DEPARTMENT OF ENERGY

Office of Energy Efficiency and Renewable Energy

10 CFR Part 431

[Docket No. EE–TP–98–550]

RIN 1904–AA85

Energy Conservation Program: Test Procedures for Distribution Transformers

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

ACTION: Final rule.

SUMMARY: Pursuant to Sections 323(b)(10) and 346(a) of the Energy Policy and Conservation Act, as amended, (EPCA or the Act), 42 U.S.C. 6293(b)(10) and 6317(a), the Department of Energy (DOE or the Department) promulgates a rule prescribing test procedures for measuring the energy efficiency of distribution transformers under EPCA, definitions to delineate the products covered by the test procedures, provisions (including a sampling plan) manufacturers must use to implement the test procedures, provisions to allow manufacturers to use calculation methods to determine the efficiency of some of their models, and enforcement testing for distribution transformers. The Department will use the new test procedures in evaluating what energy conservation standards are warranted for distribution transformers other than the low-voltage dry-type. When DOE promulgates such standards, then the test procedures and other provisions adopted today will be used to determine the efficiencies and assess compliance of the transformers subject to these standards. For low-voltage dry-type distribution transformers, the new standards prescribed for them in section 325(y) of EPCA, 42 U.S.C. 6295(y), go into effect on January 1, 2007, and all of the provisions of today's rule will become applicable to those transformers at that time.

EFFECTIVE DATE: This final rule is effective May 30, 2006, except for § 431.197(a)(4)(i), section 6.2(f) of Appendix A and section 6.2(b) and (c) of Appendix A which contain information collection requirements that have not been approved by the Office of Management and Budget (OMB). The Office of Energy Efficiency and Renewable Energy will publish a document in the **Federal Register** announcing the effective date.

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SUPPLEMENTARY INFORMATION:

I. Introduction

A. Authority and Background

Part C of Title III of the Energy Policy and Conservation Act (EPCA) provides for an energy conservation program for certain industrial equipment. (42 U.S.C. 6311–6317) Section 346 of EPCA states that the Secretary of Energy (Secretary) must prescribe testing requirements and energy conservation standards for those ''distribution transformers'' for which the Secretary determines that standards ''would be technologically feasible and economically justified, and would result in significant energy savings.'' (42 U.S.C. 6317(a)) The recent amendments to EPCA set forth in the Energy Policy Act of 2005 (EPACT 2005), Pub. L. 109–58, accomplish the following for this equipment: (1) Section 321(35) of EPCA now defines ''distribution transformer'' (42 U.S.C. 6291(35)), (2) Section 323(b)(10) of EPCA provides that the testing requirements ''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)),[1] and (3) section 325(y) of EPCA prescribes minimum efficiency levels for low-voltage dry-type distribution transformers (42 U.S.C. 6295(y)).

On October 22, 1997, the Department issued a notice setting forth its determination (hereafter referred to as the ''Determination'') that, based on the best information it had available, energy conservation standards for electric distribution transformers appeared to be technologically feasible and economically justified, and were likely to result in significant energy savings. 62 FR 54809.

The Department subsequently began the process for its issuance of test procedures for distribution transformers. On February 10, 1998, the Department held a public workshop (the ''1998 workshop'') to discuss the following issues: (a) Whether DOE

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[1] Section 323(b)(10)(B) also provides that the Department may ''review and revise'' the test procedures established under that subparagraph. (42 U.S.C. 6293(b)(10)(B))

should adopt national and international consensus standards as its test procedures for determining the energy efficiency of distribution transformers, (b) defining the transformers that the test procedures will cover, (c) whether, and to what extent, there is a burden on industry, especially on manufacturers, because of additional testing and data processing, (d) the definition of ''basic model'' for distribution transformers, (e) the sampling plan for units to be tested, (f) the selection of an energy consumption measure for distribution transformers, (g) the selection of reference temperatures, (h) the requirements for applying corrections to measurement data, and (i) the requirements for quality assurance in testing. The Department also gave interested parties an opportunity to submit written comments on these issues.

In 1998, the National Electrical Manufacturers Association (NEMA) published ''NEMA Standards Publication No. TP 2–1998, *Standard Test Method for Measuring the Energy Consumption of Distribution Transformers*,'' (NEMA TP 2–1998) a publication that extracts and presents pertinent parts of the current industry standards for distribution transformer efficiency testing. NEMA TP 2–1998 also presents a weighted average method to compute the energy efficiency of transformers, in order to demonstrate compliance with the efficiency levels in NEMA Standard TP 1–1996 (NEMA TP 1).[2] Comments received at the 1998 workshop, written comments associated with this workshop, and NEMA TP 2–1998 formed the basis for preparing the November 12, 1998, Notice of Proposed Rulemaking (the ''1998 proposed rule'') in this proceeding. 63 FR 63359.

In the 1998 proposed rule, the Department proposed to adopt testing methods that (1) it could use to evaluate distribution transformers during the development of efficiency standards, and (2) manufacturers and DOE would use to determine the efficiency of the transformers which the standards would cover. DOE proposed to incorporate by reference as its test methods the provisions from either the Institute of Electrical and Electronics Engineers (IEEE) Standards C57.12.90–1993 and C57.12.91–1993 (using IEEE C57.12.00–1993 as an additional reference source), or NEMA TP 2–1998. The 1998

proposed rule also included proposed definitions of ''distribution transformer'' and related terms, of terms used in the test procedure provisions, and of ''basic model.'' It also proposed a sampling plan for applying the test procedures to perform compliance testing. The sampling approach was based on the plan for compliance testing in 10 Code of Federal Regulations (CFR) Part 430, which contains energy efficiency requirements for consumer products, but tailored to distribution transformers and with a minimum sample size of five units. The Department selected this approach because it appeared to provide a satisfactory balance between assuring the accuracy of efficiency ratings for distribution transformers and minimizing the testing burden on manufacturers. The Department also sought comment on three alternative compliance approaches for basic models produced in small numbers.

DOE held a public meeting on January 6, 1999, on the 1998 proposed rule and received nine written comments. After reviewing the oral and written comments, DOE concluded that the comments raised a number of significant issues that required additional analysis. On June 23, 1999, the Department reopened the comment period on the 1998 proposed rule, 64 FR 33431, (the ''1999 reopening notice'') to provide an opportunity for additional public comment on the following issues: (a) The suitability of NEMA TP 2–1998 for adoption as the DOE test procedure; (b) the adequacy of stakeholder opportunity to review NEMA TP 2–1998; (c) the transformers covered under the definition of ''distribution transformer;'' (d) the suitability of the definition of ''basic model'' for the purpose of grouping transformers to limit the test burden; and (e) the appropriateness of the proposed sampling plan and a number of alternatives for demonstrating compliance. The Department received five comments in response to the 1999 reopening notice.

On the basis of these comments, two additional comments it received subsequently, and its review of the issues raised by the 1998 proposed rule and the 1999 reopening notice, the Department issued a supplemental notice of proposed rulemaking (SNOPR). 69 FR 45506 (July 29, 2004). In the SNOPR, DOE proposed to adopt (1) a new ''stand alone'' test procedure for distribution transformers, drafted by the Department and consisting almost entirely of test methods contained in NEMA TP 2–1998 and other existing industry standards, (2) revised definitions to establish which transformers the test procedure covers,

(3) a new definition of ''basic model'' and a new sampling plan, to implement the test procedures, (4) provisions to allow manufacturers to use calculation methods, instead of testing, to determine the efficiency of some of their models, and (5) enforcement procedures, including a testing protocol, for distribution transformers. DOE held a public meeting on September 27, 2004, on the SNOPR (the ''2004 public meeting'') and received six written comments.

Concurrently with this rulemaking, the Department has evaluated the establishment of energy conservation standards for distribution transformers. On October 2, 2000, the Department made available a *Framework Document for Distribution Transformer Energy Conservation Standards Rulemaking*, which was the subject of a public workshop on November 1, 2000, and on which stakeholders submitted written comments before and after the workshop. 65 FR 59761 (October 6, 2000). Thereafter, the Department visited manufacturers of distribution transformers and posted on DOE's website [3] several draft reports concerning the development of standards for these transformers. On the same day that it published the SNOPR, DOE issued an Advance Notice of Proposed Rulemaking (ANOPR) for distribution transformer standards. 69 FR 45376 (July 29, 2004). Several of the written comments DOE received in response to the ANOPR address issues raised in the SNOPR, and the Department has referenced them in the docket of this rulemaking and has considered them in formulating today's final rule.

On October 18, 2005, the Department published a final rule to place in its regulations the energy conservation standards, and related definitions, that Congress prescribed in EPACT 2005 for certain consumer products and commercial and industrial equipment. 70 FR 60407. The rule included the definitions for ''distribution transformer'' and ''low-voltage dry-type distribution transformer,'' and the standards for low-voltage dry-type distribution transformers, that were contained in EPACT 2005. 10 CFR sections 431.192 and 431.196. The Department put the provisions for all of the commercial and industrial products covered by EPACT 2005, including those for distribution transformers, in 10 CFR Part 431. 70 FR 60414–18. In the prior **Federal Register** notices dealing

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[2] NEMA TP 1 contains suggested efficiency levels. Its full name and title are ''NEMA Standards Publication No. TP 1–1996, *Guide for Determining Energy Efficiency for Distribution Transformers.*'' NEMA TP 1 was updated in 2002, with modifications to some of the efficiency levels.

[3] *http://www.eere.energy.gov/buildings/ appliance_standards/commercial/ dist_transformers.html*

with test procedures for distribution transformers, DOE had proposed adding a new part 432 to include requirements for distribution transformers. 63 FR 63376, 63369; 69 FR 45517, 45520. As a result of DOE's decision, in response to EPACT 2005, to incorporate provisions for distribution transformers into 10 CFR Part 431, today's final rule places the new test procedures for this equipment in Subpart K to 10 CFR Part 431.

B. Summary of the Final Rule

The test procedure in today's rule is based on the test methods contained in NEMA TP 2–1998 [4] and IEEE Standards C57.12.90–1999 and C57.12.91–2001. Initially, the Department will use the test procedure to evaluate distribution transformers for which it is currently developing energy conservation standards. When DOE promulgates such standards, the Department will then require manufacturers to use the test procedure to determine compliance with the standards and as a basis for their efficiency representations for covered transformers. The Department would also use the test procedure in any enforcement proceeding concerning compliance with such standards and related labeling requirements. In addition, the test procedures will become mandatory for all of these purposes—compliance determination, representations and enforcement—for low-voltage dry-type distribution transformers when standards go into effect for them, pursuant to 42 U.S.C. 6295(y), on January 1, 2007.

The language of today's rule sets forth all testing requirements, without reference to other sources, for determining the energy efficiency of distribution transformers. Measurement of electric power consumed by the transformer is in the form of no-load and load losses. The rule specifies methods with which to measure the temperature, current, voltage, extent of distortion in voltage waveform, and direct current resistance of the windings. The rule also prescribes provisions for calculating efficiency. The testing methods are largely the same as those proposed in the SNOPR, with several clarifying changes and a few changes to provide manufacturers with greater flexibility.

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[4] In September 2005, NEMA provided the Department with its revised test procedure document, TP 2–2005, which is similar to the rule language in the SNOPR. The Department has treated this submission as a comment on the SNOPR, has incorporated into today's rule a number of the changes that this revision made to the SNOPR's rule language, and addressed below the significant differences between the revision and the SNOPR.

Today's rule amends the definition of ''distribution transformer'' that DOE recently adopted, 70 FR 60416, by adding capacity limits (the same ones the Department proposed in the SNOPR), making minor language and format changes, and clarifying the exclusion of transformers with tap ranges greater than 20 percent. As discussed below, today's definition conforms to, and incorporates the relevant language from, the definition that EPACT 2005 added to EPCA. (42 U.S.C. 6291(35)) The Department's definition establishes which transformers the test procedure covers. It uses the approach DOE proposed in the SNOPR—a broad definition with numerical criteria, but narrowed by the exclusion of specific types of transformers, many of which are not commonly understood to be distribution transformers. The numerical criteria (except for the added capacity limits) and the exclusions are the same as those in EPCA's new definition. They include virtually the same primary and secondary voltage ranges the Department proposed in the SNOPR, most of the exclusions DOE proposed, and no additional exclusions. Today's definition of distribution transformer, however, does not include the exclusions of K-factor and harmonic mitigating distribution transformers, which DOE proposed in the SNOPR but which are absent from the EPCA definition. Stakeholders will have the opportunity in the energy conservation standards rulemaking to comment to the Department on whether standards should apply to these transformers.

Today's rule contains several features designed to reduce the number of transformers that manufacturers would have to test. First, the Department allows manufacturers to group models into ''basic models'' for testing purposes, and defines ''basic model'' as proposed in the SNOPR, with minor clarifications. Second, the rule includes the same type of compliance sampling plan proposed in the SNOPR, except that the sampling plan tolerance is based on a single-unit sample tolerance (confidence limit) of eight percent, rather than the five percent DOE proposed. And third, today's rule allows manufacturers to use alternative methods, other than testing, to determine the efficiency of some basic models. The rule incorporates the SNOPR proposal except that manufacturers need not use a different method for each of the following groups of distribution transformers: low-voltage dry-type, medium-voltage dry-type, and liquid-immersed. Manufacturers can use

a single method for transformers in two or all three of these groups so long as the method is validated separately in each of the groups for which the manufacturer uses it. Today's rule also contains the enforcement procedures proposed in the SNOPR, including a testing protocol, modified to be consistent with the revised compliance sampling plan tolerance. Finally, the Department is republishing in this rule, without substantive change, the standards for low-voltage dry-type distribution transformers that it originally codified at 70 FR 70417. Today's rule contains a revised table that has a clearer, more appropriate format than the table in the original rule. The table also includes the reference conditions for the standards, which DOE inadvertently omitted from the initial codification but which are essential elements of the standards, as set forth in Table 4–2 of NEMA TP 1–2002, from which EPCA incorporates the standards. (42 U.S.C. 6295(y))

II. Discussion

A. General

Representatives of several organizations attended the public meeting on September 27, 2004, including trade associations (Copper Development Association, National Electrical Manufacturers Association (NEMA), and National Rural Electric Cooperative Association), transformer manufacturers (Acme Electric Corporation (ACME), ERMCO Distribution Transformers (ERMCO), Federal Pacific Transformer (Federal Pacific or FPT), Kuhlman Electric Corporation, Pemco Corporation (Pemco), and Howard Industries, Inc. (Howard Industries or Howard)), a core steel manufacturer (AK Steel Corporation), electric utility companies (Georgia Power Company and Ameren Services), the Canadian Government (Natural Resources Canada), the National Institute of Standards and Technology (NIST) of the U.S. Department of Commerce, and private research/consulting entities (BB&F Associates, Lawrence Berkeley National Laboratory, Merritt and Associates, Navigant Consulting, Inc., and Optimized Program Services, Inc.). NEMA also submitted a written statement in advance of the public meeting. Following the public meeting, ERMCO, Federal Pacific, Howard Industries, Cooper Power Systems (Cooper) and NEMA each submitted a written statement. In addition, the Department received ten comments in its energy conservation standards rulemaking that pertained to both the

test procedure and the energy conservation standards rulemakings. Therefore, the Department cross-referenced these comments from the energy conservation standards docket (EE–RM/STD–00–550) to this proceeding. The ten cross-referenced comments were submitted by Pemco, ERMCO, Harmonics Limited, NEMA, Federal Pacific, HVOLT, Inc. (HVOLT), Oregon Department of Energy (ODOE), Howard Industries, Power Quality International (PQI) and EMS International Consulting (EMS).

The following summarizes the issues addressed in the preamble of the SNOPR and discusses in detail the points on which significant comments were presented during and after the public meeting.

B. Transformers Subject to the Test Procedure—Definition of Distribution Transformer

1. General

Although EPCA directed DOE to prescribe energy conservation standards and test procedures for certain ''distribution transformers'' (42 U.S.C. 6317(a)), until recently the Act did not define that term. Therefore, the Department undertook to adopt such a definition in this rulemaking. It proposed a definition in the 1998 proposed rule, 63 FR 63362–63, 63369–70, addressed the issue again in the 1999 reopening notice, 64 FR 33432–34, and proposed a substantially revised definition in the SNOPR. 69 FR 45506. That revised definition included transformers meeting numerical criteria as to primary and secondary voltage and capacity, and excluded specifically listed types of transformers. 69 FR 45509–10, 45520–22. The Department designed that definition primarily to (1) encompass within ''distribution transformer'' only those transformers commonly understood to be distribution transformers, i.e. those made for the distribution of electricity, and (2) exclude those distribution transformers for which standards clearly would not produce significant energy savings. 69 FR 45509–10.

EPACT 2005 recently revised EPCA to include a definition of ''distribution transformer'' (42 U.S.C. 6291(35)), thus filling the gap DOE had sought to fill with its own definition. As part of the final rule mentioned above, to place in the CFR certain provisions prescribed in EPACT 2005, the Department incorporated this new definition, almost verbatim, into 10 CFR section 431.192. 70 FR 60407, 60416–17. (In the paragraphs that follow, the new definition is referred to as the ''EPCA''

or ''new'' definition.) The EPCA definition is similar in approach and content to the definition proposed in the SNOPR. It includes numerical criteria—a maximum input voltage and frequency that are similar to those in the SNOPR definition, and a maximum output voltage that is identical—as well as a list of excluded transformers that is quite similar to the SNOPR's list of excluded transformers. (The differences between EPCA's list of exclusions and the SNOPR's list are discussed below. Today's rule adheres to the EPCA list.) The new definition also authorizes DOE to add to the list of exclusions any type of transformer that meets certain criteria.

One significant difference exists, however, between the numerical criteria in the EPCA and SNOPR definitions. No capacity ranges are stated in the new definition, whereas the SNOPR definition limits the term ''distribution transformer'' to liquid immersed units with a capacity of 10 kVA to 2500 kVA, and dry-type units with a capacity of 15 kVA to 2500 kVA. (The Department has been using a similar definition to delineate the transformers it is evaluating in the standards rulemaking. 69 FR 45381–45384.) Transformers outside of these ranges are not typically used for electricity distribution, which is the commonly understood function of a distribution transformer. The Department received no adverse comment on these proposed ranges. Moreover, NEMA agreed with the proposed lower capacity limit for dry-type transformers, indicating that efficiency standards for transformers with lower kVA ratings would fail to meet the criteria in section 346 of EPCA. (NEMA, No. 39 at p. 2; Public Meeting Transcript, No. 42.11 at p. 22) [5] But notwithstanding the lack of any explicit capacity limits in the EPCA definition of distribution transformer, as a practical matter an upper capacity limit is implicit in that definition. A transformer's capacity is to some extent tied to its primary (input) and secondary (output) voltages. Therefore, the

maximum limits for primary and secondary voltages, of 34.5 kilovolts and 600 volts, respectively, in the EPCA definition have the practical effect of limiting transformers that meet the definition to those with a maximum capacity in the range of approximately 3750 to 5000 kVA, or possibly slightly higher. The voltage limits in the EPCA definition, however, subsume no lower limit on capacity.

It is unclear whether ''distribution transformer'' as now defined in EPCA and DOE's regulations is, or can be, subject to capacity ranges other than the just-mentioned upper limit. On the one hand, the new definition includes no such capacity limitation, and it authorizes DOE to exclude from the definition, by rule, any transformer if it is designed for a special application, is unlikely to be used in a general purpose application, and significant energy savings would not result from applying standards to it. (42 U.S.C. 6291(35)(B)(iii)) This suggests that unless, and until, DOE acts and identifies capacity ranges that meet these criteria, they are not part of the new definition of distribution transformer. On the other hand, it is uncertain whether Congress intended to regulate as distribution transformers units outside of the capacity ranges in the SNOPR, because few are used to distribute electricity. In addition, at the same time it enacted the new distribution transformer definition, Congress also directed use of, and incorporated into EPCA, provisions of NEMA TP 2–1998 and NEMA TP 1–2002, respectively (42 U.S.C. 6293(b)(10) and 6295(y)), both of which apply only to transformers with capacity ranges similar to those in the SNOPR definition. Thus, Congress may have intended to limit the term ''distribution transformer'' to transformers within the capacity ranges that normally characterize transformers that distribute electricity. If so, that would mean the Department's authority to regulate the efficiency of transformers under 42 U.S.C. 6317 would be limited to transformers within these capacity ranges.

Given the inclusive language of EPCA's definition of distribution transformer, however, the Department is not prepared at this point to infer that EPCA imposes this limitation. The Department also does not possess information on whether transformers outside of these ranges would meet the criteria in 42 U.S.C. 6291(35)(B)(iii), particularly the one on energy savings from applying standards, for exclusion from the definition of distribution transformer. The standards rulemaking

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[5] A notation in the form ''NEMA, No. 39 at p. 2'' identifies a written comment the Department has received and has included in the docket of this rulemaking. This particular notation refers to a comment (1) by the National Electrical Manufacturers Association (NEMA), (2) in document number 39 in the docket of this rulemaking (maintained in the Resource Room of the Building Technologies Program), and (3) appearing on page 2 of document number 39. Likewise, ''Public Meeting Transcript, No. 42.11 at p. 22,'' for example, would refer to page 22 of the transcript of the ''Public Meeting on Test Procedures for Distribution Transformers'' held in Washington, DC, September 27, 2005, which is document number 42.11 in the docket of this rulemaking.

for distribution transformers, in which DOE would develop such information, and this test procedure rulemaking to a slightly lesser extent, have focused almost entirely on transformers within the capacity ranges. Thus, at the present time, DOE is proceeding on the premise that "distribution transformer" as defined in EPCA includes transformers outside the capacity ranges in the SNOPR.

One option, therefore, would be for the Department to retain this definition in its rules, not revise it in today's rule, and apply it in any standards rulemaking as well. That would have little or no impact on adoption of the test procedures in today's rule, but it might delay issuance of the rule. The Department believes that the test procedures as proposed in the SNOPR and revised for inclusion in today's rule would be valid for determining the efficiency of transformers with capacities up to the limits implicit in EPCA's definition, and below the lower end of the proposed ranges proposed in the SNOPR. Nevertheless, because DOE had not proposed to apply the test procedure to transformers with such capacities, it would have to provide some opportunity for public comment on the applicability of the test procedure to those transformers. Doing so could delay completion of this rulemaking.

The impact in the standards rulemaking, of applying the EPCA definition without capacity limits, would be much greater than the impact of doing so in this test procedure rulemaking. Formulating standards for a product involves developing an understanding of, and evaluating, factors such as the nature of the product, its market, the technical feasibility of potential efficiency improvements, the manufacturing costs of such improvements, the resulting energy savings, the cost of the improved product(s) to purchasers, the impact of efficiency standards on manufacturers and utilities, and environmental and employment impacts, as well as other factors unique to a particular product. The Department has been engaged in such activities with respect to distribution transformers for over five years, examining for the most part products within the capacity ranges in the SNOPR definition of distribution transformer. It is now developing proposed standards for these products. To expand that rulemaking now to include transformers outside these ranges would impose a substantial burden on DOE, and would substantially delay the rulemaking by requiring that the Department go back to

the beginning of the process of evaluating standards for these additional transformers. Neither DOE nor stakeholders contemplated that the standards rulemaking would cover these additional transformers. To the contrary, as indicated above, interested parties had reached a consensus as to the transformers to be covered in the standards rulemaking, and expect that DOE will now move as promptly as possible to promulgate standards for these transformers.

Another possibility would be for the Department to attempt to preserve the current scope of the standards and test procedure rulemakings by pursuing exclusion from the definition of distribution transformer, under 42 U.S.C. 6291(35)(B)(iii), of transformers with capacities outside the ranges specified in the SNOPR definition. This too would delay the rulemakings. For DOE to gather relevant information and assess whether transformers above and below the SNOPR's capacity ranges meet the criteria in 42 U.S.C. 6291(35)(B)(iii), would be burdensome and time consuming. And if DOE determined exclusion of these transformers to be warranted, it would have to undertake additional rulemaking proceedings to achieve such exclusion. Moreover, if DOE were to conclude that these transformers do not meet the criteria for exclusion, DOE would be in essentially the same position it is in now.

The Department is determined to avoid further delays in the rulemakings on standards and test procedures for distribution transformers. Therefore, it does not wish either to expand these rulemakings to cover transformers outside the SNOPR's capacity ranges, or to pursue at this time exclusion of such transformers from the definition of distribution transformer. Furthermore, the transformers within these capacity ranges clearly are within the new EPCA definition of distribution transformer, so the Department is authorized to pursue standards for them, and DOE believes there are ample grounds to conclude that such standards are warranted under the criteria of section 346(a) of EPCA, 42 U.S.C. 6317(a).

For these reasons, § 431.192 of today's final rule modifies the EPCA definition of distribution transformer that was recently incorporated into the DOE rules by adding to it the kVA capacity limitations in the SNOPR definition. This definition will not include, as it could not, any transformers excluded from the EPCA definition, and today's test procedure and any standards rulemaking will not cover such transformers. The Department is

adopting this definition, with its capacity limitations, for the purpose of delineating the coverage of today's rule, as well as the transformers that will be evaluated in the current standards rulemaking for distribution transformers. The inclusion of the capacity limitations in today's definition does not mean that DOE has concluded that the EPCA definition of distribution transformer includes such limitations. Rather, at some point after completion of the current rulemakings as to distribution transformers, the Department intends to evaluate transformers with larger and smaller capacities than those included in today's definition, review how EPCA should be construed with regard to those transformers, and decide what if any action to take with regard to adoption of efficiency requirements for such transformers. If DOE adopts efficiency requirements for any of these transformers, it would amend the definition of "distribution transformer" in its regulations accordingly.

Finally, the capacity limitations in today's definition of "distribution transformer" will have no effect on the existing requirements for low-voltage dry-type distribution transformers. EPCA sets forth a definition and standards for this equipment, 42 U.S.C. 6291(38) and 6295(y), which DOE incorporated into its regulations at 10 CFR sections 431.192 and 431.196(a). Because the definition states that a "low-voltage dry-type distribution transformer" is a "distribution transformer" that meets certain criteria, the addition of capacity limits to the definition of "distribution transformer" could be read as affecting what constitutes a "low-voltage dry-type distribution transformer" under the regulation. As stated above, however, the maximum limits for primary and secondary voltages of 34.5 kilovolts and 600 volts, respectively, in EPCA's definition of "distribution transformer," in effect limit transformers that meet that definition to those with a maximum capacity of approximately 3750 to 5000 kVA. Similarly, one of the criteria for a "low-voltage dry-type distribution transformer" is that its primary voltage not exceed 600 volts, 10 CFR section 431.192, which contemplates a secondary voltage much lower than 600 volts. The obvious effect of this is that a transformer will be a "low-voltage dry-type distribution transformer" under the regulations only if its maximum capacity is far less than 3750 kVA, and in all likelihood less than the 2500 kVA maximum in today's definition of distribution transformer. In addition,

EPCA and DOE rules prescribe standards for low-voltage dry-type distribution transformers only with kVA's within the range of 15 to 1000, 42 U.S.C. 6295(y) and 10 CFR section 431.196(a), which are within the 15 to 2500 kVA range that today's definition of "distribution transformer" incorporates for dry-type transformers. For these reasons, the capacity limitation in today's definition of "distribution transformer" has no impact on the current DOE and EPCA requirements for low-voltage dry-type distribution transformers.

2. Incorporation and Definition of EPCA's Exclusions—General

As indicated above, DOE incorporated into its rules the new EPCA definition of distribution transformer, including the language listing specific types of excluded transformers and authorizing DOE to add to that list. 70 FR 60416–17. Upon further review, the Department has decided to adopt in Section 431.192 of today's rule several editorial, clarifying and format changes to the language concerning the exclusions.

To begin with, this language states that the term "distribution transformer" does not include "a transformer that is designed to be used in a special purpose application and is unlikely to be used in general purpose applications, such as [the list of specifically excluded transformers]" (42 U.S.C. 6291(35)(B)(ii); 70 FR 60416–17) At first reading, this language appears to exclude unspecified types of transformers that meet the criteria just quoted, and to introduce a list consisting of specific illustrations of the transformers excluded. However, the very next paragraph of the definition states that DOE may, "by rule," exclude "any transformer not listed" which meets criteria that, in substantial part, are virtually identical to the criteria just quoted. (42 U.S.C. 6291(35)(B)(iii); 70 FR 60416) If the definition were read as excluding any transformer, in addition to those specifically listed, that met these criteria, this would obviate and render null the provision authorizing DOE to exclude additional transformers that meet these criteria, but only through rulemaking. The Department believes, however, that the soundest construction of these provisions is that transformers not specifically listed in the definition can be excluded only through a DOE rulemaking, thus providing certainty as to which transformers are covered at any given point in time. Use of the language quoted at the beginning of this paragraph to introduce the list of

specifically excluded transformers serves to describe those transformers, and helps indicate the types of transformers the statute authorizes DOE to exclude by rule. Therefore, because this provision does not actually delineate excluded transformers, and in order to avoid confusion as to the function of this language, DOE in today's rule has amended section 431.192 by excluding it.

As just indicated, DOE incorporated into its definition of distribution transformer language from EPCA that authorizes DOE to add to the list of excluded transformers. (42 U.S.C. 62912(35)(B)(iii); 70 FR 60416–17) Because this language authorizes action by DOE and does not actually describe transformers that are not "distribution transformers," upon further reflection the Department believes that the language need not be included in the definition in the DOE rules. Therefore, the Department has amended its definition of "distribution transformer" by omitting this language from section 431.92 of today's rule.

As to the specific exclusions, the Department indicated when it adopted the EPCA definition, 70 FR 60408, that the definition uses incorrect terms in its exclusions of "Uninterruptible Power System [UPS] transformer, impedance transformer, * * * [and] sealed and nonventilating transformer." (42 U.S.C. 6291(35)(B)(ii)) In accordance with its expressed intention to address such minor drafting problems in future rulemaking proceedings, where Congress has not already done so, 70 FR 60408, in today's rule DOE is amending its definition of distribution transformer to correct use of these terms. First, UPS transformers are commonly referred to as "Uninterruptible Power *Supply* transformers," not "Uninterruptible Power *System* transformers," and therefore DOE adopts the former term in today's rule. Second, every transformer has an impedance, but only transformers with impedances outside of normal ranges, *i.e.,* "special-impedance" transformers, warrant exclusion from standards. The Department had proposed to exclude such transformers from its definition of distribution transformer in the SNOPR, and NEMA excludes them from coverage of NEMA TP 1 and TP 2. Therefore, DOE construes EPCA as excluding "special impedance" transformers, and today's rule substitutes that term for "impedance" in the list of exclusions. Third, IEEE standards define "sealed" transformers separately from "nonventilated" transformers, treating them as two different types of transformers. The

definitions are such that it would be highly unlikely for a particular transformer to be both "sealed" and "nonventilated." In the SNOPR, DOE treated them as two separate exclusions from the term "distribution transformer," as it believes is appropriate. In light of the foregoing, DOE construes EPCA as containing separate exclusions for sealed and nonventilated transformers, and today's rule so provides.

The Department has also changed the format for the specific exclusions in section 431.192 of today's rule, and adopted the approach in the SNOPR, by placing the exclusions in a numbered list, rather than simply listing them seriatim in a single paragraph. The Department believes this will make the rule easier to read and use.

Finally, conforming to the approach in EPCA, DOE's recently adopted rule lists the 12 types of transformers it excludes from the term "distribution transformer," but contains no definition for any of them. 70 FR 60416–17. In the SNOPR, DOE proposed definitions for the transformers it proposed to exclude. The Department believes such definitions are warranted because they help to clarify exactly which transformers are covered. Today's rule includes seven definitions drawn from IEEE standards, and five that DOE developed based on industry catalogues, practice and nomenclature. DOE believes they represent a reasonable construction of the EPCA exclusions. Except as indicated in the discussion below of the definitions of special impedance, testing and grounding transformers, they are the same definitions DOE proposed in the SNOPR.

3. Specific EPCA Exclusions

a. Transformers With Tap Ranges of 20 Percent or More and Special Impedance Transformers

EPCA and the Department's recently adopted rule exclude from the definition of "distribution transformer" transformers with "multiple voltage taps, the highest of which equals at least 20 percent more than the lowest." 42 U.S.C. 6291(35)(B)(i); 70 FR 60416. The Department reads this language as excluding transformers with a tap range of 20 percent or more. It is similar to the exclusion in the SNOPR of transformers with a tap range greater than 15 percent. The language EPCA uses for this exclusion, however, is ambiguous.

Each distribution transformer with multiple voltage taps has a nominal voltage at which it normally operates and other voltages (taps), typically

above and below its nominal voltage at which it can also operate. The voltage taps enable the transformer to be connected to distribution lines at these other voltages. The tap range represents the difference between the highest and lowest voltage taps relative to the nominal voltage, expressed as a percentage. It is unclear whether, under the EPCA exclusion, a transformer's tap range is determined by computing the percentage of the voltage difference between its lowest and highest voltage taps relative to the voltage of the lower tap, or, as the industry has traditionally done, by adding the sum of the percentages by which the highest and the lowest voltage taps deviate from the nominal voltage. (The traditional industry method is equivalent to the percentage of the difference between the lowest and highest voltage taps relative to the nominal voltage.) These two approaches generally yield two different results for tap range value for any given transformer with multiple voltage taps. For example, a 600-volt primary transformer with two 2.5-percent taps above and four 2.5-percent taps below the nominal, with the highest tap being 630 volts and the lowest 540 volts, would normally be referred to as having a tap range of 15 percent (*i.e.,* 6 times 2.5 percent, or 90 volts as a percentage of 600 volts = 15 percent). Similarly, a 600-volt primary with three 2.5-percent taps above and three 2.5-percent taps below the nominal, with the highest tap being 645 volts and the lowest 555 volts, would also be referred to under the traditional industry approach as having a tap range of 15 percent. However, if the tap percentages for these transformers were calculated as a percentage of the voltage rating of the lowest tap (540 volts and 555 volts in these examples), these two transformers would have a tap range of 16.2 percent and a 16.7 percent, respectively.

The Department believes that EPCA's exclusion of transformers with a tap range of 20 percent or more is best construed as reflecting standard industry practice, such that tap ranges do not vary with the voltage rating of the lowest tap. Rather, tap range should be calculated, and excluded transformers identified, based on the industry practice of calculating the transformer's percent tap range relative to the nominal voltage of the transformer. Accordingly, the Department interprets EPCA as excluding transformers from the definition of "distribution transformer" when the aggregate of the transformer's highest to lowest tap voltages, relative to the nominal voltage, equals at least 20

percent. In section 431.192 of today's rule, the Department has incorporated this interpretation into its regulations by adding clarifying language to amend the regulation containing this exclusion that it adapted from EPCA in 70 FR 60416.

The Department also notes that EPCA includes this exclusion in a separate paragraph, rather than in the list that comprises the other exclusions from the definition of "distribution transformer." (42 U.S.C. 6291(35)(B)(i)–(ii)) See 70 FR 60416. To present this exclusion in the same format as the other exclusions, in section 431.192 of today's rule the Department has added "Transformer with Tap Range of 20 percent or more" to the list of exclusions and defined that term using the EPCA language that contains the exclusion, modified as just indicated.

As indicated above, the Department had proposed in the SNOPR to exclude transformers with tap ranges greater than 15 percent. 69 FR 45110, 45420–22. Pemco, a manufacturer, expressed the concern that, if the Department declines to adopt efficiency standards for distribution transformers with a tap range of greater than 15 percent (currently the standard tap range for low voltage dry-type transformers), manufacturers might begin producing transformers with a slightly larger tap range, and such transformers would not be covered by standards. (Pemco, No. 48 at p. 2) That could create a significant loophole under the regulations. Since the 20-percent tap range is larger than the previously proposed 15-percent range, exclusion of transformers with tap ranges of at least 20 percent should reduce the risk that transformers with slightly larger tap ranges would be produced in order to avoid coverage. But that risk will not be completely eliminated.

The exclusion of special impedance transformers, as provided in EPCA, as recently incorporated by DOE into 10 CFR section 431.192, and as previously proposed by DOE in the SNOPR, raises a similar issue. The issue is brought into focus by DOE's proposed definition for these transformers in the SNOPR. The proposed definition specified a normal impedance range for each standard kVA rating, and stated that a "special-impedance transformer" would be any transformer with an impedance outside the applicable range. Any such transformer would not be a "distribution transformer" covered by the proposed rule. 69 FR 45510–11, 45520–22. No commenter objected to this exclusion, and only one specifically addressed it. Howard Industries recommends that DOE replace its proposed normal impedance ranges

with ranges included in Howard's comments, which are more in line with ranges ANSI uses to delineate special impedance transformers and on which most utility systems are based. (Howard, No. 55 at p. 3) For most kVA levels, DOE's proposed ranges are broader than Howard's. Hence, DOE's ranges would result in exclusion of fewer transformers, by classifying fewer as "special impedance." In its revised test procedure document, NEMA TP 2–2005, NEMA incorporated DOE's proposed normal impedance ranges. (NEMA, No. 60 Attachment 1 at pp. 5–6)

The Department is concerned that some transformers designed for electricity distribution could be manufactured with impedances outside normal ranges so that they would not be subject to otherwise applicable efficiency standards. Such transformers could be less expensive to manufacture than normal impedance transformers manufactured in compliance with the standards, and therefore could have a competitive advantage over standards-compliant distribution transformers. If this occurred, it would subvert the standards. At best, the manufacturer(s) of such new, non-complying transformers would sell them in place of complying products they would otherwise have sold, and the product would have a share of the market for which DOE analysis demonstrated that standards were technologically feasible and economically justified. This would reduce energy savings below the levels that standards under EPCA are designed to achieve, and reduce the benefits transformer consumers and the public would realize from the standards. At worst, to avoid significant losses of market share to the competing, non-complying transformer, other manufacturers would be forced to produce the same type of non-complying unit. In that case, all or most of the benefit of standards could be lost.

The Department believes that use of the impedance ranges in the proposed rule, to delineate special impedance transformers, is a reasonable implementation of EPCA's exclusion of these transformers. This is the same approach, discussed above, that EPCA follows in its exclusion of transformers with non-standard tap ranges, in that only transformers that are considerably outside the normal ranges are excluded from coverage. To construe EPCA otherwise, that is, to construe it as excluding from coverage any transformer that falls outside the current, standard normal impedance ranges, could spawn a new generation of distribution transformers with impedances outside these ranges, which

would not be subject to Federal efficiency standards and test procedures. As just mentioned, this could subvert DOE's energy efficiency standards. NEMA's inclusion of DOE's proposed impedance ranges in the revised TP 2 standard provided to the Department, and the fact that only one commenter objected to them, indicate they are a sound basis for delineating the special impedance transformers that are excluded from coverage under today's rule and DOE's efficiency standards. Therefore, section 431.192 of today's rule retains the SNOPR's proposed definition of the ''special-impedance transformers'' excluded from the term ''distribution transformer.''

The Department recognizes that this approach may not prevent attempts to circumvent its efficiency requirements through manufacture of distribution transformers that appear to, or do, fall just within this exclusion or the exclusion of transformers with tap ranges of 20 percent or more. Such transformers could conceivably be manufactured for use in standard applications to distribute electricity in power distribution systems, but with efficiencies below those required by DOE's standards. Indeed, other exclusions from today's definition of distribution transformer could also be exploited to justify manufacture of transformers, for standard distribution applications, that do not meet DOE standards. The Department believes one such example may be the exclusion for drive (isolation) transformers. Such transformers can be similar to standard distribution transformers. A manufacturer might be able to produce and market, for standard distribution uses, a transformer that does not meet DOE efficiency standards but that clearly, or arguably meets, DOE's definition of ''drive (isolation) transformer,'' and claim that it is not a ''distribution transformer'' as defined by DOE.

The Department intends to strictly and narrowly construe the exclusions from the definition of ''distribution transformer.'' It will also take appropriate steps, including enforcement action if necessary, if any manufacturer or other party erroneously invokes one of the exclusions as a basis for marketing a transformer that is a ''distribution transformer'' under today's rule but does not meet DOE standards. Moreover, to the extent transformers that do fall within the exclusions begin to be marketed for standard distribution applications, or find widespread use in such applications, DOE will examine whether

re-defining the relevant exclusions, and/or legislative action, is warranted.

b. Testing Transformers

EPCA, and DOE's recent rule, also exclude a ''testing transformer'' from the definition of distribution transformer, 42 U.S.C. 6291(35)(B)(ii) and 70 FR 60416, as does section 431.192 of today's rule. The Department proposed this exclusion in the SNOPR. 63 FR 63363; 69 FR 45510. No stakeholder commented on it, in response to either the NOPR or SNOPR, except that in its revised TP 2–2005 document, NEMA deleted the following sentence from the SNOPR's proposed definition of ''testing transformer'': ''This type of transformer is also commonly known as an Instrument Transformer.'' (NEMA, No. 60 Attachment 1 at p. 7) An instrument transformer, however, is a type of transformer used for extending the voltage and current ranges of measuring and control instruments—such as voltmeters, ammeters, wattmeters, and relays—and is not the same as a testing transformer that supplies power to test electrical equipment. The Department recognizes that it erroneously included this sentence in the SNOPR definition of testing transformer and has deleted it from today's rule.

The Department believes that this error would not have lead stakeholders to infer that DOE had proposed to specifically exclude instrument transformers from the definition of ''distribution transformer'' in the SNOPR, for two reasons. First, the remainder of the proposed definition of testing transformer clearly did not include instrument transformers, and second, contrary to the incorrect sentence, testing transformers are not commonly known as instrument transformers. Nevertheless, to the extent the proposed rule may have been read to specifically exclude instrument transformers, DOE believes such an exclusion is unnecessary and unwarranted. The revised NEMA TP 2–2005 contains no such exclusion. Moreover, an instrument transformer would be designed to handle less power than the lower capacity limits (10 kVA for liquid-immersed and 15 kVA for dry-type) in today's definition of distribution transformer, unless it was also designed to distribute electricity. In the former case, the transformer would not be covered under today's rule (or under the SNOPR) even absent a specific exclusion, rendering an exclusion unnecessary. In the latter case, it *should* be covered, and subject to DOE efficiency standards and test procedures, as a ''distribution transformer.'' Hence, there is no reason

to consider further the exclusion of ''instrument transformers'' from today's definition of distribution transformer.

c. Grounding Transformers

Finally, section 431.192 of today's final rule contains a clarifying modification to the SNOPR's definition of ''grounding transformer.'' That definition referred to ''[a]n autotransformer with a zig-zag winding arrangement.'' 69 FR 45521. The Department has since become aware that this language is internally inconsistent, because an autotransformer with a zig-zag winding cannot be an autotransformer as defined in the rule, nor does it meet industry's conventional understanding of the term. The Department used the term autotransformer in the proposed grounding transformer definition to describe a type of transformer that does not have a separate physical secondary winding (unlike a conventional transformer). But although a three-phase autotransformer has three coils constituting the primary winding only, and no separate secondary winding, a section of each primary coil is ''tapped-off'' to create, in effect, a secondary winding. A grounding transformer, however, has only a primary winding, and no secondary winding output. In today's rule, in the definition of ''grounding transformer,'' the Department has replaced the reference to an autotransformer with a reference to a transformer with a primary winding and no secondary winding.

4. Other Exclusions Considered

The bulk of the comments on the SNOPR's definition of distribution transformer advocated eliminating or narrowing exclusions DOE had proposed, or adding other exclusions. EPACT 2005 incorporated none of these exclusions into EPCA.

In the SNOPR, DOE had proposed to exclude both harmonic mitigating transformers and K-factor (also referred to as ''harmonic tolerating'') transformers at K–13 and higher, largely based on its view that: (1) regulating them would not save significant amounts of energy, and (2) they are sufficiently expensive that there is little risk they would be purchased in place of more efficient transformers that would be subject to standards. 69 FR 45511, 45520–21. The Department also indicated its belief that few harmonic mitigating transformers would be commonly understood to be distribution transformers. 69 FR 45511. No commenter advocated retention of either exclusion, and several supported eliminating or narrowing them.

Supporting elimination of both exclusions, NEMA stated that the exclusions could be used to avoid efficiency standards. (NEMA, No. 39 at p. 2 and No. 47 at p. 2; Public Meeting Transcript, No. 42.11 at p. 22; NEMA No. 51 at p. 2) The Oregon Department of Energy raised doubts that these transformers would be unable to meet standards and saw no rationale for excluding them. (ODOE, No. 54 at p. 2) Harmonics Limited believes the market for them is large and growing, that use of K-rated transformers to circumvent existing standards has resulted in greater energy consumption, and harmonic transformers can both comply with standards and address harmonics issues. (Harmonics Limited, No. 50 at p. 1) ACME and Pemco advocated elimination of the exclusion for K-factor transformers (Public Meeting Transcript, No. 42.11 at pp. 32–33; Pemco, No. 48 at p. 2), and EMS International Consulting, Inc. (EMS) advocated elimination of the exclusion for harmonic mitigating transformers. (EMS, No. 57 at p. 3) In addition, EMS recommended that DOE cover K-rated transformers (up to a certain level which EMS did not specify), and Federal Pacific recommended narrowing the K-factor exclusion for transformers rated up to 300 kVA and broadening it for transformers above 300 kVA, both on grounds similar to those advanced by commenters who advocated its elimination. (EMS, No. 57 at p. 2; FPT, No. 44 at pp. 2–3 and No. 52 at p. 2)

Based on these comments, and upon further review, DOE has concluded there is not a sufficient basis at this point to exclude harmonic mitigating or K-factor transformers from the definition of distribution transformer. In essence, the Department proposed in the SNOPR to exclude these transformers on the grounds that they are not "distribution transformers," and that energy conservation standards for them would fail to meet the EPCA criteria in 42 U.S.C. 6317(a)(1) because such standards would not save substantial amounts of energy and/or be economically justified. Concerning the first point, as discussed above, EPCA, as amended in EPACT 2005, now defines the term "distribution transformer." Harmonic mitigating and K-factor transformers do not *per se* fail to meet the numerical criteria in this definition, nor are they in the definition's list of excluded transformers. (42 U.S.C. 6291(35)(A) and (B)(i)–(ii))

EPCA, as recently amended, now authorizes DOE, however, to exclude by rule any transformer if it is designed for a special application, if it is unlikely to be used in a general purpose

application, and if significant energy savings would not result from applying standards to it. (42 U.S.C. 6291(35)(B)(iii)) DOE previously relied on general information to support the views expressed in the SNOPR that harmonic mitigating and K-factor transformers would not be used for general purpose distribution applications, and that standards for them would not save significant amounts of energy. However, these conclusions were somewhat negated by the comments that these transformers could be sold in place of distribution transformers that are subject to standards, and that their use is increasingly common. Also, the Department is not aware of any more concrete information or analyses that address whether standards for these transformers could save energy. Thus, the Department now has no basis for excluding them under the new criteria in section 42 U.S.C. 6291(35)(B)(iii). For these reasons, DOE cannot conclude at this point that harmonic mitigating or K-factor transformers fail to meet the new EPCA definition of "distribution transformer."

Concerning the issue of whether these transformers should be excluded from DOE's definition of distribution transformer on the ground that energy conservation standards for them would not meet the criteria in 42 U.S.C. 6317(a)(1), as just set forth, there is insufficient basis to conclude that such standards would fail to save substantial amounts of energy. Furthermore, comments that harmonic mitigating and K-factor transformers could be manufactured to be in compliance with applicable efficiency standards without excessive cost suggest that standards for this equipment might well be economically justified. As with the issue of potential energy savings, the Department is not aware of any concrete information or analyses that suggest that standards for K-factor and harmonic mitigating transformers are not economically justified. Thus, the Department believes there is insufficient basis to conclude at this point that standards for these transformers would fail to meet the criteria in 42 U.S.C. 6317(a)(1).

Some commenters suggest adding other exclusions to the definition of distribution transformer. Federal Pacific recommends that mining transformers (transformers installed inside a mine, inside equipment operated in a mine, or as a component of underground-digging or tunneling machinery) be excluded from the application of standards, because of their radically different loss characteristics and special dimensional

constraints. (FPT, No. 52 at p. 2) Aligning with that comment, NEMA excludes mining transformers from its revised test procedure, TP 2–2005. (NEMA, No. 60, Attachment 1 at p. 1 and p. 4) Pemco asserts the need for an exclusion for transformers subject to dimensional, physical or design constraints, such as height limits, low temperature rise, special sound level requirements, weight limits, and suitability for high altitudes, which, according to Pemco, render it physically impossible or cost-prohibitive for these transformers to meet an efficiency standard. (Pemco, No. 48 at p. 1) Pemco also states that an exclusion is needed for retrofit transformers that have to be exactly the same as the ones they are replacing. (Pemco, No. 48 at p. 1–2) Similarly, Howard Industries advocates an exclusion for retrofit transformers, particularly underground and subway style transformers, on the grounds that they are subject to severe physical or electrical constraints, and would be unable to also meet energy conservation standards. (Public Meeting Transcript, No. 42.11 at p. 36; Howard, No. 55 at p. 3) However, although NEMA views the lack of an exclusion for retrofit transformers as problematic, it did not advocate such an exclusion because it has not formulated a definition or solution for this problem. (Public Meeting Transcript, No. 42.11 at p. 35)

In the SNOPR, DOE did not propose to exclude any of the foregoing types of transformers from its proposed definition of distribution transformer. And as with K-factor and harmonic mitigating transformers, EPCA excludes none of them from its definition of distribution transformer. (42 U.S.C. 6291(35)(A) and (B)(i)-(ii)) Furthermore, the commenters who supported these additional exclusions have provided neither data as to the energy savings potential of standards for these transformers, nor information as to the likelihood they could be used in general purpose applications, and the Department is not aware of any concrete information or analyses that address these points. Therefore, the Department has no basis for excluding any of the transformers discussed in this paragraph under section 321(35)(B)(iii) of EPCA. (42 U.S.C. 6291(35)(B)(iii)) As to whether these transformers satisfy the criteria in 42 U.S.C. 6317(a)(1) for adopting test procedures and standards, the commenters have provided broad claims, but no technical or factual evidence, that addresses this issue.

For these reasons, the Department has concluded that there is not a sufficient basis at this point to exclude harmonic mitigating or K-factor transformers, or

transformers subject to dimensional, physical or design constraints (including mining transformers), from today's definition of distribution transformer, and the definition does not exclude them.

Rather, DOE will revisit the issues of whether, and to what extent, these transformers should be subject to standards, and at what levels, during the standards rulemaking for distribution transformers. As set forth in the Determination notice, the Department can best address issues as to the technological feasibility, economic justification and potential energy savings of energy conservation standards in the standards rulemaking, particularly during evaluation of proposed standard levels. 62 FR 54810. For many products, such as the types of distribution transformers at issue here, the question of whether standards are warranted cannot adequately be addressed without detailed information and analysis. Once the Department has decided to propose additional standard levels for distribution transformers, and has provided its analysis of the levels it has considered in depth, stakeholders will have an opportunity to comment. They can provide factual information and analysis on issues such as whether the proposed standard levels, or other levels, are warranted for particular classes of transformers, including the types just discussed. These comments could also address whether some types of transformers should be completely or partially excluded from standards, including, for example, whether a portion of K-factor transformers should be excluded as advocated by Federal Pacific. To the extent information developed during the standards rulemaking warrants exclusion of any type of transformers from coverage of the new standards (and test procedures), the Department will modify its definition of "distribution transformer" accordingly.

5. Rebuilt or Refurbished Distribution Transformers

The Department did not specifically address in the SNOPR whether today's test procedure, as well as efficiency standards for distribution transformers, would apply to rebuilt distribution transformers (*i.e.,* units on which one or more windings have been replaced), or to used or repaired distribution transformers. Nor does EPCA specifically address this question. Several commenters stated that the requirements should apply to rebuilt transformers, commonly referred to also as refurbished transformers. EMS and HVOLT stated that coverage of rebuilt

units is necessary to close a potential loophole (EMS, No. 57 at p. 3; HVOLT, No. 53 at p. 3), and ERMCO stated that failure to cover rebuilt units might enable end-users to avoid standards by always rewinding failed units. (ERMCO, No. 49 at p. 2) Manufacturers appeared to be concerned that the increased cost of new, standards-compliant transformers would cause some customers to either purchase rebuilt, instead of new, transformers or rebuild existing transformers they already own. The Oregon Department of Energy agreed that rebuilt transformers should be required to meet new standards, indicating that high-quality rewinding practices can produce products that would meet standards while poor quality work can seriously degrade performance. (ODOE, No. 54 at p. 2) Some commenters also advocated coverage of used and/or repaired distribution transformers. (Howard, No. 55 at p. 3; EMS, No. 57 at p. 3)

EPCA, in essence, seems to require only new distribution transformers, that have not been sold to end users, to meet Federal efficiency requirements. (42 U.S.C. 6302, 6316(a) and 6317(a)(1)) Thus, DOE probably lacks authority to require that used and repaired transformers comply with its test procedures and standards. The same may be true for rebuilt transformers, although for them a genuine issue does exist as to DOE's authority. Generally, EPCA provides that products, when "manufactured," are subject to efficiency standards. (42 U.S.C. 6295(b)–(i) and 6313) It is arguable, but by no means clear, that rebuilt transformers could be considered to be "manufactured" again when they are rebuilt, and therefore be classified as new distribution transformers subject to DOE test procedures and standards. If, however, rebuilt products cannot be classified as newly manufactured, DOE would be subject to the same limitation on its authority to regulate them as applies to used and repaired products. In addition, contrary to the suggestion of some commenters that DOE regulate the efficiency of distribution transformers that their owners have re-wound, and where the transformer is not re-sold, EPCA provides authority to regulate only products that are sold, imported or otherwise placed in commerce. (42 U.S.C. 6291, 6311, and 6317(f)(1))

Throughout the history of its appliance efficiency program, DOE has not sought to regulate used units that have been re-conditioned or rebuilt, or have undergone major repairs. Regulating this part of the market, including the enforcement of efficiency requirements, could be an exceedingly

complex and burdensome task. By and large, the Department believes EPCA indicates a Congressional intent that DOE focus on the market for new products, and believes that this is where the largest energy savings can be achieved. For distribution transformers in particular, the Department understands that at present rebuilt transformers are only a small part of the market. Moreover, the core dimensions of existing units are fixed, whereas for many newly manufactured transformers the dimensions of existing models could be enlarged in order to allow their efficiencies to increase. Therefore, at least initially, any standard for rebuilt transformers would likely have to be lower than for comparable newly manufactured units, and given the current size of the refurbished transformer market, it appears that significant energy savings could not be achieved by adopting standards for them.

For all of these reasons, the Department does not intend to apply its standards and test procedures to used, repaired and rebuilt distribution transformers. Nevertheless, the Department recognizes that there may be some validity to the concerns raised by commenters about possible substitution of rebuilt for new transformers. If conditions change—for example, if rebuilt transformers become a larger segment of the transformer market—DOE will reconsider its decision not to subject them to energy conservation requirements.

6. Coverage of Liquid-Filled Transformers

Finally, Howard Industries suggested, with regard to liquid-filled transformers, that the utility, municipal, and co-op segment of the market not be subject to mandatory standards, because it already uses life-cycle cost methods in purchasing products, and that only the commercial and industrial segment be subject to such standards. (Howard, No. 55 at p. 4) This is an interesting suggestion, but the Department believes it is untenable because the distribution transformers used in these two market segments are not sufficiently different from one another. If the Department were to adopt efficiency requirements for transformers currently sold in one sector but not the other, DOE believes that the transformers it left unregulated would promptly find their way into the regulated market. The Department is charged with prescribing test procedures and energy conservation standards for those distribution transformers for which it determines standards are technologically feasible

and economically justified and would result in significant energy savings. Liquid-immersed distribution transformers sold into the utility, municipal and co-op segments of the market are ''distribution transformers'' as defined in section 321(35) of EPCA, and, because they clearly are designed for general purpose applications, DOE could not exclude them under paragraph (B)(iii) of that section. (42 U.S.C. 6291(35)) Moreover, in October 1997, the Department made a determination that energy conservation standards for liquid-immersed distribution transformers would appear to be technologically feasible and economically justified, and to result in significant energy savings. 62 FR 54816. For these reasons, today's definition of ''distribution transformer'' does not exclude liquid-immersed transformers, nor any subset of these transformers destined for any particular end-user or market segment.

C. Test Procedure for Distribution Transformers

1. General Discussion

The Department developed the test method in today's final rule (Appendix A to Subpart K of Part 431) in order to have a single, primary reference that would clearly set forth all testing requirements for distribution transformers that may be covered by EPCA energy conservation standards. Almost in its entirety, the test method closely follows NEMA TP 2–1998 and the following four widely used IEEE standards: (1) 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,'' (2) IEEE C57.12.91–2001, ''IEEE Standard Test Code for Dry-Type Distribution and Power Transformers,'' (3) IEEE C57.12.00–2000, ''IEEE Standard General Requirements for Liquid-Immersed Distribution, Power and Regulating Transformers,'' and (4) 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.''

As discussed in the SNOPR, the DOE did not propose to adopt NEMA TP 2–1998 verbatim as the DOE test method because of concerns about whether TP 2–1998 was sufficiently clear, detailed and accurate to serve as the DOE test procedure. 69 FR 45508–09. The Department had also identified problems with the clarity and level of detail in TP 2–1998 in the 1998

proposed rule. 63 FR 63362. Nor did the Department propose to incorporate the four IEEE standards by reference. As stated in the SNOPR, that would require users to consult several reference documents in order to construct the test procedure, whereas having a single reference test procedure would reduce the potential of misinterpreting testing requirements and would enhance the convenience to users. In addition the IEEE standards include test methods not only for distribution transformers, but also for much larger power transformers that are not covered by the DOE test procedure. Nevertheless, the Department relied heavily on techniques and methods from NEMA TP 2–1998 and the four IEEE standards in developing the proposed test procedure and today's final test procedure.

EPACT 2005, which the President signed into law on August 8, 2005, amended EPCA in effect to direct the Department to develop a test procedure for distribution transformers that is ''based on'' NEMA TP 2–1998. (42 U.S.C. 6293(b)(10)). In the SNOPR, DOE stated that it had ''adapted virtually all of the provisions of the [proposed] test procedure from NEMA TP 2[–1998] and the * * * four widely used IEEE standards'' just cited, and had used NEMA TP 2–1998 to develop the proposed test procedure. 69 FR 45508. The Department did not receive any comments from stakeholders indicating that they took issue with these statements. As stated above, today's testing methods are largely the same as those proposed in the SNOPR. Thus, as also set forth above, NEMA TP 2–1998 and the IEEE standards are the bases for these test methods. Indeed, because NEMA TP 2–1998 is based on the IEEE standards, and represents an attempt to incorporate them into a single document, any test method that incorporates the substance of these standards would conform to TP 2–1998. Furthermore, today's test methods and those in NEMA TP 2–1998 are entirely consistent with one another. For all of these reasons, it can be fairly stated that today's test procedure is ''based on'' NEMA TP 2–1998, within the meaning of 42 U.S.C. 6293(b)(10), and satisfies the Congressional intent that the DOE test procedure reflect the content of TP 2.[6]

In response to the SNOPR, several commenters requested that DOE rely on existing testing standards as much as possible, as it does for other products, instead of adopting a new stand-alone test procedure. (FPT, No. 44 at p. 7; Public Meeting Transcript, No. 42.11 at pp. 49, 54–55) NEMA expressed concern that the Department's proposal differed significantly from the existing testing methods (NEMA TP 2–1998 and IEEE), and asserted that industry engineers would need to become experts in the new method, and that this could be a difficult, time consuming process. (Public Meeting Transcript, No. 42.11 at pp. 49–51, 53, 60) The Department recognizes that there will be some burden on manufacturers resulting from today's stand-alone test procedure. This burden, however, should be minimal. The test methods in the DOE test procedure are virtually identical to those in the TP 2–1998 and IEEE standards, and require the same steps for determining losses and calculating efficiency. Comments from stakeholders offered no specifics as to why use of the DOE test procedure would be burdensome for manufacturers and identified no specific provisions in DOE's proposed test procedure that deviate from the TP 2–1998 or IEEE standards. Furthermore, in NEMA's revised TP 2 document, TP 2–2005, the test method closely parallels the SNOPR rule language. (NEMA, No. 60, Attachment 1) This indicates that, upon further reflection, NEMA believes use of DOE's proposed test procedure would not be burdensome for manufacturers.

Federal Pacific states that manufacturers will still be required to reference industry standards, in addition to DOE standards. (FPT, No. 44 at p. 6) The Department believes that due to the similarities between today's test procedure and the TP 2–1998 and IEEE documents, a manufacturer following the DOE test procedure would also be consistent with NEMA TP 2–1998 and the IEEE test procedures.

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[6] Although NEMA TP 2–1998 contains a sampling plan for establishing compliance with prescribed efficiency levels, the compliance sampling plan in today's rule, which is discussed in section II–E below, is not based on the plan in TP 2. EPACT 2005 mandates that the Department use 12 industry or voluntary test procedures, each for a different type of product, as the basis for DOE test procedures for those products. All contain test

methods, but NEMA TP 2–1998 appears to be the only one that contains a sampling plan. Moreover, for the reasons explained in the SNOPR, that sampling plan is inconsistent with the standards and labeling requirements in EPCA for distribution transformers, and with basic, long-standing elements of DOE's appliance efficiency program. 69 FR 45514. Congress gave no indication in enacting EPACT 2005 that it intended its mandate for use of NEMA TP 2–1998 to change EPCA's standards and labeling requirements, or the structure of DOE's program, for this product. For these reasons, DOE believes Congress intended to require that DOE's test methods for distribution transformers, but not its compliance sampling plan, be based on NEMA TP 2–1998. Accordingly, the Department construes 42 U.S.C. 6393(b)(10) as not affecting the content of its compliance sampling plan for distribution transformers.

Therefore, manufacturers would not have to take separate steps to assure compliance with each test procedure.

Federal Pacific also asserts that a stand-alone DOE test procedure may become a problem if IEEE, ANSI, or NEMA adopt changes to their standards because the changes may have to be incorporated into the DOE test procedure. (FPT, No. 44 at pp. 6–7) This issue is not unique to transformers, and exists whether DOE has a stand-alone test procedure or incorporates by reference one or more industry standards, such as the IEEE test methods for transformers. The Department regulates many other consumer products and commercial equipment, all of which have test procedures. Some of these are DOE-developed, stand-alone test methods, and others incorporate by reference industry standards. Even in the latter situations, no change to an industry standard becomes part of the DOE test procedure unless and until the Department adopts it. In the event of an industry-consensus revision to the test methods for distribution transformers, the Department would consider all petitions from manufacturers seeking to incorporate those changes into today's test procedure.

In sum, the Department continues to believe that having a single, reference test procedure document would enhance the convenience to users and reduce the potential for misinterpretation of testing requirements. Today's final rule adheres to that approach rather than incorporating provisions from the existing industry test procedures.

Commenters did not disagree with the Department's decision not to adopt NEMA TP 2–1998, without modification, as the DOE test procedure. In written comments and during the SNOPR public workshop meeting, however, NEMA proposed that DOE, NEMA and other stakeholders work together to reach a consensus on needed revisions of TP 2, so that NEMA could revise it and DOE could then incorporate it by reference. (NEMA, No. 39 at p. 1; Public Meeting Transcript, No. 42.11 at pp. 22, 49–51, 53, 56–57) NEMA has now completed its revision of TP 2, informing DOE that it obtained approval from its membership and adopted TP 2–2005 on September 19, 2005. (NEMA did not indicate whether other stakeholders were involved in this process.) NEMA proposes that DOE adopt the TP 2–2005 document as its test procedure for distribution transformers, and reference it in the final rule for such test procedures. (NEMA, No. 60 at p.1)

The Department believes that such action would be inappropriate. The Department recognizes NEMA's efforts to revise TP 2 and appreciates NEMA's openness, including its submission of a draft TP 2–200X document in March 2005 (NEMA, No. 59 Attachment 1) and the final TP 2–2005 document in September 2005 (NEMA, No. 60 Attachment 1). These submissions have made a definite contribution to this proceeding. As indicated elsewhere in this preamble, these submissions identified changes that were needed in the proposed rule, and that DOE has adopted in today's final rule. These changes include modification of the definition of load loss and several editorial changes. As also discussed in this preamble, however, stakeholder comments submitted in response to the SNOPR, as well as DOE's own review, have resulted in many other changes that clarify and improve the proposed test procedure. These additional changes include provisions for testing harmonic transformers, clarification of the language concerning test set neutrals, and an alternative to the proposed method for providing short-circuiting conductors. None of the additional changes are reflected in NEMA's final TP 2–2005 document. Moreover, TP 2–2005 contains a number of changes from the SNOPR that should not be included in today's final rule, such as the exclusion of mining transformers. For these reasons, the Department is not incorporating TP 2–2005 as its test procedure rule for distribution transformers. That said, in the future, the Department would consider incorporating verbatim the NEMA test method in TP 2 so long as its substance conforms with the test method then in effect.

2. Specific Provisions of the Test Procedure

a. Testing Harmonic Transformers

As discussed earlier in this notice, the Department proposed in the SNOPR to exclude both harmonic tolerating (K-factor) transformers with a K-factor of K–13 or greater and harmonic mitigating transformers from the definition of distribution transformer, but today's definition includes both of these types of transformers. Several stakeholders who recommended removal of the exemption for these transformers, also recommended that the test procedure should require testing using a linear load profile (K=1), namely, using the fundamental-frequency test current in the measurement of load loss. (NEMA, No. 47 at p. 1; NEMA, No 51 at p. 1; HVOLT, No. 53 at pp. 2–3; PQI, No. 56

at p. 3) Federal Pacific stated that absent an industry standard harmonic load profile, K=1 is the only available method for consistently testing transformers designed for harmonic currents. (Public Meeting Transcript, No. 42.11 at pp. 33–34) Federal Pacific also commented that it uses K=1 to test K-factor transformers when a customer specifies a K-factor transformer but also wants it to meet TP 1 efficiency levels. (FPT, No. 44 at p. 2) When a harmonic transformer is tested with a linear load, however, its measured losses are lower than the losses it would experience under non-linear loads. Therefore, the efficiency rating that results from testing the transformer with a linear load will be higher than the actual efficiency of the harmonic transformer during normal operation (*i.e.,* when the transformer is subject to non-linear loads). Nevertheless, as one commenter indicated, testing harmonic transformers at linear loads does offer a straight-forward testing method that avoids over-complicating the issue. (FPT, No. 44 at p. 3, and No. 52 at p. 2) The Department believes that if its efficiency standards become applicable to K-factor and harmonic mitigating transformers, more efficient harmonic transformers will be manufactured than if the standard did not apply to them. DOE agrees with the above comments, and therefore today's final rule, in Section 4.1 of the test procedure, requires that manufacturers test these transformers using fundamental-frequency test current (corresponding to a linear (K=1)) load).

b. Determining Winding Temperatures

Today's test procedure expands the options available to manufacturers for determining the winding temperature of liquid immersed transformers. IEEE C.57.12.90–1999 provides that the temperature of windings of a liquid-immersed transformer is assumed to be the same as the temperature of the liquid in which the windings are immersed. Adding specificity to this approach, the Department proposed in the SNOPR that the winding temperature of a liquid-immersed distribution transformer would be the average of two temperature sensing devices applied to the outside of the transformer tank, at top oil level and at the bottom of the tank. Howard Industries questioned the accuracy of this method for determining winding temperatures, and recommended instead that DOE require direct (internal) top and bottom measurement of the liquid temperature to determine winding temperature. (Howard, No. 45 at p. 1)

The Department understands that the most common method in the distribution transformer industry for estimating the temperature of liquid immersed windings is by using thermocouples attached to the exterior of the transformer tank, as proposed in the SNOPR. Furthermore, as also proposed in the SNOPR, today's rule requires that winding temperature be measured only after certain conditions have stabilized, which provides greater assurance that these external measurements are a good estimate of the winding temperature. For these reasons, DOE believes Howard's recommendation that DOE *require* direct top and bottom measurement of the liquid could impose significant and unnecessary burdens on manufacturers. Nevertheless, the Department recognizes that such direct measurements would be at least as accurate as external measurements, and that testers who prefer to make direct measurements should be allowed to do so. Therefore, today's final rule allows manufacturers to determine the winding temperature using either exterior tank measurements or direct liquid measurements.

The Department understands that testers normally make external tank temperature measurements using thermocouples that are designed to be thermally insulated from the surrounding environment. The use of insulated thermocouples reduces error in the temperature measurement, and offers greater accuracy in determining the winding temperatures. Therefore, the Department has modified the language in proposed section 3.2.1 to clarify that these external temperature measurements must involve the use of insulated thermocouples.

In addition, proposed section 3.2.1 would give manufacturers the choice of waiting to measure winding temperature until either (a) the windings have been under insulating liquid with no excitation and no current in the windings for four hours before the direct current (dc) resistance is measured; or (b) the temperature of the insulating liquid has stabilized, and the difference between the top and bottom temperature does not exceed 5 °C. These conditions each provide assurance that the temperature of the windings has stabilized when manufacturers measure it. The Department took these two conditions from IEEE C57.12.90–1999, which requires that *both* be met when the tester measures the winding temperature. Howard Industries commented that the DOE test procedure should also require that both be met, to be consistent with the IEEE standard. (Howard, No. 45 at p. 2) The

Department recognizes the value of being consistent with IEEE. However, the Department does not believe that for distribution transformers, meeting both conditions is necessary. The IEEE standard encompasses kVA ratings of transformers that are much larger (up to 500,000 kVA and larger) than those covered by today's final rule (no larger than 2,500 kVA). The Department believes that for distribution transformers, which are relatively small compared to many of the kVA ratings addressed by IEEE, manufacturers can achieve accurate winding temperature readings if one of these two conditions is met. Therefore, the language in today's final rule does not require that both conditions be met.

The Department has also made some clarifying and editorial changes to the language of section 3.2.2 in today's rule, which concerns determination of the winding temperature of dry-type transformers. Section 5.2 of IEEE C57.12.91–2001 allows for the determination of such winding temperatures, for both ventilated and sealed units, through either direct measurement or use of the ambient temperature of the test area. The IEEE standard permits the latter, however, only under certain conditions. The Department intended to incorporate the IEEE approach in section 3.2.2 of the test procedure in the SNOPR, but that language appeared instead to permit use of the ambient temperature only in determining the winding temperatures of sealed units, and to apply the conditions for use of ambient temperature also to use of direct measurement. Section 3.2.2 of today's final rule contains revised language that clearly incorporates the IEEE approach.

c. Test Set Neutrals

Part 4.0 of the proposed test procedure set forth provisions for determining transformer losses, including requirements for the test circuits and test sets used during testing. Section 4.3.3 of the SNOPR required use of a "four-wire, three-wattmeter test circuit," and, for delta-wound transformers, use of "a neutral deriving transformer * * * to obtain neutral and ground." Commenting on this section, Howard Industries stated that "[t]here are options for the design of the power source used to test distribution transformers," and recommended adding to this section the phrase "unless the source is WYE connected." (Howard, No. 45 at p. 2) Although the Department does not agree with the change Howard recommended, this comment indicates a need to clarify section 4.4.3. A wye-connected power

source can be used to test either a wye- or delta-wound transformer, and a neutral deriving transformer is not needed, and rarely if ever used, to obtain a neutral and ground. The Department has added language to today's final rule to make clear that the test procedure allows the use of wye- and delta-wound power source transformers for testing, and only requires use of a neutral deriving transformer in conjunction with a delta-wound transformer.

Today's final rule also contains a few editorial changes with respect to section 4.3.3 of the SNOPR test procedure. First, because the first sentence of that section, as proposed, concerned three-phase distribution transformers generally and not merely test set neutrals, DOE has now moved the language to section 4.3.2. Second, the remaining language of section 4.4.3 in the SNOPR related only to testing of three-phase transformers, and therefore it has been renumbered in today's final rule as section 4.3.2.3 (part of Three-Phase Test Sets). Third, to improve clarity, the term "grounding transformer" has replaced the term "neutral deriving transformer" throughout the test procedure. This is because "grounding transformer" is more widely understood in the distribution transformer community as referring to the type of transformer used to create a grounded neutral for a delta-wound transformer.

d. Losses From Auxiliary Devices

Sections 4.4.3.1 and 4.5.3.1 of the SNOPR test procedure required losses attributable to test instrumentation to be deducted from measured no-load and load losses, respectively, in determining the total losses of a transformer. Commenters suggested that the final rule also require manufacturers, in determining load losses, to exclude those losses attributable to auxiliary devices installed on a distribution transformer but which are separate from the transformer, such as circuit breakers, fuses, and switches, because such losses are not related to losses from the transformer's windings. (Howard, No. 45 at p. 1, and No. 55 at p. 3; ERMCO, No. 49 at pp. 1–2) These commenters raise a valid concern, although today's final rule *permits,* but does not *require,* the deduction or exclusion of auxiliary device losses from the measured load losses.

When a distribution transformer is equipped with auxiliary devices (generally specified by the customer), these devices produce some energy losses, albeit relatively small in comparison to the unit's total losses.

DOE anticipates that its efficiency standards would apply to distribution transformers without regard to whether auxiliary devices are installed. The standards therefore would not govern the efficiency of auxiliary devices, but instead would apply to the performance of the basic transformer (the equipment to which the auxiliary devices are added). Because the Department is concerned that some manufacturers may find it burdensome or problematic to exclude all or part of the losses attributable to auxiliary devices, each manufacturer will have the discretion to include or exclude some or all of the auxiliary-device losses in the determination of load losses. Although exclusion of all such losses would result in a more accurate efficiency rating for the transformer being tested, inclusion of such losses would understate the efficiency rating of the transformer, and not circumvent any applicable standard. The purchaser would be receiving a slightly more efficient piece of equipment than indicated by the rating. This approach is consistent with the Department's regulations in other portions of its appliance standards program, which generally allow manufacturers the discretion to rate their products at efficiencies lower than could be justified by test results. *e.g.*, 10 CFR section 430.24. It is also consistent with the IEEE standards, which set forth test methods for distribution transformers but do not require exclusion of losses from accessories in measuring transformer losses.

Today's final rule also takes this same approach for instrumentation losses. For the reasons just stated, the Department believes DOE's test procedure should permit, but not require, (as proposed in the SNOPR) that manufacturers deduct instrumentation losses from total losses in determining transformer efficiencies. This will allow manufacturers greater flexibility than was provided by the SNOPR proposal, with no detriment to the public or circumvention of any applicable standard.

Therefore, section 4.5.3.1 of today's test procedure allows manufacturers to exclude from measured load losses those losses attributable to auxiliary devices, and sections 4.4.3.1 and 4.5.3.1 allow exclusion of losses attributable to testing instruments from both no-load and load losses. The Department has, however, slightly modified the SNOPR language in proposed sections 4.4.3.1 and 4.5.3.1 that identified the sources of instrumentation losses. The final rule omits the reference to ''ammeter'' because, upon further consideration, DOE now realizes that no measured transformer losses are attributable to

this instrument. The Department has also made two other similar modifications. The term ''wattmeter'' is replaced by ''wattmeter voltage circuit'' because a wattmeter experiences losses through both its current and voltage circuits, but only losses from the voltage circuit are part of measured transformer losses. The term ''instrument transformer'' is changed to ''voltage transformer'' because ''instrument transformer'' refers to both current and voltage transformers, both of which experience losses, and it is only losses of the voltage transformer that are part of measured transformer losses and should be deducted from the total measured losses. None of these revisions is a departure from the substance of the SNOPR. Rather they improve the precision of the final rule and reduce the risk of misinterpretation or misapplication of the test procedure.

With respect to how to deduct the losses from auxiliary devices from the measured load losses, one commenter suggested exclusion of the losses from auxiliary devices by removing the devices (Howard, No. 45 at p. 1), and another suggested excluding the losses by deducting them from measured losses. (ERMCO, No. 49 at p. 2) Because the Department believes both approaches are sound, and would produce the same results, today's final rule allows manufacturers the flexibility of using either one.

e. Testing of Multiple Voltage Transformers

Today's final rule also clarifies treatment of dual-or multiple-voltage transformers under the Department's test procedure. Distribution transformers can be designed with multiple voltage ratings on the primary and/or secondary windings. Efficiency testing for these units can be problematic because, for a given transformer and kVA rating, DOE understands that each transformer will have two or more different efficiencies, *i.e.*, one efficiency for each of its winding configurations. In other words, each multiple voltage transformer experiences different losses (and therefore different efficiencies) when operated at different voltages. This difference in losses is due to differences in current associated with the voltage configuration selected, and generally, the lower voltage ratings will have the higher losses and therefore lower efficiency ratings. The Department intends, however, to have just one standard level that would apply to all transformers in a given class, regardless of the voltage or voltages at which each

transformer in that class is designed to operate.

Howard Industries commented that the efficiency measurement on series or multiple voltage transformers should always be based on the highest voltage configuration. (Howard, No. 45 at p. 2; Howard, No. 55 at p. 3) The Department is unable to accept this recommendation, because a transformer designed to operate at more than one nominal voltage would have to comply with the standard at all voltage ratings. Because the lowest voltage ratings would generally have the lowest efficiency ratings, to ensure that each multiple voltage transformer complies with the applicable standard at each voltage at which it operates, the manufacturer would have to determine the transformer's efficiency by testing it (or by calculating its efficiency using an AEDM), either at the voltage rating at which the highest losses occur— generally the lowest voltage—or at each voltage at which the transformer operates. Therefore, today's final rule requires the manufacturer to determine the basic model's efficiency either at the voltage at which the highest losses occur or at each voltage at which the transformer is rated to operate.

f. Short-Circuiting Conductor Strap

Section 4.5.2 of the SNOPR stated that in the test for measuring load losses, ''[t]he conductors used to short-circuit the windings must have a cross-sectional area equal to, or greater than, the corresponding transformer leads.'' 69 FR 45530. Howard Industries asserted that other methods exist for providing short-circuiting conductors or their equivalent, and that the test procedure should also permit manufacturers to use any short circuiting conductor that is ''of sufficient size to limit the tare watts to less than 10 percent of the transformer load losses.'' (Howard, No. 45 at p. 2) In industry parlance, ''tare watts'' are losses associated with the test set-up, and in this instance refer to losses in the short-circuiting conductor. The short-circuiting conductor losses incurred during testing are included in the measured load losses for the transformer being tested, but, as discussed above, may be deducted from the measured load losses. The Department's proposed requirement of a cross sectional area equal to, or greater than, the corresponding transformer leads is based on use of a simple, routine method for short-circuiting the windings by means of the shortest practical conductor between the terminals of the transformer. The Department believes this proposed

requirement would limit the short-circuiting conductor losses to approximately one to three percent of the transformer's measured load losses. Howard's recommended revision contemplates allowing a less conventional approach, and would allow losses in the short-circuiting strap to be as much as ten percent of the load losses.

The Department's proposal generally follows the approach taken in the relevant IEEE standards. The IEEE standards are voluntary, however, and do not preclude manufacturers from using new, improved methods that do not strictly adhere to those standards. But incorporating the standards into DOE's test procedure would make them mandatory and limit manufacturer flexibility to use such new methods.

The determination of losses in the short-circuiting strap is subject to errors, which will contribute to the overall error in the determination of transformer losses because manufacturers can deduct the short-circuiting losses from the measured load losses in making their determination of total losses. DOE is concerned that increasing the permissible losses, as proposed by Howard, might also increase the overall error—perhaps beyond acceptable limits—unless appropriate care is exercised to determine the higher losses of the short-circuiting conductor. Today's rule, however, does not permit automatic deduction of 10 percent or any other fixed percent of losses denominated as occurring in the short-circuiting conductor or any other instrument or device. Instead, the rule provides that, in determining measured load losses, manufacturers may deduct only the losses "attributable" to the short-circuiting conductor (as well as certain other instruments and devices). Thus, the rule allows deduction only of actual losses, *i.e.*, losses determined with a reasonable degree of accuracy. Moreover, notwithstanding any increase in the amount of error that would be introduced by adoption of Howard's proposal in today's rule, the overall limit on the range of error for measurement of power losses remains at ± 3 percent, as proposed in the SNOPR. Thus, adoption of the proposal would not have a significant effect on overall results determined under the test procedure.

For these reasons, today's rule allows manufacturers to use alternatives to the method specified in proposed section 4.5.2(b) for providing short-circuiting conductors, so long as such alternatives do not result in losses that are 10 percent or more of the total load losses.

The language to implement this approach, however, varies slightly from the language proposed by Howard Industries. Howard's proposed language could be construed as permitting losses as great as 10 percent, even if a manufacturer uses the method prescribed in the SNOPR. The Department sees no reason to allow that, and believes losses of that magnitude should be permitted only if a manufacturer uses alternative methods.

g. Revisions Suggested by NEMA in TP 2–2005

As stated above, NEMA prepared a revised version of NEMA TP 2–1998 and submitted it to the Department for review. (NEMA, No. 60 at p. 1) The Department compared this document, designated by NEMA as TP 2–2005 (NEMA, No. 60 Attachment 1), with the rule language proposed in the SNOPR to identify all changes to the SNOPR's methods, procedures and language. For the purposes of this final rule, DOE is treating the differences that it identified as written comments submitted by NEMA on the SNOPR. The following discussion examines the significant differences that DOE has not addressed elsewhere in this notice.

NEMA's TP 2–2005 contains a definition for "tolerances on measured losses" which was not provided in the SNOPR and which reads: "Measured values of electrical power, voltages, currents, resistances, and temperature are used in the calculations of reported data. To ensure sufficient accuracy in the measured and calculated data, the test system accuracy for each measurement shall fall within the limits specified in Table 4." (NEMA, No. 60 Attachment 1, p. 8) The Department has not added this definition to the list of terms it is defining in the final rule because it believes such a definition would not further clarify or add substance to the rule. Except for its range for frequency measurement accuracy, Table 2–1 [7] of TP 2–2005 sets forth the same accuracy ranges as are contained in Table 2.1 in the SNOPR. Moreover, section 2.0 of DOE's test procedure states that "measurement error will be limited to the values shown in Table 2.1." 69 FR 45524. The Department believes these accuracy requirements for the measurement of losses are sufficient and clear, and a

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[7] In the March 2005 draft of NEMA TP 2–200X, Table 4, Measurement Accuracy Requirements, was the correct citation. In preparing the final draft, Table 4 was re-labeled as Table 2–1, and all the values remained the same. The language on page 8 of TP 2–2005 makes references to Table 4; however, this appears to be a typographical error as there is no Table 4 in TP 2–2005.

definition of "tolerances on measured losses" is therefore unnecessary.

As just indicated, Table 2–1 of NEMA TP 2–2005 contains an accuracy range for frequency measurement of ± 0.5 percent. (NEMA, No. 60 Attachment 1, p. 9) The Department has decided not to add such a provision to Table 2.1 of today's final rule, however, for the following reasons. First, neither TP 2–1998 nor the widely-used IEEE test methods, which DOE used to develop today's test procedure, contain an accuracy range for frequency measurement. Secondly, except in unusual cases, it is not needed. When power is supplied from the utility grid, frequency is very accurate and there is no need to prescribe a frequency accuracy or require manufacturers to take steps to assure accuracy. The Department would only require manufacturers to assure accuracy when the power supply is not synchronized with an electric utility grid, and this is addressed in sections 4.4.2 and 4.5.2 of the SNOPR. Thus, the Department has not added a frequency accuracy range to Table 2.1.

Compared to the SNOPR, NEMA's TP 2–2005 contains slightly different and longer definitions of "load" and "no-load" loss. The SNOPR reads that "[l]oad loss means, for a distribution transformer, those losses incident to a specified load carried by the transformer, including losses in the windings as well as stray losses in the conducting parts of the transformer. It does not include no-load losses." NEMA's revised TP 2–2005 reads "load loss: The load losses of a transformer are those losses incident to the carrying of a specified load by the transformer. Load losses include I²R loss in the windings due to load and eddy currents; stray losses due to leakage fluxes in the windings, core clamps, and other parts, and the loss due to circulating currents (if any) in parallel windings, or in parallel winding strands." (NEMA, No. 60 Attachment 1, p. 4) The Department has not modified its proposed definition of "load loss," except by deleting the last sentence as NEMA did in TP 2–2005. The Department recognizes that inclusion of this last sentence would make the definition inaccurate, because an insignificant amount of no-load loss is included in the measurement of load loss. Also, retention of this sentence might incorrectly imply that manufacturers should subtract this extremely small amount of no-load loss from load-loss measurements, to determine load loss.

However, DOE believes that the remainder of its proposed definition of "load loss" is clear and not susceptible

of misunderstanding, and its brevity is preferable to the approach in TP 2–2005. The description of the various components of ''load loss'' in the NEMA definition helps explain the causes of load loss, but neither alters nor clarifies the definition or the requirements that the definition delineates. Such explanation generally is not included in rule language.

Concerning the definition of ''no-load loss,'' the Department's SNOPR reads: ''[n]o-load loss means those losses that are incident to the excitation of the transformer.'' NEMA's revised TP 2 definition reads: ''no-load (excitation) loss: No-load (excitation) losses are those losses that are incident to the excitation of the transformer. No-load (excitation) losses include core loss, dielectric loss, conductor loss in the winding due to excitation current, and conductor loss due to circulating current in parallel windings. These losses change with the excitation voltage.'' Again, the Department considers the SNOPR definition to be clear and complete for the purposes of this test procedure. As with its suggested definition of ''load loss,'' NEMA's definition of ''no-load loss'' adds information, but its list of components is explanatory rather than substantive, and DOE has concerns similar to those discussed for the ''load loss'' definition. For these reasons, the Department is not modifying, except as indicated, either the ''no-load loss'' or the ''load loss'' definitions.

NEMA TP 2–2005 introduces a definition of ambient temperature. (NEMA, No. 60 Attachment 1, p. 3) This definition appears to be derived from the *American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE) Terminology of Heating, Ventilation, Air Conditioning, & Refrigeration (Second Edition)* and has several elements that apply to types of transformers that are not distribution transformers. Therefore, it is not applicable to the Department's test procedure. Moreover, DOE believes that, in the context of today's final rule, ambient temperature clearly refers to the room temperature in the location where the measurements are being taken, as DOE intends. For these reasons, the Department believes a definition of ambient temperature is unnecessary in today's rule.

Finally, NEMA TP 2–2005 contains a number of editorial changes to the language in the SNOPR's test methods. The Department has incorporated several of these, such as edits in the first paragraph of proposed section 6.1, in today's final rule.

h. Language Corrections as to Conversion of the Resistance Measurement to the Reference Temperature and Conducting the No-Load Loss Test

Section 3.5 of DOE's proposed test procedure provided an equation for correcting measured resistance to the resistance at the reference temperature. 69 FR 45527. One of the terms of this equation, T_k, consists of a temperature level for copper windings, another for aluminum windings, and a third level ''[w]here copper and aluminum windings are employed in the same transformer.'' However, a separate resistance measurement is performed for each winding of a distribution transformer. Section 3.5 provides for adjustment of each such measurement, and each winding will be either copper or aluminum, but not both. Therefore, the equation for adjusting the measured resistance need not, and should not, include a temperature level that contemplates the use of the two metals together, and in today's final rule, the Department has deleted from section 3.5 the language that includes such a temperature level.

Section 4.4.2 of the proposed test procedure concerns testing for no-load losses. Proposed paragraph (b) of that section directed the tester to ''[e]nergize not less than 25 percent'' of either the high voltage or low voltage winding. 69 FR 45530. The Department drew the 25 percent figure from section 8.2.3 of IEEE C57.12.90–2001 and C57.12.91–2001, which recommend energizing 100 percent of the winding in conducting this test, but allow as low as 25 percent. The IEEE standards allow the 25 percent because they apply not only to distribution transformers but also to power transformers. Power transformers may require much higher voltages than are available in the power sources used in performing the no-load test. Distribution transformers, however, require much lower voltages, which can be accommodated by the available power sources. Moreover, distribution transformers rarely have a 25-percent voltage tap that would permit energizing a winding at 25 percent of its rated voltage, and DOE understands that instead, in testing distribution transformers for no-load losses, windings are energized to 100 percent of rated voltage. Hence, DOE has deleted from today's final rule the provision allowing testers to energize 25 percent or more of a winding.

Proposed paragraph (c) of section 4.4.2 required certain conditions with respect to voltage during the no-load loss test, ''unless otherwise specified.''

69 FR 45530. Once again, DOE drew the quoted language from IEEE standards, where it is included to accommodate testing as to characteristics other than efficiency, in situations where a transformer includes special features requested by a customer. Because this language has no application to efficiency testing, and such testing must always be conducted under the conditions specified in proposed paragraph (b), section 4.4.2(c) of today's final rule does not include this language.

D. Basic Model

1. General Discussion

Under the Department's energy conservation program, DOE has applied the ''basic model'' concept to alleviate burden on manufacturers, by reducing the amount of testing they must do to rate the efficiencies of their products. DOE's intent is that a manufacturer would treat each group of its models that have essentially identical energy consumption characteristics as a ''basic model,'' such that the manufacturer would derive the efficiency rating for all models in the group from testing sample units of these models. All of the models in the group would comprise the ''basic model,'' and they would all have the same efficiency rating. The proposed definition of basic model for distribution transformers implements this approach by permitting manufacturers to aggregate models that have the same energy consumption characteristics, but not models with different characteristics. Components of similar design can be substituted in a basic model without requiring additional testing if the represented measures of energy consumption continue to satisfy applicable provisions for sampling and testing.

2. Definition of a Basic Model

In the SNOPR, the Department proposed a definition of ''basic model'' for distribution transformers that included essentially the same criteria as those contained in the definition proposed in the 1998 proposed rule, plus a requirement that the transformers included in the basic model ''not have any differentiating electrical, physical or functional features that affect energy consumption.'' DOE made several other modifications to the definition, and described these changes in the SNOPR. 69 FR 45512–13.

NEMA commented that the SNOPR definition of ''basic model'' was too vague and needed clarification. (Public Meeting Transcript, No. 42.11 at pp. 22–23) Specifically NEMA was concerned

that the phrase added to the end of the basic model definition ''and do not have any differentiating electrical, physical, or functional features that affect energy consumption'' is unclear. (NEMA, No. 39 at p. 2) DOE believes that these general criteria for the creation of basic models are needed to allow manufacturers the flexibility to create basic model groupings that reflect product features that affect energy consumption. To address NEMA's concern, DOE is modifying the definition slightly to provide that voltage and basic impulse insulation level (BIL) rating are both examples of differentiating electrical features that would cause transformer models to be different basic models. DOE stated in the preamble of the SNOPR that each of these features would be a differentiating electrical characteristic, but the proposed definition itself did not include these examples.

Additionally, NEMA noted it would prefer that the rule contain a table of basic models (NEMA, No. 39 at p. 2) or a tighter definition. (Public Meeting Transcript, No. 42.11 at p. 37) DOE believes that creation of a table of basic models would be impractical for several reasons. First, there are literally thousands of possible designs for any one kVA rating and combination of core steel and winding materials. Second, for DOE to attempt to identify both the energy consumption profile of each such combination of transformer features, as well as the combinations that have common profiles, would be an enormous undertaking. Third, to the extent that any significant number of these possible transformer variations is not produced, either now or in the future, effort may be wasted. And fourth, DOE believes that neither it nor industry can accurately anticipate all future design variations of distribution transformers. A table or other rigid definition, therefore, would (1) fail to provide for future designs, and/or (2) conflict with the rationale for using the ''basic model'' construct, and (3) force future designs to be grouped with models that do not share their energy consumption characteristics. As this last point indicates, NEMA's concern that the part of the definition quoted above could allow additional basic models at a later date is misplaced. To the extent that the definition would allow creation of additional basic models that subsume models with new energy consumption characteristics, this indicates the definition is sound rather than in need of alteration.

DOE recognizes that, given the large number of variations in distribution transformer design, many manufacturers produce numerous basic models. The Department is aware, however, of no reasonable way to aggregate models with different energy consumption characteristics, for purposes of testing, that would produce an accurate efficiency rating for each model included in the grouping. Today's final rule, however, will allow manufacturers to rate the efficiency of many of their transformers based on calculations instead of testing, by using alternative efficiency determination methods. This should substantially alleviate any potential testing burden created by a manufacturer's producing large numbers of basic models.

In summary, DOE will slightly modify the proposed definition of ''basic model'' to explicitly provide that (1) voltage and BIL ratings are examples of differentiating electrical features that would cause transformer models to be different basic models, and (2) each basic model would comprise a group of *models* of distribution transformers. Otherwise, the proposed definition is sound because its specific elements and general criteria combine to allow the grouping of models with similar energy consumption characteristics without allowing models with different characteristics to be included in the same group.

E. Manufacturer's Determination of Efficiency

1. General Discussion

During this rulemaking, NEMA advocated DOE adoption of the sampling plan for compliance testing in NEMA TP 2–1998, which would allow manufacturers to demonstrate the compliance of aggregations of basic models, and the Department presented and solicited comment on several alternative approaches for demonstrating such aggregate compliance. For the reasons discussed in the SNOPR, the Department chose not to propose adoption of either the NEMA TP 2–1998 sampling plan or an alternative approach allowing aggregation. 69 FR 45513–15.

Instead, the Department has adopted both a sampling plan for compliance testing, and provisions allowing use of alternative methods (other than actual testing), for manufacturers to use to determine the efficiency of individual basic models of distribution transformers. As proposed in the SNOPR, today's rule requires each manufacturer to determine the efficiency of each of its basic models on a one-time basis by testing, at least five with compliance testing, and by rating each of the remaining basic models either by testing it, or, under the conditions set forth in the rule, by calculating the basic model's efficiency using an alternative efficiency determination method (AEDM). Where the manufacturer uses an AEDM for a basic model, it would not test units of the basic model to determine its efficiency for purposes of establishing compliance with DOE requirements.

2. Sampling Plan

The Department designed the sampling plan in today's final rule to provide a high probability that manufacturers would find each basic model to be in compliance with the efficiency level at which it is manufactured, but without creating a significant probability that models would be found to meet levels higher than those at which they are manufactured. The latter—''false positives''—would in effect create a regulatory loophole, by allowing transformer models manufactured at efficiency levels below applicable standards to be rated as compliant with those standards. The Department's goal for distribution transformers is to have about a 97.5 percent probability that tests on sample units of a basic model would verify or support an efficiency rating for the model that is equal to or less than the average efficiency of all units of that model manufactured. Stated alternatively, a basic model that is manufactured at or above its rated efficiency would have a probability of not less than 97.5 percent of passing the compliance demonstration test—*i.e.,* being found in compliance with its rated value—based on test results using any sample size.

To accomplish this goal, DOE incorporated into its proposed sampling plan a one-sided statistical z-test, with a 97.5 percent confidence limit for average efficiency or power loss, which manufacturers would apply to the test results derived from testing sample units of a basic model. The 97.5 percent confidence limit in the one-sided z-test corresponds to $2\sigma/\sqrt{n}$, where σ represents the standard deviation of units of distribution transformers, and n is the number of units, including one, in the sample. Thus, for example, if a manufacturer tested a sample of only one unit of a basic model, and its measured power loss did not exceed the rated power loss of the basic model by more than the amount representing two standard deviations, the test would confirm the validity of the rated efficiency. By way of further example, if the manufacturer tested a sample of more than one unit, the numerical value for losses corresponding to the 97.5

percent confidence limit would decrease, and the precision of the determination of the average losses for the basic model would increase.

In developing the SNOPR, DOE had information both to support a standard deviation (SD) for distribution transformers of 2.7 percent and to support one of 4 percent. Since the information in support of the 2.7 percent level was slightly stronger, DOE based the confidence limit (or "tolerance")[8] in the SNOPR sampling plan on the SD of 2.7 percent. 69 FR 45515. Two SDs of 2.7 percent correspond to a tolerance for the average efficiency of the sample of units tested of $5/\sqrt{n}$ percent. (Most commenters who commented on the sampling plan tolerance level addressed it as a straight numerical amount, although in actuality the proposed tolerance is a tolerance that depends on the size of the sample of units tested, and is $5/\sqrt{n}$ percent. The commenters may have used straight numerical amounts because application of the expression $5/\sqrt{n}$ percent to a sample size of one would always result in a flat five-percent tolerance.)

The Department received several comments stating that its proposed tolerance was too stringent, and should be relaxed. NEMA notes that the Department's equation relating the average efficiency of the sample and the represented efficiency assumes a tighter performance probability distribution function than is achievable in practice, particularly for small manufacturers. (NEMA, No. 47 at p. 3; NEMA, No. 51 at p. 3)

Four commenters requested that the tolerance for individual units be relaxed from the SNOPR proposal of five percent to eight percent. (ERMCO, No. 43 at p. 2; FPT, No. 44 at p. 6; Howard, No. 45 at p. 2; EMS, No. 57 at p. 3) Federal Pacific commented that use of a five-percent tolerance is too stringent given the variability of transformer losses, particularly the variability of no-load losses. (FPT, No. 44 at p. 6) EMS and ERMCO recommend that the tolerance should be eight percent to be consistent with IEEE/ANSI C57.12.00 and NEMA TP 2. (EMS, No. 57 at p. 3; ERMCO, No. 43 at p. 2) Howard Industries also recommended that the minimum acceptable efficiency level calculation be based on an eight-percent

[8] The precise statistics term "confidence limit" is frequently replaced in engineering applications by a more general term "tolerance." In the preceding discussion, DOE used the precise term to explain the basis of the tolerance in the SNOPR's proposed sampling plan for compliance testing. The Department will use the term "tolerance" in the discussion that follows, particularly because all of those who commented on this issue used this term.

tolerance on total loss. (Howard, No. 45 at p. 2)

Four commenters advocated a 12-percent tolerance, which would equate to three SDs of 4 percent. (Cooper, No. 46 at pp. 1–2; HVOLT, No. 53 at pp. 1–2; PQI, No. 56 at pp. 1–2; NEMA, No. 59 at p. 1, NEMA, No. 60, Attachment 1 at p. 34) This tolerance level would increase the compliance demonstration probability to 99.9 percent, but would also allow for a significant probability of false positives. For example, a basic model designed with losses 2 percent above its rated value would have a 99.4-percent probability of being found to have an efficiency at or above its rated level if the sample size is one, and would have a 97-percent probability of being found to have such an efficiency if the sample size is five. In addition, a 12-percent tolerance would be inconsistent with the much smaller tolerance, for rejection of single units, in existing IEEE standards. For these reasons, the Department is not incorporating the 12-percent tolerance level into its sampling plan.

Three of the commenters advocating the 12-percent tolerance for compliance testing based their position in part on the assertion that DOE's rule for electric motors allows a 20-percent "test tolerance band." (Cooper, No. 46 at p. 2; HVOLT, No. 53 at p. 2; PQI, No. 56 at p. 2) The tolerance to which they refer in the electric motors rule is not applicable to distribution transformers for two reasons. First, the 20-percent tolerance in the motors rule applies during testing that occurs in enforcement proceedings. The rule uses this tolerance to determine the adequacy of the size of the test sample used in the proceeding, following testing of the initial sample, and determination of the sample's mean, standard deviation, and standard error. This 20-percent tolerance has no relevance to compliance testing. Second, application of a particular tolerance with respect to efficiency and losses for electric motors does not indicate the appropriate tolerance for distribution transformers. Induction motors have a similarity to transformers in that their stator and rotor windings are akin somewhat to the primary and secondary windings of a transformer. However, at that point the similarity ends. A transformer has no moving parts in normal operation whereas a motor's main feature is the spinning of the rotor, a mechanical process which in itself absorbs considerable energy. Thus, motors, in addition to having electrical power losses, also have mechanical losses. Consequently the comparison of motors and transformers when discussing

tolerances used in determining efficiency is inappropriate.

Based on the information provided in comments, DOE now believes that 4 percent is the better SD to use, and that the available information supporting the 4 percent figure outweighs that supporting the 2.7-percent SD. Two SDs at 4 percent equates to an eight-percent single unit tolerance, and results in a tolerance for the average efficiency of the sample of units tested of $8/\sqrt{n}$ percent. Increasing the tolerance from $5/\sqrt{n}$ percent to $8/\sqrt{n}$ percent increases the probability of demonstrating compliance of a product manufactured at the applicable standard level from about 89 percent to about 98 percent, without introducing a significant probability that a product manufactured below the standard level would be found in compliance. This assumes that the variability of units of the basic model being tested have a standard deviation of 4 percent. The probability of a significant false positive—finding a model in compliance with its rated efficiency where on average the units of that model as manufactured actually experience a power loss 2-percent larger than the rated loss—is approximately 93 percent for a sample of one unit and 81 percent for a sample of five units. Both probabilities, especially the second one, are sufficiently low that a manufacturer would not risk producing a product with power losses 2 percent or more above the losses at which it seeks to rate the product. Thus, today's final rule increases the tolerance from $5/\sqrt{n}$ percent to $8/\sqrt{n}$ percent.

Several manufacturers submitted comments asking that DOE confirm that they have the option of testing all transformers of a basic model or some basic models. (Public Meeting Transcript, No. 42.11 at p. 22; NEMA, No. 39 at p. 2) One stakeholder requested clarification that if it chooses to test 100 percent of its production, it would not have to use the sampling plan or an AEDM (alternative efficiency determination method). (Public Meeting Transcript, No. 42.11 at p. 65) NEMA also requested clarification on the number of samples that would have to be tested if the sample size is small. (Public Meeting Transcript, No. 42.11 at p. 67)

As indicated above, once efficiency standards for distribution transformers have gone into effect, today's rule will require each manufacturer to rate the efficiency of each of its basic models on a one-time basis. The rating would enable the manufacturer to establish that the basic model complies with the applicable standard, and provide the basis for any energy representations

(e.g., labeling and certification) required by DOE. 69 FR 45514. The Department intended in its SNOPR proposal, and wishes to confirm with respect to today's rule, that where a manufacturer arrives at this rating through testing, rather than use of an AEDM, the sampling plan would permit the manufacturer to test 100 percent of the units available for testing. The language of section 431.194(b)(2) of the final rule has been modified to make this clear. Thus, where manufacturers have on hand more than five units of a basic model at the time they do compliance testing to rate the basic model, or produce more than five over a six-month period, they would have the discretion to rate the basic model based on testing either all of the units or a sample of at least five units. In addition, the final rule clearly requires compliance testing of 100 percent of the units for basic models for which a manufacturer produces five or fewer units during a six-month period.

None of the provisions in today's rule would prevent a manufacturer from doing continuous testing of 100 percent of the units it produces in order to meet contractual obligations to report to its customers the losses, efficiency or other energy consumption characteristics of each individual unit it sells to them. Nor does the Department anticipate that provisions it may adopt, for assuring compliance with energy conservation standards and for manufacturer representations (e.g., labeling) as to efficiency, would prevent manufacturers from testing all of their units in order to meet such obligations.

3. Alternative Efficiency Determination Method (AEDM)

Under the proposed rule, a manufacturer would have to validate each AEDM it uses based on test data for at least five basic models, derived by testing at least five units of each of these basic models. 69 FR 45522. Taken together, these provisions would require testing of at least 25 units to validate an AEDM. Howard Industries commented that five basic models is too small a sample to adequately represent all the different kVA/voltages/BIL requirements when validating an AEDM and recommended that DOE require 75 models to be tested to validate an AEDM. (Howard, No. 45 at p. 3, and No. 55 at p. 3) Howard also asserted that five basic models was too low a number to verify that the AEDM would accurately predict the efficiency of all liquid-immersed transformers. It stated that transformers vary considerably, with a large number of design options. (Howard, No. 58 at p. 1) In addition to

containing the validation requirement, however, the final rule (in section 431.197(a)(2)(i)) also precludes a manufacturer from applying an AEDM to a basic model unless "the AEDM has been derived from a mathematical model that represents the electrical characteristics of that basic model." Thus, apart from any testing to validate the accuracy of an AEDM, this language will require each AEDM to represent any unique or custom-designed electrical characteristics of any basic model to which it applies. DOE believes that this provision satisfactorily addresses Howard's concern that DOE require AEDMs to reflect the particular characteristics of the transformers to which they apply.

The Department believes that to require each AEDM to be validated based on testing of 75 basic models, or some other number larger than five, would create undue burden. The foregoing is particularly true because DOE understands that manufacturers use design models and software to design their distribution transformers, and DOE believes that most AEDMs would be derived from, or consist of, such models and software. Since these design tools would have validity independent of the AEDM substantiation required by DOE regulations, extensive testing to substantiate the validity of AEDMs appears to be unnecessary.

Section 432.12(a)(2)(iii) of the proposed rule restricted the use of each AEDM to one of the following groups of distribution transformers: low-voltage dry-type transformers, medium-voltage dry-type transformers, and liquid-immersed transformers. 69 FR 45522. Upon further review, the Department believes that this provision is too restrictive, and that manufacturers should be permitted to use a single AEDM for distribution transformers in two or all three of these groups, so long as the manufacturer validates the AEDM separately for each group. The Department is aware of no reason why it should limit use of each AEDM to transformers in one of these groups, if the AEDM can validly predict the efficiency for transformers in more than one group. Accordingly, today's final rule allows a single AEDM to apply to two or all three of these groupings. See 10 CFR section 431.197(a)(2) of the rule. The rule also requires that the manufacturer validate each AEDM separately for each group—*i.e.,* low-voltage dry-type, medium-voltage dry-type, and liquid-immersed—for which it uses the AEDM, based on test data for five basic models from such group. 10 CFR section 431.197(a)(2)(iii) of the

rule. Thus to substantiate a single global AEDM that would apply to the entire range of distribution transformers (all three groups), a manufacturer would have to test not fewer than 15 basic models (a total of at least 75 units), and it would have to test at least 10 basic models (a total of at least 50 units) to substantiate an AEDM that would apply to two groups. DOE believes this amount of testing to validate the AEDM is sufficient.

The SNOPR also included a requirement that manufacturers "periodically" verify each AEDM that they use. 69 FR 45523. Howard Industries recommended that the Department change "periodically" to "annually." (Howard, No. 45 at p. 3, and No. 55 at p. 3) The Department considered this proposal, but decided that annual verification of an AEDM, which could include testing, could be unduly burdensome on manufacturers. The Department has also decided, however, largely because of the particular circumstances of the distribution transformer industry, to eliminate the periodic verification requirement from today's final rule. Many distribution transformer manufacturers already engage in continuous testing—sometimes by testing 100 percent of their units—to assure that the actual performance, including efficiency, of their products conforms to the manufacturer's design software and representations to customers. In addition, other provisions of today's final rule authorize DOE to obtain information from manufacturers concerning their use of AEDMs, and to require a manufacturer to do sample testing or take other steps. Thus, DOE now believes that mandatory, periodic, subsequent verification of AEDMs for distribution transformers is unwarranted.

F. Enforcement Procedures

The SNOPR included proposed enforcement procedures, including a sampling plan and other provisions for enforcement testing. 69 FR 45415–17, 45523–23, 45533–34. The Department based the proposed procedures on enforcement provisions in 10 CFR Part 430, which apply when DOE examines whether a basic model of a covered product complies with efficiency requirements set forth in those parts. The SNOPR's enforcement sampling plan was based on the plan in Part 430, but was developed specifically for distribution transformers. It allows testing of small sample sizes and applies only to energy efficiency testing, whereas the Part 430 plan contemplates

larger sample sizes and covers energy use testing.

NEMA requested clarification on when the process of enforcement commences. (Public Meeting Transcript, No. 42.11 at p. 73) The Department initiates the enforcement process when it receives information, either from a third party or other source, indicating that a manufacturer's units may not be in compliance with the national standard. Initially, DOE seeks to meet with the manufacturer and review its underlying test data as to the models in question. DOE would commence enforcement testing procedures if these steps do not resolve identified compliance issues.

The Department also received comments relating to enforcement as to stock units and imported units. Cooper sought clarification on application of efficiency standards to units in stock when standards take effect, and to foreign manufacturers. (Cooper, No. 46 at p. 2) Traditionally, new DOE standards for a product have applied to units manufactured after a certain date, or, in the case of foreign-manufactured units, imported after that date. See, e.g., 42 U.S.C. 6291, 6295, 6311 and 6313. The Department anticipates that this will also be the case for distribution transformers. Therefore, the efficiency levels would not apply to units in a domestic manufacturer's stock prior to the date standards become applicable, or to units imported prior to that date. In all other respects, DOE anticipates that the same requirements and enforcement provisions that apply to domestic units will also apply to imported units. In addition, however, imported units are subject to the provisions of 42 U.S.C. 6301 of EPCA, concerning importation of products subject to EPCA requirements.

HVOLT commented that the Department should require that the efficiency of any foreign-built transformer be verified by a third party before it can be sold in the U.S. (HVOLT, No. 53 at p. 3) The Department believes that this issue is outside the scope of this rulemaking. Today's final rule does not address the DOE administrative framework for manufacturers to follow to demonstrate compliance with distribution transformer energy conservation standards. The Department will likely address such requirements in conjunction with the standards rulemaking.

The SNOPR enforcement sampling plan contained several calculation equations. 69 FR 45533. Federal Pacific requested further explanation and examples of the enforcement

calculations. (FPT, No. 44 at p. 6) As explained in the SNOPR, the statistical methods used in those calculations were based on well-established statistical methods for obtaining a confidence interval on a mean. 69 FR 45516. Hence, the Department believes these calculations can be understood by any statistician. In addition, a complete explanation is set forth in NIST Technical Note 1456, *Operating Characteristics of the Proposed Sampling Plans for Testing Distribution Transformers, May 2004,* which has been placed in the docket for this rulemaking and is publicly available at *http://www.eere.energy.gov/buildings/ appliance_standards/commercial/ dist_transformers.html.* On the other hand, it would be very burdensome for DOE to develop and include in this notice a detailed explanation, in layman's terms, of the statistics and operation of these equations. Furthermore, these equations will be used by DOE, and would not be applied by manufacturers. For these reasons, the Department has concluded that the type of explanation Federal Pacific requests is unwarranted, and would add little useful information to the record of this rulemaking.

III. Procedural Requirements

A. Review Under Executive Order 12866

The Office of Information and Regulatory Affairs of the Office of Management and Budget (OMB) has determined that today's regulatory action is not a ''significant regulatory action'' under Executive Order 12866, ''Regulatory Planning and Review,'' 58 FR 51735 (October 4, 1993). Accordingly, this action was not subject to review under the Executive Order.

B. Review Under the Regulatory Flexibility Act of 1980

The Regulatory Flexibility Act (5 U.S.C. 601 *et seq.*) requires preparation of an initial regulatory flexibility analysis for any rule that by law must be proposed for public comment, unless the agency certifies that the rule, if promulgated, will not have a significant economic impact on a substantial number of small entities. As required by Executive Order 13272, *Proper Consideration of Small Entities in Agency Rulemaking,* 67 FR 53461 (August 16, 2002), DOE published procedures and policies on February 19, 2003, to ensure that the potential impacts of its rules on small entities are properly considered during the rulemaking process. 68 FR 7990. The Department has made its procedures and policies available on the Office of

General Counsel's Web site: *http:// www.gc.doe.gov.*

The Department reviewed today's final rule under the provisions of the Regulatory Flexibility Act and the procedures and policies published on February 19, 2003, and certified in the SNOPR that the proposed rule would not impose a significant economic impact on a substantial number of small entities. 69 FR 45517. As indicated in section I-A above, when it issued the SNOPR DOE was concurrently pursuing a rulemaking to develop energy conservation standards for low-voltage dry type, medium-voltage dry type and liquid immersed distribution transformers. The Department explained in the SNOPR that, unless and until DOE adoption of such standards, no entities, small or large, would be required to comply with today's final rule. 69 FR 45517. Once the Department adopted standards, however, the rule would become binding on, and could have an economic impact on, small entities which manufacture the distribution transformers subject to the standards. But the nature and extent of such impact, if any, could not be assessed until the Department has promulgated the standards. The Department stated in the SNOPR that, in light of these circumstances, at an appropriate point in conjunction with the standards rulemaking, it will conduct further review under the Regulatory Flexibility Act. The Department received no comments on this issue in response to the SNOPR.

For medium-voltage dry-type and liquid immersed distribution transformers, DOE is continuing to pursue its standards-development rulemaking and the circumstances described in the SNOPR still exist. Therefore, after considering the potential impact of this final rule on small entities that manufacture these transformers, DOE affirms the certification that this rule will not have a significant economic impact on a substantial number of these small entities.

Low-voltage dry-type distribution transformers, however, are no longer included in DOE's rulemaking on energy conservation standards for distribution transformers. Instead, EPCA, as amended in EPACT 20005, now specifies minimum standards for all such transformers manufactured after January 1, 2007, 42 U.S.C. 6295(y), and the Department has incorporated those standards into its regulations. 10 CFR section 431.196. Because today's rule will apply to all distribution transformers that become subject to standards, as of January 1, 2007, the rule

would become binding on all manufacturers, small and large, of low-voltage dry-type distribution transformers. Consequently, under the Regulatory Flexibility Act, the Department must assess the economic impact of this rule on small manufacturers of these transformers.

Small businesses, as defined by the Small Business Administration (SBA) for the distribution transformer manufacturing industry, are manufacturing enterprises with 750 employees or fewer. The Department estimates that, of a total of approximately 55 manufacturers of low-voltage dry-type distribution transformers, about 45 are small businesses under the SBA definition. In today's rule, the enforcement provisions and the methods manufacturers must use to rate its products could potentially impose burdens on these small manufacturers. But DOE has examined these aspects of the rule and determined that they will not have a significant economic impact on a substantial number of small manufacturers of low-voltage dry-type distribution transformers.

As to the enforcement provisions, they require DOE to first attempt to resolve a transformer's possible non-compliance with EPCA requirements by reviewing available information and meeting with the manufacturer. Then, if necessary, DOE must test sample units of the allegedly non-complying basic model(s) to determine whether they comply. See Section 431.198 of the attached rule. Only provisions that come into play once DOE invokes testing—specifically, manufacturers must provide and ship sample units to DOE and must retain all units in the batch sample until a final determination of compliance or non-compliance, and manufacturers may conduct additional testing at their own expense if the DOE testing indicates non-compliance—could impose a significant burden on manufacturers.

None of the enforcement provisions imposes on-going duties on manufacturers. They apply only when an issue of compliance is raised, which at this point is speculative. Indeed, even when they are invoked as to a particular manufacturer, they will only apply to the specific basic model(s) at issue. Moreover, these types of enforcement provisions have been in place for DOE's program for appliance energy conservation standards for more than 15 years, and the Department has commenced the process at most two or three times a year. In every instance it has resolved the matter without proceeding to enforcement testing, the

only part of the process that could impose a significant burden on manufacturers. For all of these reasons the Department concludes that the enforcement provisions in today's rule will not have a significant impact on a substantial number of entities, whether small or large.

As to the methods for manufacturers to rate the efficiencies of low-voltage dry-type distribution transformers, DOE notes initially that requirements for testing and rating these transformers are already implicit in EPCA. Specifically, to comply with EPCA's efficiency standards for low-voltage dry-type distribution transformers, 42 U.S.C. 6295(y), manufacturers will have to determine the efficiencies of any such transformers they produce. This necessarily entails the use of testing and rating methods, and if DOE does not prescribe such methods, manufacturers would still be subject to the burden of using such tools. In addition, as noted above, EPCA requires DOE to prescribe testing requirements for any transformers subject to standards, and states that these requirements "shall be based on" NEMA TP 2–1998. 42 U.S.C. 6293(b)(10) and 6317(a). Although these provisions allow the Department substantial discretion in prescribing a test method for distribution transformers, they indicate that EPCA contemplates that the DOE method likely would impose burdens equivalent or similar to those imposed by NEMA TP 2–1998. Thus, today's rule itself has an impact on small manufacturers only to the extent it imposes an incremental burden beyond what they would be required to do to comply with EPCA's standards or NEMA TP 2–1998.

This is significant under the Regulatory Flexibility Act because the Act applies only where the agency's rule has a significant impact on small entities. It does not apply to a rule if the agency certifies that "*the rule* will not * * * have a significant impact on a substantial number of small entities." 5 U.S.C. 605(a) (Emphasis added). Thus, the Act does not apply, for example, where the agency merely incorporates statutory requirements into its rules, or adopts the equivalent of statutory requirements without adding any significant impact on small entities. In such instances, it is the statutory requirements, and not the agency's rule, that could have an impact on small entities. The Department therefore examines in the following paragraphs whether today's rule imposes any burdens on small entities beyond those imposed by EPCA.

In prescribing efficiency rating methods, today's rule (1) addresses the

number of its basic models a manufacturer must rate through actual testing and how may units of each it must test, (2) prescribes a detailed method for testing each unit, and (3) provides for use of alternative efficiency determination methods for transformers that manufacturers do not rate through testing. See Section 431.193 and 431.197 of the attached rule. As to whether today's method for testing each unit is more burdensome than NEMA TP 2–1998, the two are nearly identical except that the Department's method adds technical detail, clarifying language, and editorial improvements. Thus, the DOE method is no more burdensome, and may alleviate burden because it reduces the need for manufacturers to do background work to provide missing details and clarify ambiguous provisions.

Nor does today's test method impose significantly, if any, more burden than other methods a small manufacturer might reasonably use to comply with the EPACT standards for low-voltage dry-type transformers. A manufacturer might choose to use NEMA TP 2–1998, which as just indicated is no more burdensome than today's method, or NEMA TP 2–2005, which is almost word-for-word the same as the SNOPR's test method and which varies little from today's rule. A manufacturer might also craft a test method from the standards of accepted engineering practice as set forth in IEEE standards. On the one hand, except for the requirements as to equipment calibration in today's rule, the test method in the rule is the equivalent to the method in the four relevant IEEE standards. On the other hand, DOE believes it is possible that small manufacturers might each be able to modify the details of the IEEE test method so as to best fit its products. As a result its costs of testing needed to comply with the EPACT efficiency standards, *i.e.,* implicit in the EPACT requirements, could be lower than the cost of testing under the test method in today's rule. The Department believes that such savings would not be significant, and to some extent would be offset by the resources a small manufacturer would have to expend to research and develop such a customized test method. Today's method does include requirements to calibrate equipment and maintain records of such calibrations, which are not explicitly included in the IEEE standards. But to achieve the accuracy levels required under these standards, a manufacturer would have to engage in some calibration effort. In any event, DOE estimates that today's rule would

require only about one week of staff time to satisfy the calibration requirements in the first year the rule is operative, and about two days a year thereafter. For the foregoing reasons, the Department concludes that, although today's test method might impose modest burdens on small manufacturers of low-voltage dry-type distribution transformers, these burdens are not significant.

However, the final rule's provisions as to the amount of testing required to rate distribution transformer efficiencies are clearly far less burdensome to small manufacturers than methodologies currently in use. The rule requires each manufacturer to test at least five basic models. For each such model, the manufacturer must test the lesser of all units manufactured over a 180 day period or five units, and must rate the basic model's efficiency by applying a formula to the test results. The rule also allows use of AEDMs to rate the remaining basic models. The IEEE standards contain no provision for sampling, or for use of AEDMs, in rating the efficiency of distribution transformers. Moreover, DOE understands that, under current practice, where a manufacturer must rate a low-voltage dry-type transformer's losses—the equivalent of efficiency determination—typically it will test all units and rate them based on their average efficiency. Although, as explained below in footnote 6, EPCA does not direct DOE to use the sampling regimen in NEMA TP 2–1998, that is a methodology a manufacturer might use to determine whether its low-voltage dry-type transformers comply with EPCA's standards. NEMA TP 2–1998's sampling plan provides that, over a 180-day period, either all units manufactured be tested, or that five or more units per month be tested, thus requiring approximately six times as much testing as today's rule. It also contains no provision for rating transformer efficiencies through use of AEDMs. As explained in the SNOPR, 69 FR 45514–15, NEMA TP 2–1998 clearly requires considerably more testing that today's final rule (which requires the same amount of testing as DOE's proposal in the SNOPR).

Insofar as the final rule's reduction in testing burden results from the use of AEDMs, however, this benefit is not without cost. The Department estimates that a manufacturer would have to incur approximately three to six weeks of engineering staff time to develop a valid AEDM, and approximately two weeks of staff time to administer and maintain the AEDM(s) thereafter. The Department estimates, however, that use of AEDMs

would allow a manufacturer to do less than 20 percent of the testing that would otherwise be required.

For all of these reasons, the Department certifies that today's final rule would not have a significant economic impact on a substantial number of small entities. Accordingly, DOE has not prepared a regulatory flexibility analysis for this rulemaking. DOE has transmitted the certification and supporting statement of factual basis to the Chief Counsel for Advocacy of the Small Business Administration for review pursuant to 5 U.S.C. 605(b).

C. Review Under the Paperwork Reduction Act

As indicated in the SNOPR, today's final rule contains certain record-keeping requirements. 69 FR 45517. The situation with respect to the Paperwork Reduction Act (44 U.S.C. 3501 *et seq.*) is similar to that described in Section III.B. with respect to the Regulatory Flexibility Act. For the reasons stated there, unless and until the Department requires manufacturers to comply with energy conservation standards for medium-voltage and liquid immersed distribution transformers, no manufacturer of those products would be required to comply with these record-keeping provisions. Therefore, today's rule would not impose on those manufacturers any new reporting requirements requiring clearance by OMB under the Paperwork Reduction Act. The Department recognizes, however, as also set forth in the SNOPR, that if it adopts standards for those distribution transformers, once the standards become operative manufacturers will become subject to the record-keeping requirements in today's rule, and possibly additional reporting and/or record-keeping requirements. 69 FR 45517.

We received no comments on this issue. For medium-voltage and liquid immersed distribution transformers, the Department intends, as stated in the SNOPR, to comply with the Paperwork Reduction Act with respect to the record-keeping requirements in today's rule at the appropriate point in conjunction with the standards development rulemaking.

Since the publication of the SNOPR, however, the Department has adopted standards prescribed by EPCA for low-voltage dry-type distribution transformers. When these standards become operative on January 1, 2007, manufacturers of those products will be required to comply with the record-keeping provisions in today's rule. Therefore, as to these manufacturers today's final rule contains certain

record-keeping requirements that must be approved by the OMB pursuant to the Paperwork Reduction Act before the manufacturers may be required to comply with them. Section 431.197(a)(4)(i) would require manufacturers of distribution transformers to have records as to alternative efficiency determination methods available for DOE inspection; section 6.2 of Appendix A would require maintenance of calibration records. As a result, concurrent with or shortly after publication of today's rule, the Department will issue a notice seeking public comment under the Paperwork Reduction Act, with respect to these manufacturers, on the record-keeping requirements in today's rule. After considering any public comments received in response to that notice, DOE will submit the proposed collection of information to OMB for approval pursuant to 44 U.S.C. 3507.

An agency may not conduct or sponsor, and a person is not required to respond to a collection of information unless it displays a currently valid OMB control number. As stated in the "EFFECTIVE DATE" line of this notice of final rulemaking, the information collection requirements in § 431.197(a)(4)(i) and section 6.2(b) and (c) of Appendix A will not become effective until OMB approves them. The Department will publish a document in the **Federal Register** advising low-voltage dry-type manufacturers of their effective date. That document also will display the OMB control number.

D. Review Under the National Environmental Policy Act of 1969

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 the Department's implementing regulations at 10 CFR part 1021. Specifically, this rule establishing test procedures will not affect the quality or distribution of energy and, will not result in any environmental impacts, and, therefore, is covered by the Categorical Exclusion in paragraph A6 to subpart D, 10 CFR part 1021. Accordingly, neither an environmental assessment nor an environmental impact statement is required.

E. 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 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 today's final rule and has determined that it does not preempt State law and does 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. No further action is required by Executive Order 13132.

F. Review Under Executive Order 12988

With respect to the review of existing regulations and the promulgation of new regulations, section 3(a) of Executive Order 12988, ''Civil Justice Reform'' (61 FR 4729, February 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; and (3) provide a clear legal standard for affected conduct rather than a general standard and 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 section 3(a) and section 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, this rule meets the relevant standards of Executive Order 12988.

G. Review Under the Unfunded Mandates Reform Act of 1995

Title II of the Unfunded Mandates Reform Act of 1995 (UMRA) (Pub. L. 104–4) requires each Federal agency to assess the effects of Federal regulatory actions on State, local, and Tribal governments and the private sector. 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://www.gc.doe.gov*). Today's rule does not contain any Federal mandate likely to result in an aggregate expenditure of $100 million or more in any year, so these requirements under the Unfunded Mandates Reform Act do not apply.

H. Review Under the Treasury and General Government Appropriations Act of 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 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.

I. Review Under Executive Order 12630

The Department 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 which might require compensation under the Fifth Amendment to the United States Constitution.

J. Review Under the 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 (February 22, 2002), and DOE's guidelines were published at 67 FR 62446 (October 7, 2002). The Department has reviewed today's final 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 the Office of Information and Regulatory Affairs (OIRA), Office of Management and Budget, 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.

This final rule is not a significant regulatory action under Executive Order 12866 or any successor order. In addition, it is not likely to have a significant adverse effect on the supply, distribution, or use of energy, nor has it been designated by the Administrator of OIRA as a significant energy action. Thus, 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), the Department must comply with Section 32 of the Federal Energy Administration Act of 1974 (FEAA), as amended by the Federal Energy Administration Authorization Act of 1977. (15 U.S.C. 788) The Department indicated in the SNOPR that Section 32 applies to the portion of today's rule that incorporates testing methods contained in five commercial standards, requiring consultation with the Attorney General and the Chairman of the Federal Trade Commission concerning the impact of these standards on competition. 69 FR 45506, 45519 (July 29, 2004).

Since publication of the SNOPR, DOE has reviewed this requirement for consultation as it applies to this final rule. While DOE now believes that such consultation is not necessarily required for this rule, since DOE stated in the SNOPR that it would submit it for consultation under Section 32, it has done so. Neither the Attorney General nor the Chairman of the Federal Trade Commission has recommended against incorporation of these standards.

M. Congressional Notification

As required by 5 U.S.C. 801, DOE will report to Congress on the promulgation of this rule prior to its effective date. The report will state that it has been determined that the rule is not a "major rule" as defined by 5 U.S.C. 804(2).

IV. Approval of the Office of the Secretary

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

List of Subjects in 10 CFR Part 431

Administrative practice and procedure, Distribution transformers, Energy conservation.

Issued in Washington, DC, on March 28, 2006.

Douglas L. Faulkner,

Acting Assistant Secretary, Energy Efficiency and Renewable Energy.

■ For the reasons set forth in the preamble, Part 431 of Chapter II of Title 10, Code of Federal Regulations, is amended 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.

■ 2. Section 431.191 is revised to read as follows:

§ 431.191 Purpose and scope.

This subpart contains energy conservation requirements for distribution transformers, pursuant to Parts B and C of Title III of the Energy Policy and Conservation Act, as amended, 42 U.S.C. 6291–6317.

■ 3. Section 431.192 is amended by:
■ a. Revising the Section heading.
■ b. Adding introductory language.
■ c. Adding in alphabetical order definitions of "autotransformer," "basic model," "drive (isolation) transformer," "efficiency," "excitation current or no-load current," "grounding transformer," "liquid-immersed distribution transformer," "load loss," "machine-tool (control) transformer," "medium-voltage dry-type distribution transformer," "no-load loss," "nonventilated transformer," "phase angle," "phase angle correction," "phase angle error," "rectifier transformer," "reference temperature," "regulating transformer," "sealed transformer," "special-impedance transformer," "temperature correction," "test current," "test frequency," "test voltage," "testing transformer," "total loss," "transformer with tap range of 20 percent or more," "uninterruptible power supply transformer," "waveform correction," and "welding transformer."
■ d. Revising the definition of "distribution transformer."

The revision and additions read as follows:

§ 431.192 Definitions.

The following definitions apply for purposes of this subpart:

Autotransformer means a transformer that:

(1) Has one physical winding that consists of a series winding part and a common winding part;

(2) Has no isolation between its primary and secondary circuits; and

(3) During step-down operation, has a primary voltage that is equal to the total of the series and common winding voltages, and a secondary voltage that is equal to the common winding voltage.

Basic model means a group of models of distribution transformers manufactured by a single manufacturer, that have the same insulation type (*i.e.,* liquid-immersed or dry-type), have the same number of phases (*i.e.,* single or three), have the same standard kVA rating, and do not have any differentiating electrical, physical or functional features that affect energy consumption. Differences in voltage and differences in basic impulse insulation level (BIL) rating are examples of

differentiating electrical features that affect energy consumption.

Distribution transformer means 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; but

(5) The term "distribution transformer" does not include a transformer that is an—

(i) Autotransformer;

(ii) Drive (isolation) transformer;

(iii) Grounding transformer;

(iv) Machine-tool (control) transformer;

(v) Nonventilated transformer;

(vi) Rectifier transformer;

(vii) Regulating transformer;

(viii) Sealed transformer;

(ix) Special-impedance transformer;

(x) Testing transformer;

(xi) Transformer with tap range of 20 percent or more;

(xii) Uninterruptible power supply transformer; or

(xiii) Welding transformer.

Drive (isolation) transformer means a transformer that:

(1) Isolates an electric motor from the line;

(2) Accommodates the added loads of drive-created harmonics; and

(3) Is designed to withstand the additional mechanical stresses resulting from an alternating current adjustable frequency motor drive or a direct current motor drive.

Efficiency means the ratio of the useful power output to the total power input.

Excitation current or no-load current means the current that flows in any winding used to excite the transformer when all other windings are open-circuited.

Grounding transformer means a three-phase transformer intended primarily to provide a neutral point for system-grounding purposes, either by means of:

(1) A grounded wye primary winding and a delta secondary winding; or

(2) A transformer with its primary winding in a zig-zag winding arrangement, and with no secondary winding.

Liquid-immersed distribution transformer means a distribution transformer in which the core and coil assembly is immersed in an insulating liquid.

Load loss means, for a distribution transformer, those losses incident to a specified load carried by the

transformer, including losses in the windings as well as stray losses in the conducting parts of the transformer.

* * * * *

Machine-tool (control) transformer means a transformer that is equipped with a fuse or other over-current protection device, and is generally used for the operation of a solenoid, contactor, relay, portable tool, or localized lighting.

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.

No-load loss means those losses that are incident to the excitation of the transformer.

Nonventilated transformer means a transformer constructed so as to prevent external air circulation through the coils of the transformer while operating at zero gauge pressure.

Phase angle means the angle between two phasors, where the two phasors represent progressions of periodic waves of either:

(1) Two voltages;
(2) Two currents; or
(3) A voltage and a current of an alternating current circuit.

Phase angle correction means the adjustment (correction) of measurement data to negate the effects of phase angle error.

Phase angle error means incorrect displacement of the phase angle, introduced by the components of the test equipment.

Rectifier transformer means a transformer that operates at the fundamental frequency of an alternating-current system and that is designed to have one or more output windings connected to a rectifier.

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. (These temperatures are specified in the test method in Appendix A to this part.)

Regulating transformer means a transformer that varies the voltage, the phase angle, or both voltage and phase angle, of an output circuit and compensates for fluctuation of load and input voltage, phase angle or both voltage and phase angle.

Sealed transformer means a transformer designed to remain hermetically sealed under specified conditions of temperature and pressure.

Special-impedance transformer means any transformer built to operate at an impedance outside of the normal impedance range for that transformer's kVA rating. The normal impedance range for each kVA rating for liquid-immersed and dry-type transformers is shown in Tables 1 and 2, respectively.

TABLE 1.—NORMAL IMPEDANCE RANGES FOR LIQUID-IMMERSED TRANSFORMERS

Single-phase transformers		Three-phase transformers	
kVA	Impedance (%)	kVA	Impedance (%)
10	1.0–4.5	15	1.0–4.5
15	1.0–4.5	30	1.0–4.5
25	1.0–4.5	45	1.0–4.5
37.5	1.0–4.5	75	1.0–5.0
50	1.5–4.5	112.5	1.2–6.0
75	1.5–4.5	150	1.2–6.0
100	1.5–4.5	225	1.2–6.0
167	1.5–4.5	300	1.2–6.0
250	1.5–6.0	500	1.5–7.0
333	1.5–6.0	750	5.0–7.5
500	1.5–7.0	1000	5.0–7.5
667	5.0–7.5	1500	5.0–7.5
833	5.0–7.5	2000	5.0–7.5
		2500	5.0–7.5

TABLE 2.—NORMAL IMPEDANCE RANGES FOR DRY-TYPE TRANSFORMERS

Single-phase transformers		Three-phase transformers	
kVA	Impedance (%)	kVA	Impedance (%)
15	1.5–6.0	15	1.5–6.0
25	1.5–6.0	30	1.5–6.0
37.5	1.5–6.0	45	1.5–6.0
50	1.5–6.0	75	1.5–6.0
75	2.0–7.0	112.5	1.5–6.0
100	2.0–7.0	150	1.5–6.0
167	2.5–8.0	225	3.0–7.0
250	3.5–8.0	300	3.0–7.0
333	3.5–8.0	500	4.5–8.0
500	3.5–8.0	750	5.0–8.0
667	5.0–8.0	1000	5.0–8.0
833	5.0–8.0	1500	5.0–8.0
		2000	5.0–8.0
		2500	5.0–8.0

Temperature correction means the mathematical correction(s) of measurement data, obtained when a transformer is tested at a temperature that is different from the reference temperature, to the value(s) that would have been obtained if the transformer had been tested at the reference temperature.

Test current means the current of the electrical power supplied to the transformer under test.

Test frequency means the frequency of the electrical power supplied to the transformer under test.

Test voltage means the voltage of the electrical power supplied to the transformer under test.

Testing transformer means a transformer used in a circuit to produce a specific voltage or current for the purpose of testing electrical equipment.

Total loss means the sum of the no-load loss and the load loss for a transformer.

* * * * *

Transformer with tap range of 20 percent or more means a transformer with multiple voltage taps, the highest of which equals at least 20 percent more than the lowest, computed based on the sum of the deviations of the voltages of these taps from the transformer's nominal voltage.

Uninterruptible power supply transformer means a transformer that supplies power to an uninterruptible power system, which in turn supplies power to loads that are sensitive to power failure, power sags, over voltage, switching transients, line noise, and other power quality factors.

Waveform correction means the adjustment(s) (mathematical correction(s)) of measurement data obtained with a test voltage that is non-sinusoidal, to a value(s) that would have been obtained with a sinusoidal voltage.

Welding transformer means a transformer designed for use in arc welding equipment or resistance welding equipment.

■ 4. Section 431.193 is added to subpart K, under the heading ''Test Procedures,'' to read as follows:

Test Procedures

§ 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.

■ 5. Section 431.196 is amended in paragraph (a) by revising the table to read as follows:

§ 431.196 Energy conservation standards and their effective dates.

(a) * * *

Single phase		Three phase	
kVA	Efficiency (%) [1]	kVA	Efficiency (%) [1]
15	97.7	15	97.0
25	98.0	30	97.5
37.5	98.2	45	97.7
50	98.3	75	98.0
75	98.5	112.5	98.2
100	98.6	150	98.3
167	98.7	225	98.5
250	98.8	300	98.6
333	98.9	500	98.7
		750	98.8
		1000	98.9

[1] Efficiencies are determined at the following reference conditions: (1) for no-load losses, at the temperature of 20 °C, and (2) for load-losses, at the temperature of 75 °C and 35 percent of nameplate load.
(Source: Table 4–2 of National Electrical Manufacturers Association (NEMA) Standard TP–1–2002, "Guide for Determining Energy Efficiency for Distribution Transformers.")

* * * * *

■ 6. Sections 431.197 through 431.198 are added to subpart K, under the heading ''Compliance and Enforcement,'' to read as follows:

Compliance and Enforcement

§ 431.197 Manufacturer's determination of efficiency for distribution transformers.

When a manufacturer or other party (both of which this section refers to as a ''manufacturer'') determines the efficiency of a distribution transformer in order to comply with an obligation imposed on it by or pursuant to Part C of Title III of EPCA, 42 U.S.C. 6311–6317, this section applies. This section does not apply to enforcement testing conducted pursuant to § 431.198 of this part.

(a) *Methods used to determine efficiency*—(1) *General requirements.* A manufacturer must determine the efficiency of each basic model of distribution transformer either by testing, in accordance with § 431.193 of this part and paragraphs (b)(2) and (b)(3) of this section, or by application of an alternative efficiency determination method (AEDM) that meets the requirements of paragraphs (a)(2) and (a)(3) of this section; provided, however, that a manufacturer may use an AEDM to determine the efficiency of one or more of its untested basic models only if it determines the efficiency of at least five of its other basic models (selected in accordance with paragraph (b)(1) of this section) through actual testing. For each basic model of distribution transformer that has a configuration of windings which allows for more than one nominal rated voltage, the manufacturer must determine the basic

model's efficiency either at the voltage at which the highest losses occur or at each voltage at which the transformer is rated to operate.

(2) *Alternative efficiency determination method.* A manufacturer may apply an AEDM to a basic model pursuant to paragraph (a)(1) of this section only if:

(i) The AEDM has been derived from a mathematical model that represents the electrical characteristics of that basic model;

(ii) The AEDM is based on engineering and statistical analysis, computer simulation or modeling, or other analytic evaluation of performance data; and

(iii) The manufacturer has substantiated the AEDM, in accordance with paragraph (a)(3) of this section, by applying it to, and testing, at least five

other basic models of the same type, *i.e.,* low-voltage dry-type distribution transformers, medium-voltage dry-type distribution transformers, or liquid-immersed distribution transformers.

(3) *Substantiation of an alternative efficiency determination method.* Before using an AEDM, the manufacturer must substantiate the AEDM's accuracy and reliability as follows:

(i) Apply the AEDM to at least five of the manufacturer's basic models that have been selected for testing in accordance with paragraph (b)(1) of this section, and calculate the power loss for each of these basic models;

(ii) Test at least five units of each of these basic models in accordance with the applicable test procedure and paragraph (b)(2) of this section, and determine the power loss for each of these basic models;

(iii) The predicted total power loss for each of these basic models, calculated by applying the AEDM pursuant to paragraph (a)(3)(i) of this section, must be within plus or minus five percent of the mean total power loss determined from the testing of that basic model pursuant to paragraph (a)(3)(ii) of this section; and

(iv) Calculate for each of these basic models the percentage that its power loss calculated pursuant to paragraph (a)(3)(i) is of its power loss determined from testing pursuant to paragraph (a)(3)(ii), compute the average of these percentages, and that calculated average power loss, expressed as a percentage of the average power loss determined from testing, must be no less than 97 percent and no greater than 103 percent.

(4) *Subsequent verification of an AEDM.* (i) Each manufacturer that has used an AEDM under this section shall have available for inspection by the Department of Energy records showing: The method or methods used; the mathematical model, the engineering or statistical analysis, computer simulation or modeling, and other analytic evaluation of performance data on which the AEDM is based; complete test data, product information, and related information that the manufacturer has generated or acquired pursuant to paragraph (a)(3) of this section; and the calculations used to determine the efficiency and total power losses of each basic model to which the AEDM was applied.

(ii) If requested by the Department, the manufacturer shall conduct simulations to predict the performance of particular basic models of distribution transformers specified by the Department, analyses of previous simulations conducted by the manufacturer, sample testing of basic

models selected by the Department, or a combination of the foregoing.

(b) *Additional testing requirements—* (1) *Selection of basic models for testing if an AEDM is to be applied.* (i) A manufacturer must select basic models for testing in accordance with the following criteria:

(A) Two of the basic models must be among the five basic models with the highest unit volumes of production by the manufacturer in the prior year, or during the prior 12-calendar-month period beginning in 2003,[1] whichever is later;

(B) No two basic models should have the same combination of power and voltage ratings; and

(C) At least one basic model should be single-phase and at least one should be three-phase.

(ii) In any instance where it is impossible for a manufacturer to select basic models for testing in accordance with all of these criteria, the criteria shall be given priority in the order in which they are listed. Within the limits imposed by the criteria, basic models shall be selected randomly.

(2) *Selection of units for testing within a basic model.* For each basic model a manufacturer selects for testing, it shall select and test units as follows:

(i) If the manufacturer would produce five or fewer units of a basic model over a reasonable period of time (approximately 180 days), then it must test each unit. However, a manufacturer may not use a basic model with a sample size of fewer than five units to substantiate an AEDM pursuant to paragraph (a)(3) of this section.

(ii) If the manufacturer produces more than five units over such period of time, it must either test all such units or select a sample of at least five units at random and test them. Any such sample shall be comprised of production units of the basic model, or units that are representative of such production units.

(3) *Applying results of testing.* In a test of compliance with a represented efficiency, the average efficiency of the sample, $\bar{X}$, which is defined by

$$\bar{X} = \frac{1}{n}\sum_{i=1}^{n} X_i$$

where X_i is the measured efficiency of unit i and n is the number of units tested, must satisfy the condition:

[1] When identifying these five basic models, any basic model that does not comply with Federal energy conservation standards for distribution transformers that may be in effect shall be excluded from consideration.

$$\bar{X} \geq \frac{100}{1 + \left(1 + \frac{0.08}{\sqrt{n}}\right)\left(\frac{100}{RE} - 1\right)}$$

where RE is the represented efficiency.

§ 431.198 Enforcement testing for distribution transformers.

(a) *Test notice.* Upon receiving information in writing, concerning the energy performance of a particular distribution transformer sold by a particular manufacturer or private labeler, which indicates that the transformer may not be in compliance with the applicable energy efficiency standard, or upon undertaking to ascertain the accuracy of the efficiency rating on the nameplate or in marketing materials for a distribution transformer, disclosed pursuant to this part, the Department may conduct testing of that equipment under this subpart by means of a test notice addressed to the manufacturer in accordance with the following requirements:

(1) The test notice procedure will only be followed after the Department has examined the underlying test data (or, where appropriate, data as to use of an AEDM) provided by the manufacturer and after the manufacturer has been offered the opportunity to meet with the Department to verify, as applicable, compliance with the applicable efficiency standard, or the accuracy of labeling information, or both. In addition, where compliance of a basic model was certified based on an AEDM, the Department shall have the discretion to pursue the provisions of § 431.197(a)(4)(ii) prior to invoking the test notice procedure. The Department shall be permitted to observe any reverification procedures undertaken pursuant to this subpart, and to inspect the results of such reverification.

(2) The Department will mail or deliver the test notice to the plant manager or other responsible official, as designated by the manufacturer.

(3) The test notice will specify the basic model(s) to be selected for testing, the method of selecting the test sample, the date and time at which testing shall be initiated, the date by which testing is scheduled to be completed and the facility at which testing will be conducted. The test notice may also provide for situations in which a specified basic model is unavailable for testing, and may include alternative basic models. The specified basic model may be one either that the manufacturer has rated by actual testing or that it has rated by the use of an AEDM.

(4) The Department may require in the test notice that the manufacturer shall

ship at its expense a reasonable number of units of each basic model specified in such test notice to a testing laboratory designated by the Department. The number of units of each basic model specified in a test notice shall not exceed twenty (20).

(5) Except as required or provided in paragraphs (a)(6) or (a)(7) of this section, initially the Department will test five units.

(6) Except as provided in paragraph (a)(7) of this section, if fewer than five units of a basic model are available for testing when the manufacturer receives the test notice, then

(i) DOE will test the available unit(s); or

(ii) If one or more other units of the basic model are expected to become available within six months, DOE may instead, at its discretion, test either:

(A) The available unit(s) and one or more of the other units that subsequently become available (up to a maximum of twenty); or

(B) Up to twenty of the other units that subsequently become available.

(7) Notwithstanding paragraphs (a)(5) and (a)(6) of this section, if testing of the available or subsequently available units of a basic model would be impractical, as for example where a basic model is very large, has unusual testing requirements, or has limited production, the Department may in its discretion decide to base the determination of compliance on the testing of fewer than the available number of units, if the manufacturer so requests and demonstrates that the criteria of this paragraph are met.

(8) When testing units under paragraphs (a)(5), (a)(6), or (a)(7) of this section, DOE shall perform the following number of tests:

(i) If DOE tests four or more units, it will test each unit once;

(ii) If DOE tests two or three units, it will test each unit twice; or

(iii) If DOE tests one unit, it will test that unit four times.

(9) Within five working days of the time the units are selected, the manufacturer shall ship the specified test units of the basic model to the testing laboratory.

(b) *Testing laboratory.* Whenever the Department conducts enforcement testing at a designated laboratory in accordance with a test notice under this section, the resulting test data shall constitute official test data for that basic model. Such test data will be used by the Department to make a determination of compliance or noncompliance.

(c) *Sampling.* The determination that a manufacturer's basic model complies with its labeled efficiency, or the

applicable energy efficiency standard, shall be based on the testing conducted in accordance with the statistical sampling procedures set forth in Appendix B of this subpart and the test procedures specified for distribution transformers.

(d) *Test unit selection.* The Department shall select a batch, a batch sample, and test units from the batch sample in accordance with the following provisions of this paragraph and the conditions specified in the test notice.

(1) The batch may be subdivided by the Department utilizing criteria specified in the test notice.

(2) The Department will then randomly select a batch sample of up to 20 units from one or more subdivided groups within the batch. The manufacturer shall keep on hand all units in the batch sample until such time as the basic model is determined to be in compliance or non-compliance.

(3) The Department will randomly select individual test units comprising the test sample from the batch sample.

(4) All random selection shall be achieved by sequentially numbering all of the units in a batch sample and then using a table of random numbers to select the units to be tested.

(e) *Test unit preparation.* (1) Prior to and during the testing, a test unit selected in accordance with paragraph (d) of this section shall not be prepared, modified, or adjusted in any manner unless such preparation, modification, or adjustment is allowed by the applicable Department of Energy test procedure.

(2) No quality control, testing, or assembly procedures shall be performed on a test unit, or any parts and sub-assemblies thereof, that is not performed during the production and assembly of all other units included in the basic model.

(3) A test unit shall be considered defective if such unit is inoperative or is found to be in noncompliance due to failure of the unit to operate according to the manufacturer's design and operating instructions. Defective units, including those damaged due to shipping or handling, shall be reported immediately to the Department. The Department shall authorize testing of an additional unit on a case-by-case basis.

(f) *Testing at manufacturer's option.* (1) If a manufacturer's basic model is determined to be in noncompliance with the applicable energy performance standard at the conclusion of Department testing in accordance with the sampling plan specified in Appendix B of this subpart, the manufacturer may request that the

Department conduct additional testing of the basic model according to procedures set forth in Appendix B of this subpart and the test procedures specified for distribution transformers.

(2) All units tested under this paragraph (f) shall be selected and tested in accordance with the provisions given in paragraphs (a)(9), (b), (d) and (e) of this section.

(3) The manufacturer shall bear the cost of all testing conducted under this paragraph (f).

(4) The manufacturer shall cease distribution of the basic model tested under the provisions of this paragraph from the time the manufacturer elects to exercise the option provided in this paragraph until the basic model is determined to be in compliance. The Department may seek civil penalties for all units distributed during such period.

(5) If the additional testing results in a determination of compliance, a notice of allowance to resume distribution shall be issued by the Department.

■ 7. Appendices A and B are added to subpart K, to read as follows:

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

1.0 Definitions.

The definitions contained in §§ 431.2 and 431.192 are applicable to this Appendix A.

2.0 Accuracy Requirements.

(a) Equipment and methods for loss measurement shall be sufficiently accurate that measurement error will be limited to the values shown in Table 2.1.

TABLE 2.1.—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	± 1.0 °C

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

3.0 Resistance Measurements

3.1 *General Considerations*

(a) Measure or establish the winding temperature at the time of the winding resistance measurement.

(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 2.1.

3.2 *Temperature Determination of Windings and Pre-conditions for Resistance Measurement.*

Make temperature measurements in protected areas where the air temperature is stable and there are no drafts. Determine the winding temperature (T_{dc}) for liquid-immersed and dry-type distribution transformers by the methods described in sections 3.2.1 and 3.2.2, respectively.

3.2.1 *Liquid-Immersed Distribution Transformers.*

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 oil 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 transformer liquid, with one located directly above the winding and other located directly below the winding.

3.2.1.2 *Conditions*

Make this determination under either of the following conditions:

(a) The windings have been under insulating liquid with no excitation and no current in the windings for four hours before the dc resistance is measured; or

(b) The temperature of the insulating liquid has stabilized, and the difference between the top and bottom temperature does not exceed 5 °C.

3.2.2 *Dry-Type Distribution Transformers.*

Record the winding temperature (T_{dc}) of dry-type transformers as either 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. 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

(b) For both ventilated and sealed units, use the ambient temperature of the test area, under the following conditions:

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

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

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

(4) 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.

3.3 *Resistance Measurement Methods.*

Make resistance measurements using either the resistance bridge method, the voltmeter-ammeter method or a resistance meter. In each instance when this Uniform Test Method 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.

3.3.1 *Resistance Bridge Methods.*

If the resistance bridge method is selected, use either the Wheatstone or Kelvin bridge circuit (or the equivalent of either).

3.3.1.1 *Wheatstone Bridge*

(a) This bridge is best suited for measuring resistances larger than ten ohms. A schematic diagram of a Wheatstone bridge with a representative transformer under test is shown in Figure 3.1.
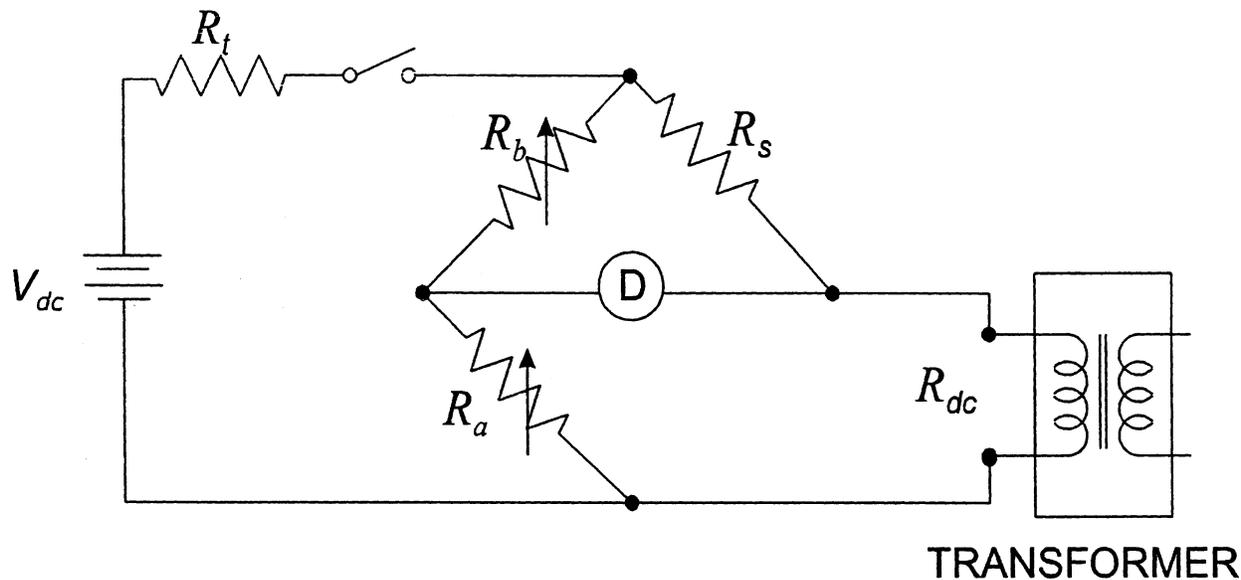

Figure 3.1 Wheatstone Bridge

Where:

R_{dc} is the resistance of the transformer winding being measured,

R_s is a standard resistor having the resistance R_s,

R_a, R_b are two precision resistors with resistance values R_a and R_b, respectively; at least one resistor must have a provision for resistance adjustment,

R_t is a resistor for reducing the time constant of the circuit,

D is a null detector, which may be either a micro ammeter or microvoltmeter or equivalent instrument for observing that no signal is present when the bridge is balanced, and

V_{dc} is a source of dc voltage for supplying the power to the Wheatstone Bridge.

(b) In the measurement process, turn on the source (V_{dc}), and adjust the resistance ratio (R_a/R_b) to produce zero signal at the detector (D). Determine the winding resistance by using equation 3–1 as follows:

$$R_{dc} = R_s \left(R_a / R_b \right) \qquad (3\text{-}1)$$

3.3.1.2 *Kelvin Bridge*

(a) This bridge separates the resistance of the connecting conductors to the transformer winding being measured from the resistance of the winding, and therefore is best suited for measuring resistances of ten ohms and smaller. A schematic diagram of a Kelvin bridge with a representative transformer under test is shown in Figure 3.2.
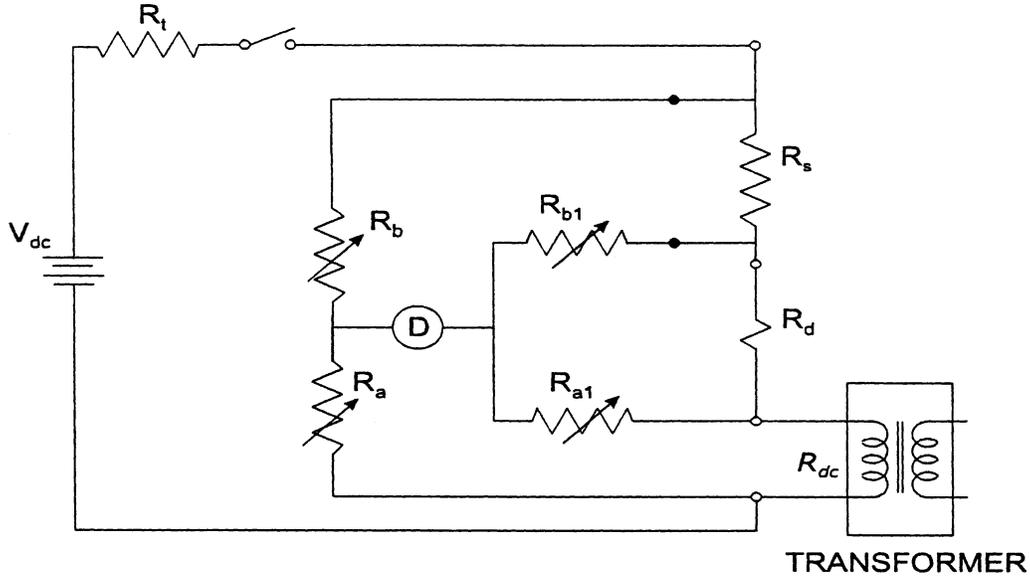

Figure 3.2 Kelvin Bridge

(b) The Kelvin Bridge has seven of the same type of components as in the Wheatstone Bridge. It has two more resistors than the Wheatstone bridge, R_{a1} and R_{b1}. At least one of these resistors must have adjustable resistance. In the measurement process, the source is turned on, two resistance ratios (R_a/R_b) and (R_{a1}/R_{b1}) are adjusted to be equal, and then the two ratios are adjusted together to balance the bridge producing zero signal at the detector.

Determine the winding resistance by using equation 3–2 as follows:

$$R_{dc} = R_s \left(R_a / R_b \right) \qquad (3\text{-}2),$$

as with the Wheatstone bridge, with an additional condition that:

$$\left(R_a / R_b \right) = \left(R_{a1} / R_{b1} \right) \qquad (3\text{-}3)$$

(c) The Kelvin bridge provides two sets of leads, current-carrying and voltage-sensing, to the transformer terminals and the standard resistor, thus eliminating voltage drops from the measurement in the current-carrying leads as represented by R_d.

3.3.2 *Voltmeter-Ammeter Method.*

(a) Employ the voltmeter-ammeter method only if the rated current of the winding is greater than one ampere and 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.
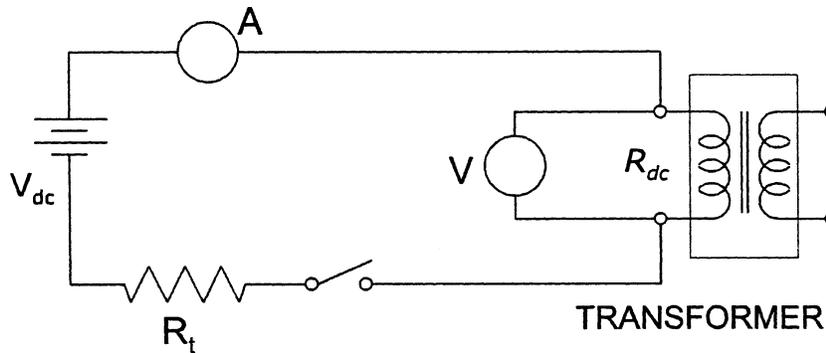

Figure 3.3 Voltmeter-Ammeter Method

Where:

A is an ammeter or a voltmeter-shunt combination for measuring the current (I_{mdc}) in the transformer winding,

V is a voltmeter with sensitivity in the millivolt range for measuring the voltage

(V_{mdc}) applied to the transformer winding,

R_{dc} is the resistance of the transformer winding being measured,

R_t is a resistor for reducing the time constant of the circuit, and

V_{dc} is a source of dc voltage for supplying power to the measuring circuit.

(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 simultaneous readings of voltage and current. Determine the winding resistance R_{dc} by using equation 3–4 as follows:

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

Where:

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

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

(c) As shown in Figure 3.3, separate current and voltage leads must be brought to the transformer terminals. (This eliminates the errors due to lead and contact resistance.)

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 2.1 in section 2.0.

3.4 *Precautions in Measuring Winding Resistance.*

3.4.1 *Required actions.*

The following guidelines must be observed when making resistance measurements:

(a) Use separate current and voltage leads when measuring small (< 10 ohms) resistance.

(b) Use null detectors in bridge circuits, and measuring instruments in voltmeter-ammeter circuits, that have sensitivity and resolution sufficient to enable observation of at least 0.1 percent change in the measured resistance.

(c) Maintain the dc test current at or below 15 percent of the rated winding current.

(d) Inclusion of a stabilizing resistor R_t (see section 3.4.2) will require higher source voltage.

(e) Disconnect the null detector (if a bridge circuit is used) and voltmeter from the circuit before the current is switched off, and switch off current by a suitable insulated switch.

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 2.0:

(b) The accurate reading of resistance R_{dc} may be facilitated by shortening the time constant. This is done by introducing a resistor R_t in series with the winding under test in both the bridge and voltmeter-ammeter circuits as shown in Figures 3.1 to 3.3. The relationship for the time constant is:

$$T_c = \left(L_{tc}/R_{tc} \right) \qquad (3\text{-}5)$$

Where:

T_c is the time constant in seconds,

L_{tc} is the total magnetizing and leakage inductance of the winding under test, in henries, and

R_{tc} is the total resistance in ohms, consisting of R_t in series with the winding resistance R_{dc} and the resistance R_s of the standard resistor in the bridge circuit.

(c) Because R_{tc} is in the denominator of the expression for the time constant, increasing the resistance R_{tc} will decrease the time constant. If the time constant in a given test circuit is too long for the resistance readings to be stable, then a higher resistance can be substituted for the existing R_{tc}, and successive replacements can be made until adequate stability is reached.

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. As specified in these test procedures, the reference temperature for liquid-immersed transformers loaded at 50 percent of the rated load is 55 °C. For medium-voltage, dry-type transformers loaded at 50 percent of the rated load, and for low-voltage, dry-type transformers loaded at 35 percent of the rated load, the reference temperature is 75 °C.

(b) Correct the measured resistance to the resistance at the reference temperature using equation 3–6 as follows:

$$R_{ts} = R_{dc} \left[\left(T_s + T_k \right)/\left(T_{dc} + T_k \right) \right] \qquad (3\text{-}6)$$

Where:

R_{ts} is the resistance at the reference temperature, T_s,

R_{dc} is the measured resistance at temperature, T_{dc},

T_s is the reference temperature in °C,

T_{dc} is the temperature at which resistance was measured in °C, and

T_k is 234.5 °C for copper or 225 °C for aluminum.

4.0 Loss Measurement

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 will 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 distribution transformers designed for harmonic currents using a sinusoidal waveform (k=1).

4.2 *Measurement of Power Losses.*

4.2.1 *No-Load Loss.*

Measure the no-load loss and apply corrections as described in section 4.4, using the appropriate test set as described in section 4.3.

4.2.2 *Load Loss.*

Measure the load loss and apply corrections as described in section 4.5, using the appropriate test set as described in section 4.3.

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 2.1 in section 2.0. 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 2.0 or the individual phase angle error exceeds the values specified in section 4.5.3.

(b) A test set based on the wattmeter-voltmeter-ammeter principle may be used to measure the power loss and the applied voltage and current of a transformer where the transformer's test current and voltage are within the measurement capability of the measuring instruments. Current and voltage transformers, known collectively as instrument transformers, or other scaling devices such as resistive or capacitive dividers for voltage, may be used in the above circumstance, and must be used together with instruments to measure current, voltage, or power where the current or voltage of the transformer under test exceeds the measurement capability of such instruments. Thus, a test set may include a combination of measuring instruments and instrument transformers (or other scaling devices), so long as the current or voltage of the transformer under test does not exceed the measurement capability of any of the instruments.

4.3.1 *Single-Phase Test Sets.*

Use these for testing single-phase distribution transformers.

4.3.1.1 *Without Instrument Transformers.*

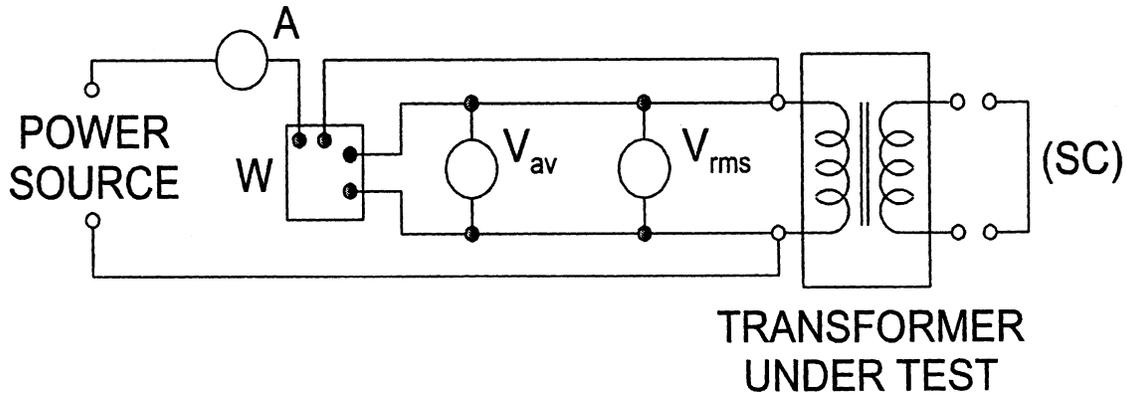(a) A single-phase test set without an instrument transformer is shown in Figure 4.1.

Figure 4.1   Single-Phase Test Set Without Instrument Transformers

Where:

W is a wattmeter used to measure P_{nm} and P_{lm}, the no-load and load loss power, respectively,

V_{rms} is a true root-mean-square (rms) voltmeter used to measure $V_{r(nm)}$ and V_{lm}, the rms test voltages in no-load and load loss measurements, respectively,

V_{av} is an average sensing voltmeter, calibrated to indicate rms voltage for sinusoidal waveforms and used to measure $V_{a(nm)}$, the average voltage in no-load loss measurements,

A is an rms ammeter used to measure test current, especially I_{lm}, the load loss current, and

(SC) is a conductor for providing a short-circuit across the output windings for the load loss measurements.

(b) Either the primary or the secondary winding can be connected to the test set. However, more compatible voltage and current levels for the measuring instruments are available if for no-load loss measurements the secondary (low voltage) winding is connected to the test set, and for load loss

measurements the primary winding is connected to the test set. Use the average-sensing voltmeter, V_{av}, only in no-load loss measurements.

4.3.1.2   *With Instrument Transformers.*

A single-phase test set with instrument transformers is shown in Figure 4.2. This circuit has the same four measuring instruments as that in Figure 4.1. The current and voltage transformers, designated as (CT) and (VT), respectively, are added.
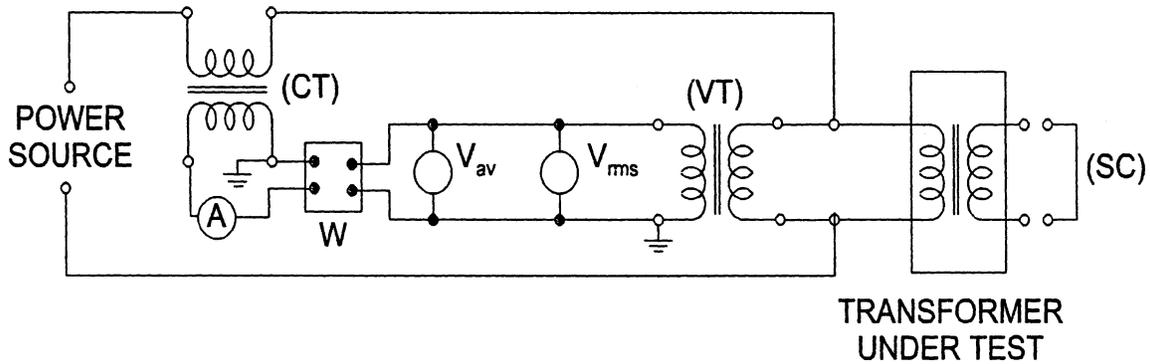

Figure 4.2   Single-Phase Test Set With Instrument Transformers

4.3.2   *Three-Phase Test Sets.*

Use these for testing three-phase distribution transformers. Use in a four-wire, three-wattmeter test circuit.

4.3.2.1   *Without Instrument Transformers.*

(a) A three-phase test set without instrument transformers is shown in Figure 4.3. This test set is essentially the same circuit shown in Figure 4.1 repeated three times, and the instruments are individual

devices as shown. As an alternative, the entire instrumentation system of a three-phase test set without transformers may consist of a multi-function analyzer.
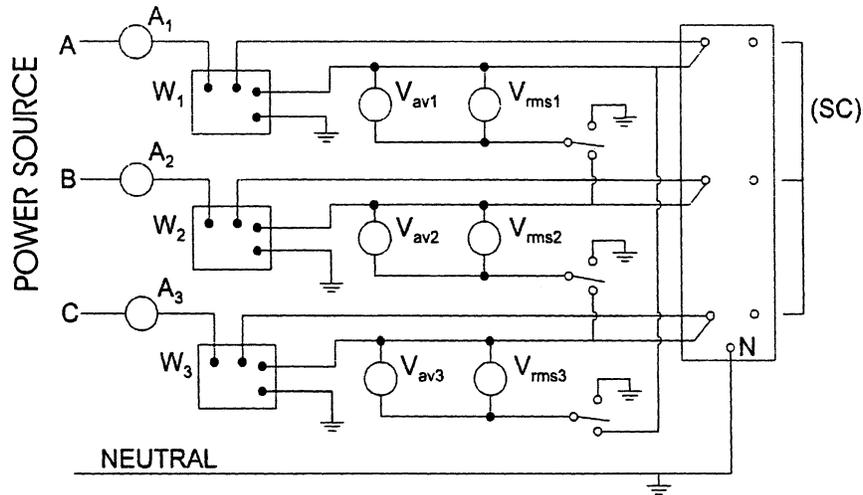
Figure 4.3   Three-Phase Test Set Without Instrument
                  Transformers

(b) Either group of windings, the primary or the secondary, can be connected in wye or delta configuration. If both groups of windings are connected in the wye configuration for the no-load test, the neutral of the winding connected to the test set must be connected to the neutral of the source to provide a return path for the neutral current.

(c) In the no-load loss measurement, the voltage on the winding must be measured.

Therefore a provision must be made to switch the voltmeters for line-to-neutral measurements for wye-connected windings and for line-to-line measurements for delta-connected windings.

4.3.2.2 *With Instrument Transformers.*

A three-phase test set with instrument transformers is shown in Figure 4.4. This test set is essentially the same circuit shown in Figure 4.2 repeated three times. Provision

must be made to switch the voltmeters for line-to-neutral and line-to-line measurements as in section 4.3.2.1. The voltage sensors ("coils") of the wattmeters must always be connected in the line-to-neutral configuration.
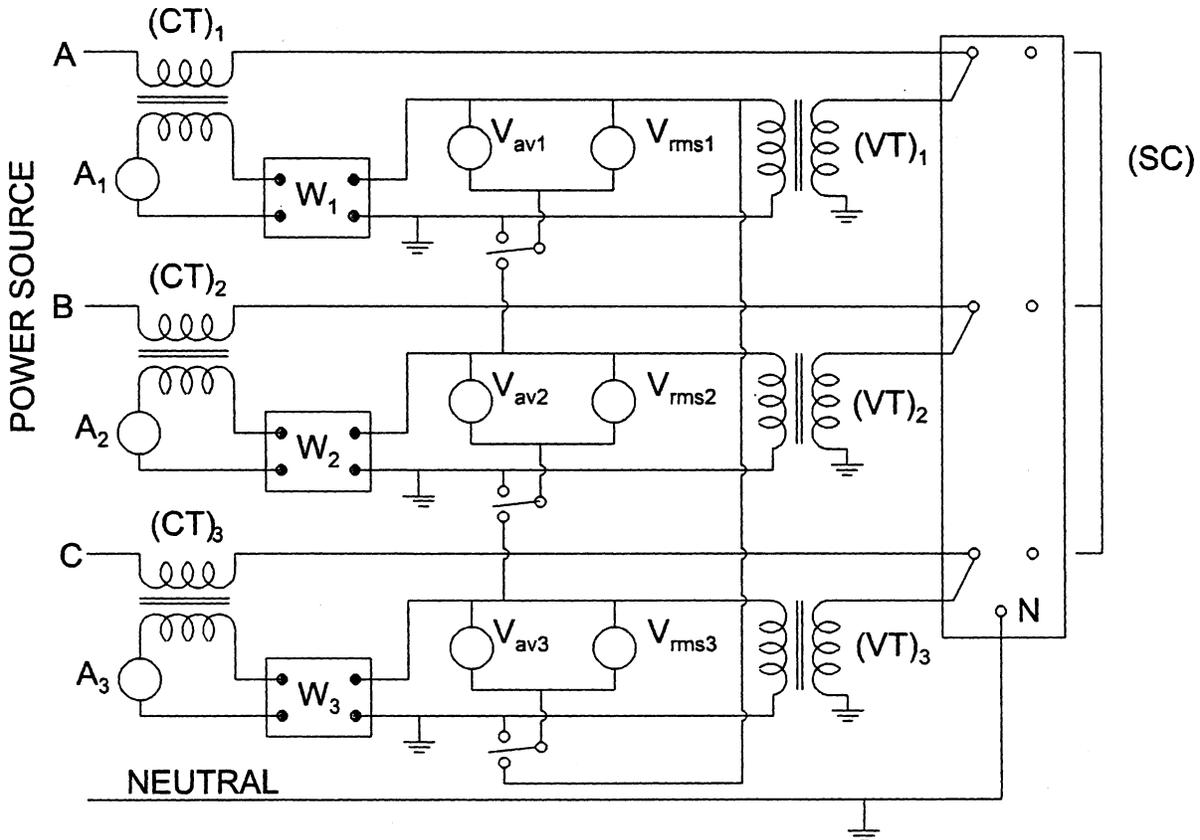

Figure 4.4 Three-Phase Test Set with Instrument Transformers

4.3.2.3 *Test Set Neutrals.*

If the power source in the test circuit is wye-connected, ground the neutral. If the power source in the test circuit is delta-connected, use a grounding transformer to obtain neutral and ground for the test.

4.4 *No-Load Losses: Measurement and Calculations.*

4.4.1 *General Considerations.*

Measurement corrections are permitted but not required for instrumentation losses and for losses from auxiliary devices. Measurement corrections are required:

(a) When the waveform of the applied voltage is non-sinusoidal; and

(b) When the core temperature or liquid temperature is outside the 20 °C ± 10 °C range.

4.4.2 *No-Load Loss Test.*

(a) The purpose of the no-load loss test is to measure no-load losses at a specified excitation voltage and a specified frequency. The no-load loss determination must be based on a sine-wave voltage corrected to the reference temperature. Connect either of the transformer windings, primary or secondary, to the appropriate test set of Figures 4.1 to 4.4, giving consideration to section 4.4.2(a)(2). Leave the unconnected winding(s) open circuited. Apply the rated voltage at rated frequency, as measured by the average-sensing voltmeter, to the transformer. Take the readings of the wattmeter(s) and the average-sensing and true rms voltmeters. Observe the following precautions:

(1) Voltmeter connections. When correcting to a sine-wave basis using the average-voltmeter method, the voltmeter connections must be such that the waveform applied to the voltmeters is the same as the waveform across the energized windings.

(2) Energized windings. Energize either the high voltage or the low voltage winding of the transformer under test.

(3) Voltage and frequency. The no-load loss test must be conducted with rated voltage impressed across the transformer terminals using a voltage source at a frequency equal to the rated frequency of the transformer under test.

(b) Adjust the voltage to the specified value as indicated by the average-sensing voltmeter. Record the values of rms voltage, rms current, electrical power, and average voltage as close to simultaneously as possible. 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 *Corrections.*

4.4.3.1 *Correction for Instrumentation Losses.*

Measured losses attributable to the voltmeters and wattmeter voltage circuit, and to voltage transformers if they are used, may be deducted from the total no-load losses measured during testing.

4.4.3.2 *Correction for Non-Sinusoidal Applied Voltage.*

(a) The measured value of no-load loss must be corrected to a sinusoidal voltage, except when waveform distortion in the test voltage causes the magnitude of the correction to be less than 1 percent. In such a case, no correction is required.

(b) To make a correction where the distortion requires a correction of 5 percent or less, use equation 4–1. If the distortion requires a correction to be greater than 5 percent, improve the test voltage and re-test. Repeat until the distortion requires a correction of 5 percent or less.

(c) Determine the no-load losses of the transformer corrected for sine-wave basis from the measured value by using equation 4–1 as follows:

$$P_{ncl} = \frac{P_{nm}}{P_1 + kP_2} \qquad (4\text{-}1)$$

Where:

P_{ncl} is the no-load loss corrected to a sine-wave basis at the temperature (T_{nm}) at which no-load loss is measured,

P_{nm} is the measured no-load loss at temperature T_{nm},

P_1 is the per unit hysteresis loss,

P_2 is the per unit eddy-current loss,

$P_1 + P_2 = 1$,

$$k = \left(\frac{V_{r(nm)}}{V_{a(nm)}}\right)^2 ,$$

$V_{r(nm)}$ is the test voltage measured by rms voltmeter, and

$V_{a(nm)}$ is the test voltage measured by average-voltage voltmeter.

(d) The two loss components (P_1 and P_2) are assumed equal in value, each assigned a value of 0.5 per unit, unless the actual measurement-based values of hysteresis and eddy-current losses are available (in per unit form), in which case the actual measurements apply.

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 of 20 °C. If the no-load loss measurements were made between 10 °C and 30 °C, this correction is not required. 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. Correct the no-load loss to the reference temperature by using equation 4–2 as follows:

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

Where:

P_{nc} is the no-load losses corrected for waveform distortion and then to the reference temperature of 20 °C,

P_{ncl} 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, 20 °C.

4.5 *Load Losses: Measurement and Calculations.*

4.5.1 *General Considerations.*

(a) The load losses of a transformer are those losses incident to a specified load carried by the transformer. Load losses consist of ohmic loss in the windings due to the load current and stray losses due to the eddy currents induced by the leakage flux in the windings, core clamps, magnetic shields, tank walls, and other conducting parts. The ohmic loss of a transformer varies directly with temperature, whereas the stray losses vary inversely with temperature.

(b) For a transformer with a tap changer, conduct the test at the rated current and rated-voltage tap position. For a transformer that has a configuration of windings which allows for more than one nominal rated voltage, determine its load losses either in the winding configuration in which the highest losses occur or in each winding configuration in which the transformer can operate.

4.5.2 *Tests for Measuring Load Losses.*

(a) Connect the transformer with either the high-voltage or low-voltage windings to the appropriate test set. Then short-circuit the winding that was not connected to the test set. Apply a voltage at the rated frequency (of the transformer under test) to the connected windings to produce the rated current in the transformer. Take the readings of the wattmeter(s), the ammeters(s), and rms voltmeter(s).

(b) Regardless of the test set selected, the following preparatory requirements must be satisfied for accurate test results:

(1) Determine the temperature of the windings using the applicable method in section 3.2.1 or section 3.2.2.

(2) The conductors used to short-circuit the windings must have a cross-sectional area equal to, or greater than, the corresponding transformer leads, or, if the tester uses a different method to short-circuit the windings, the losses in the short-circuiting conductor assembly must be less than 10 percent of the transformer's load losses.

(3) When the tester uses a power supply that is not synchronized with an electric utility grid, such as a dc/ac motor-generator set, follow the provisions of the ''Note'' in section 4.4.2.

4.5.3 *Corrections.*

4.5.3.1 *Correction for Losses from Instrumentation and Auxiliary Devices.*

4.5.3.1.1 *Instrumentation Losses.*

Measured losses attributable to the voltmeters, wattmeter voltage circuit and short-circuiting conductor (SC), and to the voltage transformers if they are used, may be deducted from the total load losses measured during testing.

4.5.3.1.2 *Losses from Auxiliary Devices.*

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. To exclude these losses, either (1) measure transformer losses without the auxiliary devices by removing or by-passing them, or (2) measure transformer losses with the auxiliary devices connected, determine the losses associated with the

auxiliary devices, and deduct these losses from the load losses measured during testing.

4.5.3.2 *Correction for Phase Angle Errors.*

(a) Corrections for phase angle errors are not required if the instrumentation is calibrated over the entire range of power factors and phase angle errors. Otherwise, determine whether to correct for phase angle errors from the magnitude of the normalized per unit correction, β_n, obtained by using equation 4–3 as follows:

$$\beta_n = \frac{V_{lm} I_{lm} \left(\beta_w - \beta_v + \beta_c\right)\sin\ \phi}{p_{lm}} \qquad (4\text{-}3)$$

(b) The correction must be applied if β_n is outside the limits of ±0.01. If β_n is within the limits of ±0.01, the correction is permitted but not required.

(c) If the correction for phase angle errors is to be applied, first examine the total system phase angle ($\beta_w - \beta_v + \beta_c$). Where the total system phase angle is equal to or less than ±12 milliradians (±41 minutes), use either equation 4–4 or 4–5 to correct the measured load loss power for phase angle errors, and where the total system phase angle exceeds ±12 milliradians (±41 minutes) use equation 4–5, as follows:

$$P_{lcl} = P_{lm} - V_{lm} I_{lm} \left(\beta_w - \beta_v + \beta_c\right)\sin\ \phi \qquad (4\text{-}4)$$

$$P_{lcl} = V_{lm} I_{lm} \cos\left(\phi + \beta_w - \beta_v + \beta_c\right) \qquad (4\text{-}5)$$

(d) The symbols in this section (4.5.3.2) have the following meanings:

P_{lc1} is the corrected wattmeter reading for phase angle errors,

P_{lm} is the actual wattmeter reading,

V_{lm} is the measured voltage at the transformer winding,

I_{lm} is the measured rms current in the transformer winding,

$$\phi = \cos^{-1} \frac{P_{lm}}{V_{lm} I_{lm}}$$

is the measured phase angle between V_{lm} and I_{lm},

β_w is the phase angle error (in radians) of the wattmeter; the error is positive if the phase angle between the voltage and current phasors as sensed by the wattmeter is smaller than the true phase angle, thus effectively increasing the measured power,

β_v is the phase angle error (in radians) of the voltage transformer; the error is positive if the secondary voltage leads the primary voltage, and

β_c is the phase angle error (in radians) of the current transformer; the error is positive if the secondary current leads the primary current.

(e) The instrumentation phase angle errors used in the correction equations must be specific for the test conditions involved.

4.5.3.3 *Temperature Correction of Load Loss.*

(a) When the measurement of load loss is made at a temperature T_{lm} that is different from the reference temperature, use the procedure summarized in the equations 4–6 to 4–10 to correct the measured load loss to the reference temperature. The symbols used in these equations are defined at the end of this section.

(b) Calculate the ohmic loss (P_e) by using equation 4–6 as follows:

$$P_e = P_{e(p)} + P_{e(s)}$$

$$= I_{lm(p)}^2 R_{dc(p)} \frac{T_{k(p)} + T_{lm}}{T_{k(p)} + T_{dc}} + I_{lm(s)}^2 R_{dc(s)} \frac{T_{k(s)} + T_{lm}}{T_{k(s)} + T_{dc}}$$

$$= I_{lm(p)}^2 \left[R_{dc(p)} \frac{T_{k(p)} + T_{lm}}{T_{k(p)} + T_{dc}} + \left[\frac{N_1}{N_2}\right]^2 R_{dc(s)} \frac{T_{k(s)} + T_{lm}}{T_{k(s)} + T_{dc}} \right] \qquad (4\text{-}6)$$

(c) Obtain the stray loss by subtracting the calculated ohmic loss from the measured load loss, by using equation 4–7 as follows:

$$P_s = P_{lc1} - P_e \qquad (4\text{-}7)$$

(d) Correct the ohmic and stray losses to the reference temperature for the load loss by using equations 4–8 and 4–9, respectively, as follows:

$$P_{er} = P_{e(p)} \frac{T_{k(p)} + T_{lr}}{T_{k(p)} + T_{lm}} + P_{e(s)} \frac{T_{k(s)} + T_{lr}}{T_{k(s)} + T_{lm}}$$

$$= I_{lm(p)}^2 \left[R_{dc(p)} \frac{T_{k(p)} + T_{lr}}{T_{k(p)} + T_{dc}} + \left[\frac{N_1}{N_2}\right]^2 R_{dc(s)} \frac{T_{k(s)} + T_{lr}}{T_{k(s)} + T_{dc}} \right] \qquad (4\text{-}8)$$

$$P_{sr} = \left(P_{lc1} - P_e\right) \frac{T_k + T_{lm}}{T_k + T_{lr}} \qquad (4\text{-}9)$$

(e) Add the ohmic and stray losses, corrected to the reference temperature, to give the load loss, P_{lc2}, at the reference temperature, by using equation 4–10 as follows:

$$P_{lc2} = P_{er} + P_{sr}$$

$$= I_{lm(p)}^2 \left[R_{dc(p)} \frac{T_{k(p)} + T_{lr}}{T_{k(p)} + T_{dc}} + \left[\frac{N_1}{N_2} \right]^2 R_{dc(s)} \frac{T_{k(s)} + T_{lr}}{T_{k(s)} + T_{dc}} \right]$$

$$+ \left[P_{lc1} - I_{lm(p)}^2 \left[R_{dc(p)} \frac{T_{k(p)} + T_{lm}}{T_{k(p)} + T_{dc}} + \left[\frac{N_1}{N_2} \right]^2 R_{dc(s)} \frac{T_{k(s)} + T_{lm}}{T_{k(s)} + T_{dc}} \right] \right] \frac{T_k + T_{lm}}{T_k + T_{lr}} \qquad (4\text{-}10)$$

(f) The symbols in this section (4.5.3.3) have the following meanings:

$I_{lm(p)}$ is the primary current in amperes,

$I_{lm(s)}$ is the secondary current in amperes,

P_e is the ohmic loss in the transformer in watts at the temperature T_{lm},

$P_{e(p)}$ is the ohmic loss in watts in the primary winding at the temperature T_{lm},

$P_{e(s)}$ is the ohmic loss in watts in the secondary winding at the temperature T_{lm},

P_{er} is the ohmic loss in watts corrected to the reference temperature,

P_{lc1} is the measured load loss in watts, corrected for phase angle error, at the temperature T_{lm},

P_{lc2} is the load loss at the reference temperature,

P_s is the stray loss in watts at the temperature T_{lm},

P_{sr} is the stray loss in watts corrected to the reference temperature,

$R_{dc(p)}$ is the measured dc primary winding resistance in ohms,

$R_{dc(s)}$ is the measured dc secondary winding resistance in ohms,

T_k is the critical temperature in degrees Celsius for the material of the transformer windings. Where copper is used in both primary and secondary windings, T_k is 234.5 °C; where aluminum is used in both primary and secondary windings, T_k is 225 °C; where both copper and aluminum are used in the same transformer, the value of 229 °C is used for T_k,

$T_{k(p)}$ is the critical temperature in degrees Celsius for the material of the primary winding: 234.5 °C if copper and 225 °C if aluminum,

$T_{k(s)}$ is the critical temperature in degrees Celsius for the material of the secondary winding: 234.5 °C if copper and 225 °C if aluminum,

T_{lm} is the temperature in degrees Celsius at which the load loss is measured,

T_{lr} is the reference temperature for the load loss in degrees Celsius,

T_{dc} is the temperature in degrees Celsius at which the resistance values are measured, and

N_1/N_2 is the ratio of the number of turns in the primary winding (N_1) to the number of turns in the secondary winding (N_2); for a primary winding with taps, N_1 is the number of turns used when the voltage applied to the primary winding is the rated primary voltage.

5.0 Determining the Efficiency Value of the Transformer

This section presents the equations to use in determining the efficiency value of the transformer at the required reference conditions and at the specified loading level. The details of measurements are described in sections 3.0 and 4.0. For a transformer that has a configuration of windings which allows for more than one nominal rated voltage, determine its efficiency either at the voltage at which the highest losses occur or at each voltage at which the transformer is rated to operate.

5.1 *Output Loading Level Adjustment.*

If the output loading level for energy efficiency is different from the level 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:

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

Where:

P_{lc} is the adjusted load loss power to the specified energy efficiency load level,

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 specified energy efficiency load level, where , and $P_{os} = P_{or}L^2$, and

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

5.2 *Total Loss Power Calculation.*

Calculate the corrected total loss power by using equation 5–2 as follows:

$$P_{ts} = P_{nc} + P_{lc} \qquad (5\text{-}2)$$

Where:

P_{ts} is the corrected total loss power adjusted for the transformer output loading specified by the standard,

P_{nc} is as calculated in section 4.4.3.3, and

P_{lc} is as calculated in section 5.1.

5.3 *Energy Efficiency Calculation.*

Calculate efficiency (η) in percent at specified energy efficiency load level, P_{os}, by using equation 5–3 as follows:

$$\eta = 100 \left(\frac{P_{os}}{P_{os} + P_{ts}} \right) \qquad (5\text{-}3)$$

Where:

P_{os} is as described and calculated in section 5.1, and

P_{ts} is as described and calculated in section 5.2.

5.4 *Significant Figures in Power Loss and Efficiency Data.*

In measured and calculated data, retain enough significant figures to provide at least 1 percent resolution in power loss data and 0.01 percent resolution in efficiency data.

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 2.0, Table 2.1.

6.1 *Test Equipment.*

The party performing the tests shall 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 shall 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.*

The party performing the tests must:

(a) Identify the measurements to be made, the accuracy required (section 2.0) and select the appropriate measurement and test equipment;

(b) At prescribed intervals, or prior to use, identify, check and calibrate, if needed, all measuring and test equipment systems or devices that affect test accuracy, against certified equipment having a known valid relationship to nationally recognized standards; where no such standards exist, the basis used for calibration must be documented;

(c) Establish, document and maintain calibration procedures, including details of equipment type, identification number, location, frequency of checks, check method, acceptance criteria and action to be taken when results are unsatisfactory;

(d) Ensure that the measuring and test equipment is capable of the accuracy and precision necessary, taking into account the voltage, current and power factor of the transformer under test;

(e) Identify measuring and test equipment with a suitable indicator or approved identification record to show the calibration status;

(f) Maintain calibration records for measuring and test equipment;

(g) Assess and document the validity of previous test results when measuring and test equipment is found to be out of calibration;

(h) Ensure that the environmental conditions are suitable for the calibrations, measurements and tests being carried out;

(i) Ensure that the handling, preservation and storage of measuring and test equipment is such that the accuracy and fitness for use is maintained; and

(j) Safeguard measuring and test facilities, including both test hardware and test software, from adjustments which would invalidate the calibration setting.

Appendix B to Subpart K of Part 431—Sampling Plan for Enforcement Testing

Step 1. The number of units in the sample (m_1) shall be in accordance with §§ 431.198(a)(4), 431.198(a)(5), 431.198(a)(6) and 431.198(a)(7) and shall not be greater than twenty. The number of tests in the first sample (n_1) shall be in accordance with § 431.198(a)(8) and shall be not fewer than four.

Step 2. Compute the mean ($\bar{X}_i$) of the measured energy performance of the n_1 tests in the first sample by using equation 1 as follows:

$$\bar{X}_1 = \frac{1}{n_1} \sum_{i=1}^{n_1} X_i \qquad (1)$$

where X_i is the measured efficiency of test i.

Step 3. Compute the sample standard deviation (S_1) of the measured efficiency of the n_1 tests in the first sample by using equation 2 as follows:

$$S_1 = \sqrt{\frac{\sum_{i=1}^{n_1} \left(X_i - \bar{X}_1\right)^2}{n_1 - 1}} \qquad (2)$$

Step 4. Compute the standard error ($SE(\bar{X}_1)$) of the mean efficiency of the first sample by using equation 3 as follows:

$$SE\left(\bar{X}_1\right) = \frac{S_1}{\sqrt{n_1}} \qquad (3)$$

Step 5. Compute the sample size discount ($SSD(m_1)$) by using equation 4 as follows:

$$SSD\left(m_1\right) = \frac{100}{1 + \left(1 + \frac{.08}{\sqrt{m_1}}\right)\left(\frac{100}{RE} - 1\right)} \qquad (4)$$

where m_1 is the number of units in the sample, and RE is the applicable EPCA efficiency when the test is to determine compliance with the applicable statutory standard, or is the labeled efficiency when

the test is to determine compliance with the labeled efficiency value.

Step 6. Compute the lower control limit (LCL_1) for the mean of the first sample by using equation 5 as follows:

$$LCL_1 = SSD\left(m_1\right) - tSE\left(\bar{X}_1\right) \qquad (5)$$

where t is the 2.5th percentile of a t-distribution for a sample size of n_1, which yields a 97.5 percent confidence level for a one-tailed t-test.

Step 7. Compare the mean of the first sample ($\bar{X}_1$) with the lower control limit (LCL_1) to determine one of the following:

(i) If the mean of the first sample is below the lower control limit, then the basic model is in non-compliance and testing is at an end.

(ii) If the mean is equal to or greater than the lower control limit, no final determination of compliance or non-compliance can be made; proceed to Step 8.

Step 8. Determine the recommended sample size (n) by using equation 6 as follows:

$$n = \left[\frac{tS_1\left(108 - 0.08RE\right)}{RE\left(8 - 0.08RE\right)}\right]^2 \qquad (6)$$

where S_1 and t have the values used in Steps 3 and 6, respectively. The factor

$$\frac{108 - 0.08RE}{RE\left(8 - 0.08RE\right)}$$

is based on an 8-percent tolerance in the total power loss.

Given the value of n, determine one of the following:

(i) If the value of n is less than or equal to n_1 and if the mean energy efficiency of the first sample ($\bar{X}_1$) is equal to or greater than the lower control limit (LCL_1), the basic model is in compliance and testing is at an end.

(ii) If the value of n is greater than n_1, and no additional units are available for testing, testing is at an end and the basic model is in non-compliance. If the value of n is greater than n_1, and additional units are available for testing, select a second sample n_2. The size of the n_2 sample is determined to be the smallest integer equal to or greater than the difference $n-n_1$. If the value of n_2 so calculated is greater than $20-n_1$, set n_2 equal to $20-n_1$.

Step 9. After testing the n_2 sample, compute the combined mean ($\bar{X}_2$) of the measured energy performance of the n_1 and n_2 tests of the combined first and second samples by using equation 7 as follows:

$$\bar{X}_2 = \frac{1}{n_1 + n_2} \sum_{i=1}^{n_1 + n_2} X_i \qquad (7)$$

Step 10. Compute the standard error ($SE(\bar{X}_2)$) of the mean efficiency of the n_1 and n_2 tests in the combined first and second samples by using equation 8 as follows:

$$SE\left(\bar{X}_2\right) = \frac{S_1}{\sqrt{n_1 + n_2}} \qquad (8)$$

(Note that S_1 is the value obtained above in Step 3.)

Step 11. Set the lower control limit (LCL_2) to,

$$LCL_2 = SSD\left(m_1\right) - tSE\left(\bar{X}_2\right) \qquad (9)$$

where t has the value obtained in Step 5 and $SSD(m_1)$ is sample size discount from Step 5. Compare the combined sample mean ($\bar{X}_2$) to the lower control limit (LCL_2) to find one of the following:

(i) If the mean of the combined sample ($\bar{X}_2$) is less than the lower control limit (LCL_2), the basic model is in non-compliance and testing is at an end.

(ii) If the mean of the combined sample ($\bar{X}_2$) is equal to or greater than the lower control limit (LCL_2), the basic model is in compliance and testing is at an end.

Manufacturer-Option Testing

If a determination of non-compliance is made in Steps 6, 7 or 11, above, the manufacturer may request that additional testing be conducted, in accordance with the following procedures.

Step A. The manufacturer requests that an additional number, n_3, of units be tested, with n_3 chosen such that $n_1+n_2+n_3$ does not exceed 20.

Step B. Compute the mean efficiency, standard error, and lower control limit of the new combined sample in accordance with the procedures prescribed in Steps 8, 9, and 10, above.

Step C. Compare the mean performance of the new combined sample to the lower control limit (LCL_2) to determine one of the following:

(a) If the new combined sample mean is equal to or greater than the lower control limit, the basic model is in compliance and testing is at an end.

(b) If the new combined sample mean is less than the lower control limit and the value of $n_1+n_2+n_3$ is less than 20, the manufacturer may request that additional units be tested. The total of all units tested may not exceed 20. Steps A, B, and C are then repeated.

(c) Otherwise, the basic model is determined to be in non-compliance.

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