkeeping requirements for all covered consumer products and commercial equipment, including distribution transformers. (See generally 10 CFR part 429.) The collection-of-information requirement for the certification and recordkeeping is subject to review and approval by OMB under the Paperwork Reduction Act (PRA). This requirement has been approved by OMB under OMB control number 1910-1400. Public reporting burden for the certification is estimated to average 35 hours per response, including the time for reviewing instructions, searching existing data sources, gathering and maintaining the data needed, and completing and reviewing the collection of information.

Notwithstanding any other provision of the law, no person is required to respond to, nor shall any person be subject to a penalty for failure to comply with, a collection of information subject to the requirements of the PRA, unless that collection of information displays a currently valid OMB Control Number.

D. Review Under the Treasury and General Government Appropriations Act, 1999

Section 654 of the Treasury and General Government Appropriations Act, 1999 (Pub. L. 105-277) requires Federal agencies to issue a Family Policymaking Assessment for any rule that may affect family well-being. This proposed rule would not have any impact on the autonomy or integrity of the family as an institution. Accordingly, DOE has concluded that it is not necessary to prepare a Family Policymaking Assessment.

E. Review Under the National Environmental Policy Act of 1969

In this proposed rule, DOE proposes test procedure amendments that it expects will be used to develop and implement future energy conservation standards for distribution transformers. DOE has determined that this rule falls into a class of actions that are categorically excluded from review under the National Environmental Policy Act of 1969 (42 U.S.C. 4321 *et seq*.) and DOE's implementing regulations at 10 CFR part 1021. Specifically, this proposed rule would amend the existing test procedures without affecting the amount, quality or distribution of energy usage, and, therefore, would not result in any environmental impacts. Thus, this rulemaking is covered by Categorical Exclusion A5 under 10 CFR part 1021, subpart D, which applies to any rulemaking that interprets or amends an existing rule without changing the environmental effect of that rule. Accordingly, neither an environmental assessment nor an environmental impact statement is required.

F. Review Under Executive Order 13132

Executive Order 13132, "Federalism," 64 FR 43255 (August 4, 1999) imposes certain requirements on agencies formulating and implementing policies or regulations that preempt State law or that have Federalism implications. The Executive Order requires agencies to

examine the constitutional and statutory authority supporting any action that would limit the policymaking discretion of the States and to carefully assess the necessity for such actions. The Executive Order also requires agencies to have an accountable process to ensure meaningful and timely input by State and local officials in the development of regulatory policies that have Federalism implications. On March 14, 2000, DOE published a statement of policy describing the intergovernmental consultation process it will follow in the development of such regulations. 65 FR 13735. DOE has examined this proposed rule and has determined that it would not have a substantial direct effect on the States, on the relationship between the national government and the States, or on the distribution of power and responsibilities among the various levels of government. EPCA governs and prescribes Federal preemption of State regulations as to energy conservation for the products that are the subject of this proposed rule. States can petition DOE for exemption from such preemption to the extent, and based on criteria, set forth in EPCA. (42 U.S.C. 6297(d)) No further action is required by Executive Order 13132.

G. Review Under Executive Order 12988

Regarding the review of existing regulations and the promulgation of new regulations, section 3(a) of Executive Order 12988, "Civil Justice Reform," 61 FR 4729 (Feb. 7, 1996), imposes on Federal agencies the general duty to adhere to the following requirements: (1) eliminate drafting errors and ambiguity, (2) write regulations to minimize litigation, (3) provide a clear legal standard for affected conduct rather than a general standard, and (4) promote simplification and burden reduction. Section 3(b) of Executive Order 12988 specifically requires that Executive agencies make every reasonable effort to ensure that the regulation (1) clearly specifies the preemptive effect, if any, (2) clearly specifies any effect on existing Federal law or regulation, (3) provides a clear legal standard for affected conduct while promoting

simplification and burden reduction, (4) specifies the retroactive effect, if any, (5) adequately defines key terms, and (6) addresses other important issues affecting clarity and general draftsmanship under any guidelines issued by the Attorney General. Section 3(c) of Executive Order 12988 requires Executive agencies to review regulations in light of applicable standards in sections 3(a) and 3(b) to determine whether they are met or it is unreasonable to meet one or more of them. DOE has completed the required review and determined that, to the extent permitted by law, the proposed rule meets the relevant standards of Executive Order 12988.

H. Review Under the Unfunded Mandates Reform Act of 1995

Title II of the Unfunded Mandates Reform Act of 1995 (UMRA) requires each Federal agency to assess the effects of Federal regulatory actions on State, local, and Tribal governments and the private sector. Pub. L. No. 104-4, sec. 201 (codified at 2 U.S.C. 1531). For a proposed regulatory action likely to result in a rule that may cause the expenditure by State, local, and Tribal governments, in the aggregate, or by the private sector of $100 million or more in any one year (adjusted annually for inflation), section 202 of UMRA requires a Federal agency to publish a written statement that estimates the resulting costs, benefits, and other effects on the national economy. (2 U.S.C. 1532(a), (b)) The UMRA also requires a Federal agency to develop an effective process to permit timely input by elected officers of State, local, and Tribal governments on a proposed "significant intergovernmental mandate," and requires an agency plan for giving notice and opportunity for timely input to potentially affected small governments before establishing any requirements that might significantly or uniquely affect small governments. On March 18, 1997, DOE published a statement of policy on its process for intergovernmental consultation under UMRA. 62 FR 12820; also available at *http://energy.gov/gc/office-general-counsel*. DOE examined this proposed rule according to

UMRA and its statement of policy and determined that the rule contains neither an intergovernmental mandate, nor a mandate that may result in the expenditure of $100 million or more in any year, so these requirements do not apply.

I. Review Under Executive Order 12630

DOE has determined, under Executive Order 12630, "Governmental Actions and Interference with Constitutionally Protected Property Rights" 53 FR 8859 (March 18, 1988) that this regulation would not result in any takings that might require compensation under the Fifth Amendment to the U.S. Constitution.

J. Review Under Treasury and General Government Appropriations Act, 2001

Section 515 of the Treasury and General Government Appropriations Act, 2001 (44 U.S.C. 3516 note) provides for agencies to review most disseminations of information to the public under guidelines established by each agency pursuant to general guidelines issued by OMB. OMB's guidelines were published at 67 FR 8452 (Feb. 22, 2002), and DOE's guidelines were published at 67 FR 62446 (Oct. 7, 2002). DOE has reviewed this proposed rule under the OMB and DOE guidelines and has concluded that it is consistent with applicable policies in those guidelines.

K. Review Under Executive Order 13211

Executive Order 13211, "Actions Concerning Regulations That Significantly Affect Energy Supply, Distribution, or Use," 66 FR 28355 (May 22, 2001), requires Federal agencies to prepare and submit to OMB, a Statement of Energy Effects for any proposed significant energy action. A "significant energy action" is defined as any action by an agency that promulgated or is

expected to lead to promulgation of a final rule, and that (1) is a significant regulatory action under Executive Order 12866, or any successor order; and (2) is likely to have a significant adverse effect on the supply, distribution, or use of energy; or (3) is designated by the Administrator of OIRA as a significant energy action. For any proposed significant energy action, the agency must give a detailed statement of any adverse effects on energy supply, distribution, or use should the proposal be implemented, and of reasonable alternatives to the action and their expected benefits on energy supply, distribution, and use.

The proposed regulatory action to amend the test procedure for measuring the energy efficiency of distribution transformers is not a significant regulatory action under Executive Order 12866. Moreover, it would not have a significant adverse effect on the supply, distribution, or use of energy, nor has it been designated as a significant energy action by the Administrator of OIRA. Therefore, it is not a significant energy action, and, accordingly, DOE has not prepared a Statement of Energy Effects.

L. Review Under Section 32 of the Federal Energy Administration Act of 1974

Under section 301 of the Department of Energy Organization Act (Pub. L. 95–91; 42 U.S.C. 7101), DOE must comply with section 32 of the Federal Energy Administration Act of 1974, as amended by the Federal Energy Administration Authorization Act of 1977. (15 U.S.C. 788; FEAA) Section 32 essentially provides in relevant part that, where a proposed rule authorizes or requires use of commercial standards, the notice of proposed rulemaking must inform the public of the use and background of such standards. In addition, section 32(c) requires DOE to consult with the Attorney General and the Chairman of the Federal Trade Commission (FTC) concerning the impact of the commercial or industry standards on competition.

The proposed modifications to the test procedure for distribution transformers in this NOPR do not incorporate by reference any commercial testing standards. Therefore, the requirements of section 32(b) of the FEAA do not apply.

M. Description of Materials Incorporated by Reference

In this NOPR, DOE does not propose to incorporate by reference any industry test standards. Rather, DOE proposes that the test procedure continue to be stand-alone, and be based on NEMA TP 2-1998 and NEMA TP 2-2005, and the latest versions of the IEEE standards, IEEE C57.12.90-2015, IEEE C57.12.91-2011, IEEE C57.12.00-2015, and IEEE C57.12.01-2015.

V. Public Participation

A. Submission of Comments

DOE will accept comments, data, and information regarding this proposed rule no later than the date provided in the **DATES** section at the beginning of this proposed rule. Interested parties may submit comments using any of the methods described in the **ADDRESSES** section at the beginning of this notice.

Submitting comments via *http://www.regulations.gov*. The *http://www.regulations.gov* webpage will require you to provide your name and contact information. Your contact information will be viewable to DOE Building Technologies staff only. Your contact information will not be publicly viewable except for your first and last names, organization name (if any), and submitter representative name (if any). If your comment is not processed properly

because of technical difficulties, DOE will use this information to contact you. If DOE cannot read your comment due to technical difficulties and cannot contact you for clarification, DOE may not be able to consider your comment.

However, your contact information will be publicly viewable if you include it in the comment itself or in any documents attached to your comment. Any information that you do not want to be publicly viewable should not be included in your comment, nor in any document attached to your comment. Otherwise, persons viewing comments will see only first and last names, organization names, correspondence containing comments, and any documents submitted with the comments.

Do not submit to *http://www.regulations.gov* information for which disclosure is restricted by statute, such as trade secrets and commercial or financial information (hereinafter referred to as Confidential Business Information (CBI)). Comments submitted through *http://www.regulations.gov* cannot be claimed as CBI. Comments received through the website will waive any CBI claims for the information submitted. For information on submitting CBI, see the Confidential Business Information section.

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Submitting comments via email, hand delivery/courier, or mail. Comments and documents submitted via email, hand delivery/courier, or mail also will be posted to

http://www.regulations.gov. If you do not want your personal contact information to be publicly viewable, do not include it in your comment or any accompanying documents. Instead, provide your contact information in a cover letter. Include your first and last names, email address, telephone number, and optional mailing address. The cover letter will not be publicly viewable as long as it does not include any comments.

Include contact information each time you submit comments, data, documents, and other information to DOE. If you submit via mail or hand delivery/courier, please provide all items on a CD, if feasible, in which case it is not necessary to submit printed copies. No telefacsimiles (faxes) will be accepted.

Comments, data, and other information submitted to DOE electronically should be provided in PDF (preferred), Microsoft Word or Excel, WordPerfect, or text (ASCII) file format. Provide documents that are not secured, that are written in English, and that are free of any defects or viruses. Documents should not contain special characters or any form of encryption and, if possible, they should carry the electronic signature of the author.

Campaign form letters. Please submit campaign form letters by the originating organization in batches of between 50 to 500 form letters per PDF or as one form letter with a list of supporters' names compiled into one or more PDFs. This reduces comment processing and posting time.

Confidential Business Information. Pursuant to 10 CFR 1004.11, any person submitting information that he or she believes to be confidential and exempt by law from public disclosure should submit via email, postal mail, or hand delivery/courier two well-marked copies: one copy of the document marked "confidential" including all the information believed to be confidential,

and one copy of the document marked "non-confidential" with the information believed to be confidential deleted. Submit these documents via email or on a CD, if feasible. DOE will make its own determination about the confidential status of the information and treat it according to its determination.

Factors of interest to DOE when evaluating requests to treat submitted information as confidential include (1) a description of the items, (2) whether and why such items are customarily treated as confidential within the industry, (3) whether the information is generally known by or available from other sources, (4) whether the information has previously been made available to others without obligation concerning its confidentiality, (5) an explanation of the competitive injury to the submitting person that would result from public disclosure, (6) when such information might lose its confidential character due to the passage of time, and (7) why disclosure of the information would be contrary to the public interest.

It is DOE's policy that all comments may be included in the public docket, without change and as received, including any personal information provided in the comments (except information deemed to be exempt from public disclosure).

DOE considers public participation to be a very important part of the process for developing test procedures and energy conservation standards. DOE actively encourages the participation and interaction of the public during the comment period in each stage of this process. Interactions with and between members of the public provide a balanced discussion of the issues and assist DOE in the process. Anyone who wishes to be added to the DOE mailing list to receive future notices and information about this process should contact Appliance and Equipment Standards Program staff at (202) 586-6636 or via e-mail at

ApplianceStandardsQuestions@ee.doe.gov.

B. Issues on Which DOE Seeks Comment

Although DOE welcomes comments on any aspect of this proposal, DOE is particularly interested in receiving comments and views of interested parties concerning the following issues:

1) DOE requests comment on: (1) whether the current definition of rectifier transformer is sufficiently specific, (2) if not, what modifications would make it sufficiently specific, and (3) whether partial output phase shift, harmonic current tolerance, or other electrical properties may be used to reliably identify rectifier transformers.
2) DOE requests comment on: (1) whether the current definition of drive transformer is sufficiently specific, (2) if not, what modifications would make it sufficiently specific, and (3) the level of technical similarity drive transformers bear to rectifier transformers.
3) DOE requests comment on its proposed definition of "per-unit load" and its proposal to consolidate the usage of various terms referring to less-than-full rated load to the single term "per-unit load."
4) DOE requests comment on its proposed definition of "terminal."
5) DOE requests comment on its proposed definition of "auxiliary device," and whether certain components should be added or removed from the listed auxiliary devices and why. DOE also requests comment on whether it is appropriate to include functional component designations as part of a definition of "auxiliary device" and, if so, which functions and why.

6) DOE requests comment on its proposed updated definition of "low-voltage dry-type distribution transformer."
7) DOE requests comment on its proposed updated definition of "reference temperature."
8) DOE requests comment on the proposed updates based on the latest version of the applicable IEEE standards for testing distribution transformers, and specifically regarding whether industry is already testing to the requirements of those IEEE standards.
9) DOE requests comment on the tentative determination that each of the proposals do not increase test cost or burden, and that they would not result in different measured values than the current test procedure.
10) DOE requests comment on the proposal to amend the DOE test procedure to permit manufacturers to make voluntary representations at any additional PUL and/or reference temperature, and whether this would assist consumers in making better purchasing decisions based on their specific installation conditions. DOE requests comment on whether the current DOE test procedure would be appropriate at non-mandatory PULs and reference temperatures.
11) DOE requests comment on secondary winding configurations. DOE also requests comment on the magnitude of the additional losses associated with the less efficient configurations as well as the relative period of operation in each winding configuration.

12) DOE requests comments regarding when, or at what number of time constants, stability is reached for the voltmeter-ammeter method and the resistance bridge method.

13) DOE seeks comment on its proposal to maintain the laboratory ambient and transformer internal temperature requirements with no changes.

14) DOE seeks comment on its proposal to modify section 4.1 of appendix A to read "…Test all distribution transformers using a sinusoidal waveform (k=1)."

15) DOE requests comment on its understanding of the impact and associated costs of the proposed test procedure. To the extent commenters believe that manufacturers would not be able to rely on data generated under the current test procedure should the proposed amendments be finalized, DOE requests comment on the potential associated costs.

16) DOE seeks comment on the degree to which the DOE test procedure should consider and be harmonized further with the most recent relevant industry standards for distribution transformers, and whether any changes to the Federal test method would provide additional benefits to the public. DOE also requests comment on the benefits and burdens of adopting any industry/voluntary consensus-based or other appropriate test procedure, without modification.

17) DOE seeks comment on whether the proposed test procedure changes would place new and significant burdens on a substantial number of small entities.

VI. Approval of the Office of the Secretary

The Secretary of Energy has approved publication of this proposed rule.

List of Subjects in 10 CFR Part 431

Administrative practice and procedure, Confidential business information, Energy conservation test procedures, Incorporation by reference, and Reporting and recordkeeping requirements.

Signed in Washington, DC, on April 23, 2019.

Steven Chalk
Acting Deputy Assistant Secretary for Energy Efficiency
Energy Efficiency and Renewable Energy

For the reasons stated in the preamble, DOE is proposing to amend part 431 of Chapter II of Title 10, Code of Federal Regulations as set forth below:

PART 431-- ENERGY EFFICIENCY PROGRAM FOR CERTAIN COMMERCIAL AND INDUSTRIAL EQUIPMENT

1. The authority citation for part 431 continues to read as follows:

   Authority: 42 U.S.C. 6291-6317; 28 U.S.C. 2461 note.

2. Section 431.192 is amended by revising the definitions of *Low-voltage dry-type distribution transformer* and *Reference temperature*, and adding in alphabetical order, definitions for *Auxiliary device*, *Per-unit load*, and *Terminal,* to read as follows:

§431.192 Definitions.

* * * * *

Auxiliary device means a localized component of a distribution transformer that is a circuit breaker, switch, fuse, or surge/lightning arrester.

* * * * *

Low-voltage dry-type distribution transformer means a distribution transformer that—

(1) Has an input voltage of 600 volts or less;

(2) Is air-cooled; and

(3) Does not use insulating liquid as a coolant.

* * * * *

Per-unit load means the fraction of rated load.

* * * * *

Reference temperature means the temperature at which the transformer losses are determined, and to which such losses are corrected if testing is done at a different point. (Reference temperature values are specified in the test method in appendix A to this subpart.)

* * * * *

Terminal means a conducting element of a distribution transformer providing electrical connection to an external conductor that is not part of the transformer.

* * * * *

3. Section 431.193 is revised to read as follows:

§431.193 Test procedures for measuring energy consumption of distribution transformers.

The test procedures for measuring the energy efficiency of distribution transformers for purposes of EPCA are specified in appendix A to this subpart. The test procedures specified in appendix A to this subpart apply only to distribution transformers subject to energy conservation standards at §431.196.

4. Section 431.196 is amended by revising the Notes in paragraphs (a)(1), (a)(2), (b)(1), (b)(2), (c)(1), and (c)(2), to read as follows:

§431.196 Energy conservation standards and their effective dates.

(a) *Low-Voltage Dry-Type Distribution Transformers*.

(1) * * *

* * * * *

Note: All efficiency values are at 35 percent per-unit load.

(2) * * *

* * * * *

Note: All efficiency values are at 35 percent per-unit load.

(b) *Liquid Immersed Distribution Transformers*.

(1) * * *

* * * * *

Note: All efficiency values are at 50 percent per-unit load.

(2) * * *

* * * * *

Note: All efficiency values are at 50 percent per-unit load.

(c) *Medium-Voltage Dry-Type Distribution Transformers*.

(1) * * *

* * * * *

Note: All efficiency values are at 50 percent per-unit load.

(2) * * *

* * * * *

Note: All efficiency values are at 50 percent per-unit load.

* * * * *

5. Appendix A to subpart K of part 431 is amended by:

    a. Revising section 2.0,

    b. Adding sections 2.1, Per-unit Load, 2.2, Reference Temperature, and 2.3, Accuracy,

    c. Revising paragraph b in section 3.1, General Considerations,

    d. Adding paragraph c in section 3.1, General Considerations,

    e. Revising section 3.2.1.1, Methods,

    f. Revising paragraph b of section 3.2.1.2, Conditions,

    g. Revising section 3.2.2, Dry-Type Distribution Transformers,

    h. Revising section 3.3, Resistance Measurement Methods,

    i. Revising the first sentence in paragraph a and revising paragraph b in section 3.3.2, Voltmeter-Ammeter Method,

    j. Revising section 3.3.3, Resistance Meters,

    k. Revising the introductory text in section 3.4.1, Required Actions,

    l. Adding paragraphs f, g, h, and i, to section 3.4.1, Required Actions,

    m. Revising paragraph a in section 3.4.2,

    n. Revising paragraph a in section 3.5, Conversion of Resistance Measurements,

    o. Revising section 4.1, General Considerations,

    p. Revising paragraph a in section 4.3, Test Sets,

    q. Adding paragraph c to section 4.3, Test Sets,

r. Revising paragraph b in section 4.4.2, No-Load Loss Test,

s. Revising section 4.4.3.3, Correction of No-Load Loss to Reference Temperature

t. Revising section 5.1, Output Loading Level Adjustment,

u. Revising section 6.0, Test Equipment Calibration and Certification,

v. Revising section 6.1, Test Equipment,

w. Revising paragraph a of section 6.2, Calibration and Certification, and

x. Adding section 7.0.

The additions and revisions read as follows:

Appendix A to Subpart K of Part 431—Uniform Test Method for Measuring the Energy Consumption of Distribution Transformers

* * * * *

2.0 PER-UNIT LOAD, REFERENCE TEMPERATURE, AND ACCURACY REQUIREMENTS.

2.1 *Per-unit Load*

In conducting the test procedure in this Appendix for the purpose of (1) certification to an energy conservation standard, the applicable per-unit load in Table 2.1 must be used; or (2) making voluntary representations as provided in section 7.0 at an additional per-unit load, select the per-unit load of interest.

TABLE 2.1—PER-UNIT LOAD FOR CERTIFICATION TO ENERGY CONSERVATION STANDARDS

Distribution Transformer Category	Per-unit Load
Liquid-immersed	50 percent
Medium-voltage dry-type	50 percent
Low-voltage dry-type	35 percent

2.2 *Reference Temperature*

In conducting the test procedure in this Appendix for the purpose of (1) certification to an energy conservation standard, the applicable reference temperature in Table 2.2 must be used; or (2) making voluntary representations as provided in section 7.0 at an additional reference temperature, select the reference temperature of interest.

TABLE 2.2—REFERENCE TEMPERATURE FOR CERTIFICATION TO ENERGY CONSERVATION STANDARDS

Distribution Transformer Category	Reference Temperature
Liquid-immersed	20°C for no-load loss 55°C for load loss
Medium-voltage dry-type	20°C for no-load loss 75°C for load loss
Low-voltage dry-type	20°C for no-load loss 75°C for load loss

2.3 *Accuracy Requirements*

(a) Equipment and methods for loss measurement must be sufficiently accurate that measurement error will be limited to the values shown in Table 2.3.

TABLE 2.3—TEST SYSTEM ACCURACY REQUIREMENTS FOR EACH MEASURED QUANTITY

Measured quantity	Test system accuracy
Power Losses	±3.0%

Voltage	±0.5%
Current	±0.5%
Resistance	±0.5%
Temperature	±1.5 °C for liquid-immersed distribution transformers, and ±2.0 °C for low-voltage dry-type and medium-voltage dry-type distribution transformers

(b) Only instrument transformers meeting the 0.3 metering accuracy class, or better, may be used under this test method.

* * * * *

3.1 *General Considerations*

* * * * *

(b) Measure the direct current resistance (R_{dc}) of transformer windings by one of the methods outlined in section 3.3. The methods of section 3.5 must be used to correct load losses to the applicable reference temperature from the temperature at which they are measured. Observe precautions while taking measurements, such as those in section 3.4, in order to maintain measurement uncertainty limits specified in Table 2.3.

(c) Measure resistance with the transformer energized by a 60 Hz supply.

* * * * *

3.2.1.1 Methods

Record the winding temperature (T_{dc}) of liquid-immersed transformers as the average of either of the following:

(a) The measurements from two temperature sensing devices (for example, thermocouples) applied to the outside of the transformer tank and thermally insulated from the surrounding environment, with one located at the level of the insulating liquid and the other located near the tank bottom or at the lower radiator header if applicable; or

(b) The measurements from two temperature sensing devices immersed in the insulating liquid, with one located directly above the winding and other located directly below the winding.

3.2.1.2 Conditions

* * * * *

(b) The temperature of the insulating liquid has stabilized, and the difference between the top and bottom temperature does not exceed 5 °C. The temperature of the insulating liquid is considered stable if the top liquid temperature does not vary more than 2 ºC in a 1-h period.

3.2.2 *Dry-Type Distribution Transformers*.

Record the winding temperature (T_{dc}) of dry-type transformers as one of the following:

(a) For ventilated dry-type units, use the average of readings of four or more thermometers, thermocouples, or other suitable temperature sensors inserted within the coils. Place the sensing points of the measuring devices as close as possible to the winding conductors; or

(b) For sealed units, such as epoxy-coated or epoxy-encapsulated units, use the average of four or more temperature sensors located on the enclosure and/or cover, as close to different parts of the winding assemblies as possible; or

(c) For ventilated units or sealed units, use the ambient temperature of the test area, only if the following conditions are met:

1) All internal temperatures measured by the internal temperature sensors must not differ from the test area ambient temperature by more than 2 °C.

Enclosure surface temperatures for sealed units must not differ from the test area ambient temperature by more than 2 °C.

2) Test area ambient temperature must not have changed by more than 3 °C for 3 hours before the test.

3) Neither voltage nor current has been applied to the unit under test for 24 hours. In addition, increase this initial 24-hour period by any added amount of time necessary for the temperature of the transformer windings to stabilize at the level of the ambient temperature. However, this additional amount of time need not exceed 24 hours (*i.e.*, after 48 hours, the transformer windings can be assumed to have stabilized at the level of the ambient temperature. Any stabilization time beyond 48 hours is optional).

3.3 *Resistance Measurement Methods.*

Make resistance measurements using either the resistance bridge method (section 3.3.1), the voltmeter-ammeter method (section 3.3.2) or resistance meters (section 3.3.3). In each instance when this Appendix is used to test more than one unit of a basic model to determine the efficiency of that basic model, the resistance of the units being tested may be determined from making resistance measurements on only one of the units.

* * * * *

3.3.2 *Voltmeter-Ammeter Method.*

(a) Employ the voltmeter-ammeter method only if the test current is limited to 15 percent of the winding current. Connect the transformer winding under test to the circuit shown in Figure 3.3. * * *

(b) To perform the measurement, turn on the source to produce current no larger than 15 percent of the rated current for the winding. Wait until the current and voltage readings have stabilized and then take a minimum of four readings of voltage and current. Voltage and current readings must be taken simultaneously for each of the readings. Calculate the average voltage and average current using the readings. Determine the winding resistance R_{dc} by using equation 3-4 as follows:

$$R_{dc} = (V_{mdc}/I_{mdc}) \qquad (3\text{-}4)$$

Where:

V_{mdc} is the average voltage measured by the voltmeter V, and

I_{mdc} is the average current measured by the ammeter (A).

* * * * *

3.3.3 *Resistance Meters.*

Resistance meters may be based on voltmeter-ammeter, or resistance bridge, or some other operating principle. Any meter used to measure a transformer's winding resistance must have specifications for resistance range, current range, and ability to measure highly inductive

resistors that cover the characteristics of the transformer being tested. Also, the meter's specifications for accuracy must meet the applicable criteria of Table 2.3 in section 2.3.

* * * * *

3.4.1 *Required actions.*

The following requirements must be observed when making resistance measurements:

* * * * *

(f) Keep the polarity of the core magnetization constant during all resistance measurements.

(g) For single-phase windings, measure the resistance from terminal to terminal. The total winding resistance is the terminal-to-terminal measurement. For series-parallel windings, the total winding resistance is the sum of the series terminal-to-terminal section measurements.

(h) For wye windings, measure the resistance from terminal to terminal or from terminal to neutral. For the total winding resistance, the resistance of the lead from the neutral connection to the neutral bushing may be excluded. For terminal-to-terminal measurements, the total resistance reported is the sum of the three measurements divided by two.

(i) For delta windings, measure resistance from terminal to terminal with the delta closed or from terminal to terminal with the delta open to obtain the individual phase readings. The total winding resistance is the sum of the three-phase readings if the delta is open. If the delta is closed, the total winding resistance is the sum of the three phase-to-phase readings times 1.5.

3.4.2 *Guideline for Time Constant.*

(a) The following guideline is suggested for the tester as a means to facilitate the measurement of resistance in accordance with the accuracy requirements of section 2.3:

* * * * *

3.5 *Conversion of Resistance Measurements*.

(a) Resistance measurements must be corrected from the temperature at which the winding resistance measurements were made, to the reference temperature.

* * * * *

4.1 *General Considerations*

The efficiency of a transformer is computed from the total transformer losses, which are determined from the measured value of the no-load loss and load loss power components. Each of these two power loss components is measured separately using test sets that are identical, except that shorting straps are added for the load-loss test. The measured quantities need correction for instrumentation losses and may need corrections for known phase angle errors in measuring equipment and for the waveform distortion in the test voltage. Any power loss not measured at the applicable reference temperature must be adjusted to that reference temperature. The measured load loss must also be adjusted to a specified output loading level if not measured at the specified output loading level. Test all distribution transformers using a sinusoidal waveform (k = 1). Measure losses with the transformer energized by a 60 Hz supply.

* * * * *

4.3 *Test Sets.*

(a) The same test set may be used for both the no-load loss and load loss measurements provided the range of the test set encompasses the test requirements of both tests. Calibrate the test set to national standards to meet the tolerances in Table 2.3 in section 2.3. In addition, the wattmeter, current measuring system and voltage measuring system must be calibrated separately if the overall test set calibration is outside the tolerance as specified in section 2.3 or the individual phase angle error exceeds the values specified in section 4.5.3.

(b) * * *

(c) Both load loss and no-load loss measurements must be made from terminal to terminal.

* * * * *

4.4.2 *No-Load Loss Test*.

* * * * *

(b) Adjust the voltage to the specified value as indicated by the average-sensing voltmeter. Automatically and simultaneously record the values of rms voltage, rms current, electrical power, and average voltage using a digital data acquisition system. For a three-phase transformer, take all of the readings on one phase before proceeding to the next, and record the average of the three rms voltmeter readings as the rms voltage value. NOTE: When the tester uses a power supply that is not synchronized with an electric utility grid, such as a dc/ac motor-generator set, check the frequency and maintain it within ±0.5 percent of the rated frequency of the transformer under test. A power source

that is directly connected to, or synchronized with, an electric utility grid need not be monitored for frequency.

* * * * *

4.4.3.3 *Correction of No-Load Loss to Reference Temperature.*

After correcting the measured no-load loss for waveform distortion, correct the loss to the reference temperature. For both certification to energy conservation standards and voluntary representations, if the correction to reference temperature is applied, then the core temperature of the transformer during no-load loss measurement (T_{nm}) must be determined within ±10 °C of the true average core temperature. For certification to energy conservation standards only, if the no-load loss measurements were made between 10 °C and 30 °C, this correction is not required. Correct the no-load loss to the reference temperature by using equation 4-2 as follows:

$$P_{nc} = P_{nc1}[1 + 0.00065(T_{nm} - T_{nr})] \quad (4\text{-}2)$$

Where:

P_{nc} is the no-load losses corrected for waveform distortion and then to the reference temperature,

P_{nc1} is the no-load losses, corrected for waveform distortion, at temperature T_{nm},

T_{nm} is the core temperature during the measurement of no-load losses, and

T_{nr} is the reference temperature.

* * * * *

5.1 *Output Loading Level Adjustment.*

If the per-unit load selected in section 2.1 is different from the per-unit load at which the load loss power measurements were made, then adjust the corrected load loss power, P_{lc2}, by using equation 5-1 as follows:

$$P_{lc} = P_{lc2}\left[\frac{P_{os}}{P_{or}}\right]^2 = P_{lc2}L^2 \quad (5\text{-}1)$$

Where:

P_{lc} is the adjusted load loss power to the per-unit load,

P_{lc2} is as calculated in section 4.5.3.3,

P_{or} is the rated transformer apparent power (name plate),

P_{os} is the adjusted rated transformer apparent power, where $P_{os} = P_{or}L$, and

L is the per-unit load, e.g., if the per-unit load is 50 percent then "L" is 0.5.

* * * * *

6.0 TEST EQUIPMENT CALIBRATION AND CERTIFICATION

Maintain and calibrate test equipment and measuring instruments, maintain calibration records, and perform other test and measurement quality assurance procedures according to the following sections. The calibration of the test set must confirm the accuracy of the test set to that specified in section 2.3, Table 2.3.

6.1 *Test Equipment.*

The party performing the tests must control, calibrate and maintain measuring and test equipment, whether or not it owns the equipment, has the equipment on loan, or the equipment is

provided by another party. Equipment must be used in a manner which assures that measurement uncertainty is known and is consistent with the required measurement capability.

6.2 *Calibration and Certification.*

* * * * *

(a) Identify the measurements to be made, the accuracy required (section 2.3) and select the appropriate measurement and test equipment;

* * * * *

7.0 TEST PROCEDURE FOR VOLUNTARY REPRESENTATIONS

Follow sections 1 through 6 of this appendix using the per-unit load and/or reference temperature of interest for voluntary representations of efficiency, and corresponding values of load loss and no-load loss at additional per-unit load and/or reference temperature. Representations made at a per-unit load and/or reference temperature other than those required to comply with the energy conservation standards at §431.196 must be in addition to, and not in place of, a representation at the required DOE settings for per-unit load and reference temperature. As a best practice, the additional settings of per-unit load and reference temperature should be provided with the voluntary representations.