DEPARTMENT OF ENERGY

Office of Energy Efficiency and Renewable Energy

10 CFR Part 432

[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: Supplemental notice of proposed rulemaking and public meeting.

SUMMARY: The Department of Energy (DOE or the Department) previously published a notice of proposed rulemaking to adopt test procedures for measuring the energy efficiency of distribution transformers under the Energy Policy and Conservation Act (EPCA or the Act), definitions to delineate the products covered by the test procedures and provisions (including a sampling plan) for implementing the test procedures. The Department now proposes to adopt revised test procedures for distribution transformers, primarily based upon existing industry standards. The proposed rule also contains revised definitions and provisions to implement the test procedures, calculation methods that manufacturers could use to determine the efficiency of some of their models, and enforcement methods for distribution transformers. The Department would use the test procedures in evaluating whether, and to what extent, energy conservation standards are warranted for distribution transformers. If standards are promulgated, then these test procedures and the other provisions proposed today would be used to determine efficiency and assess compliance of the transformers subject to the standards.

DATES: The Department will hold a public meeting on the matters addressed in this document, on Monday, September 27, 2004, beginning at 9 a.m. in Room 1E–245, in Washington, DC. The Department must receive requests to speak at the meeting, and a signed original and electronic copy of statements to be given at the meeting, no later than 4 p.m., Monday, September 13, 2004. The Department will accept written comments, data, and information in response to this notice before or after the public meeting, but no later than Monday, November 8, 2004. See section IV, ''Public Participation,'' of this notice for details.

ADDRESSES: You may submit comments, identified by docket number EE–TP–98–550 and/or RIN number 1904–AA85, by any of the following methods:

- Federal eRulemaking Portal: *http://www.regulations.gov.* Follow the instructions for submitting comments.
- E-mail: *DistTransformersTP–SNOPR@ee.doe.gov.* Include EE–TP–98–550 and/or RIN 1904–AA85 in the subject line of the message.
- Mail: Ms. Brenda Edwards-Jones, U.S. Department of Energy, Building Technologies Program, Mailstop EE–2J, SNOPR for Distribution Transformer Test Procedures, EE–TP–98–550 and/or RIN 1904–AA85, 1000 Independence Avenue, SW., Washington, DC, 20585–0121. Telephone: (202) 586–2945. Please submit one signed original paper copy.
- Hand Delivery/Courier: Ms. Brenda Edwards-Jones, U.S. Department of Energy, Building Technologies Program, Room 1J–018, 1000 Independence Avenue, SW., Washington, DC, 20585.

Instructions: All submissions received must include the agency name and docket number or Regulatory Information Number (RIN) for this rulemaking. For detailed instructions on submitting comments and additional information on the rulemaking process, see section IV of this document (Public Participation).

Docket: For access to the docket to read background documents or comments received, go to the U.S. Department of Energy, Forrestal Building, Room 1J–018 (Resource Room of the Building Technologies Program), 1000 Independence Avenue, SW., Washington, DC, (202) 586–9127, between 9 a.m. and 4 p.m., Monday through Friday, except Federal holidays. Please call Ms. Brenda Edwards-Jones at the above telephone number for additional information regarding visiting the Resource Room. Please note: The Department's Freedom of Information Reading Room (formerly Room 1E–190 at the Forrestal Building) is no longer housing rulemaking materials.

FOR FURTHER INFORMATION CONTACT:
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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)) 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 currently available, energy conservation standards for electric distribution transformers appear to be technologically feasible and economically justified, and are likely to result in significant energy savings. 62 FR 54809. The Determination was based, in part, on analyses conducted by the Oak Ridge National Laboratory (ORNL), as explained in reports issued in July 1996 and September 1997.[1] 62 FR at 54811–54816.

The Department subsequently began the process for its adoption of test procedures for distribution transformers. On February 10, 1998, the Department held a public workshop (1998 workshop) to discuss the following issues: (a) Adoption of national and international consensus standards as the test procedures for determining the energy efficiency of distribution transformers, (b) defining the transformers that the test procedures will cover, (c) imposition of a burden on industry, especially on manufacturers, with additional testing and data processing, (d) definition of ''basic model'' for distribution transformers, (e) sampling plan for units to be tested, (f) selection of an energy consumption measure for distribution transformers, (g) selection of reference temperatures, (h) requirements for applying corrections to measurement data, and (i) requirements for quality assurance in testing. The Department also gave interested parties an opportunity to submit 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) a publication that extracts and presents the pertinent parts of the current industry standards for distribution transformer efficiency testing. NEMA TP 2 presents a weighted average method to use 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 formed the basis for preparing the November 12, 1998, Notice of Proposed Rulemaking (the ''1998 proposed rule''). 63 FR 63359.

In the 1998 proposed rule, the Department proposed to adopt test procedures that (1) it would use to evaluate distribution transformers for efficiency standards, and (2) manufacturers and DOE would use to determine the efficiency of any transformers which the standards covered. DOE proposed to incorporate by reference as its test procedures, provisions from either 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. 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,'' and 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 CFR part 430, which contains energy efficiency requirements for consumer products, but with modifications geared to transformers and a minimum sample size of five units. The Department selected this approach because it appeared to provide a satisfactory balance between assuring accuracy of efficiency ratings for distribution transformers and minimizing the test burden on manufacturers. The Department also sought comment on three alternative compliance approaches for basic models produced in small numbers.

DOE held a public hearing 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 3343, (the ''1999 reopening notice'') to provide an opportunity for additional public comment on the following issues: (a) The suitability of NEMA TP 2 for adoption as the DOE test procedure; (b) the adequacy of stakeholder opportunity to review NEMA TP 2; (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 and two additional comments during the development of today's proposed test procedure. These comments are addressed throughout section II of this supplemental notice of proposed rulemaking.

Finally, concurrent 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 Web site[3] several draft reports concerning the development of standards for these transformers. The next step in this process is the Department's issuance of an Advance Notice of Proposed Rulemaking (ANOPR) for distribution transformer standards. The Department expects to publish the ANOPR in the **Federal Register** later this year.

B. Summary of the Proposed Rule

In today's notice, the Department proposes to adopt a new test procedure for determining the energy efficiency of distribution transformers. The test procedure consists primarily of test methods contained in IEEE Standards C57.12.90–1999 and C57.12.91–2001, and NEMA TP 2. Initially, the Department would use the test procedure to test distribution transformers for which it is considering energy conservation standards. If DOE promulgates minimum efficiency standards, the Department would then require manufacturers to use the test procedure to determine compliance with the standards and as a basis for efficiency representations for transformers they produce that the standards cover. The Department would also use the test procedure in enforcement proceedings concerning compliance with standards or labeling requirements.

The proposed test procedure is a ''stand alone'' document. Thus, the

[1] The titles and references for these reports are ''Determination Analysis of Energy Conservation Standards for Distribution Transformers, ORNL–6847'' and ''Supplement to the 'Determination Analysis' (ORNL–6847) and Analysis of NEMA Efficiency Standard for Distribution Transformers, ORNL–6925.''

[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.*''

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

language of today's proposed rule sets forth all testing requirements, without reference to other sources, for determining the energy efficiency of distribution transformers. The measurement of electric power consumed by the transformer is in the form of no-load and load losses. The proposed rule specifies methods with which to measure the following quantities: Temperature of the windings and the core, current, voltage, waveform, and direct current resistance of the windings. The proposed rule also contains definitions that establish which transformers the test procedure covers and that clarify terms used in the test procedure. In addition, to reduce the number of transformers that manufacturers would have to test, the Department proposes to define ''basic model,'' proposes a sampling plan, and proposes to allow manufacturers to use alternative methods, other than testing, for determining the efficiency of some basic models. Finally, the proposed rule also sets forth enforcement procedures, including a testing protocol, for distribution transformers.

The Department's adoption of uniform test procedures would not necessarily mean that it would adopt a single efficiency standard or set of labeling requirements for all transformers that today's proposed rule covers. In the separate rulemaking proceeding concerning energy conservation standards for distribution transformers, the Department intends to divide such transformers into classes and may conclude that standards are not warranted for some classes of transformers that are within the scope of today's test procedure. Furthermore, for the classes for which DOE decides to adopt standards, it may create a separate standard for each class of products where the record indicates the products include a utility or performance-related feature that other products lack and that affects energy efficiency.

II. Discussion

A. The Test Procedure for Distribution Transformers

1. General Discussion

The Department developed today's proposed test procedure in order to have a single primary reference standard that would clearly set forth all testing requirements for the distribution transformers that might be covered by an EPCA energy conservation standard. DOE adapted virtually all of the provisions of the test procedure from NEMA TP 2 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.'' [4]

IEEE C57.12.90–1999 and IEEE C57.12.91–2001 address tests and measurements leading to the energy consumption and efficiency values. IEEE C57.12.00–2000 and C57.12.01–1998 complement IEEE C57.12.90–1999 and IEEE C57.12.91–2001 by specifying requirements such as measurement tolerances, which are critical for defining the testing conditions. Each of these four IEEE standards contains different elements of the energy efficiency test procedure for distribution transformers, as well as material not required for efficiency testing. Thus, if the Department were to prescribe the transformer test procedure by reference to these sources, it would require the user to consult several references, and applicable sections and clauses within those references, in order to construct a single test procedure. DOE believes that having a single, reference test procedure document would enhance the convenience to users and reduce the potential for misinterpretation of testing requirements.

Because NEMA TP 2 was designed to be a document that would contain all applicable testing provisions, the Department considered adopting it as the DOE test procedure. 63 FR at 63362, 63370–72; 64 FR at 33431–32. The Department therefore reviewed NEMA TP 2 and compared it with the similar material in the IEEE standards. NEMA TP 2 excerpts the information pertinent to transformer efficiency testing from these standards (using earlier editions of the standards), and presents it in abbreviated form. As a result of its review, the Department determined that NEMA TP 2 lacks the clarity and detail required in a regulatory document, and also contains a number of technical and typographical errors. Consequently, DOE is not proposing to use it as the DOE test procedure. Nevertheless, because NEMA TP 2 brings transformer efficiency testing provisions into a single document, the Department used it to develop today's proposed test procedure, which is designed to approach the level of detail of the IEEE standards. The following are examples of the ways in which the Department found NEMA TP 2 to be unsatisfactory for use as the DOE test procedure, and in which today's proposed test procedure differs from NEMA TP 2:

(1) Section 3 in NEMA TP 2, Resistance Measurements, contains insufficient detail, particularly in describing instrumentation. The proposed test procedure provides greater detail on the description of instrumentation, especially resistance bridges and their operating equations, and provides more information on temperature measurements.

(2) Figures 2 and 3 in NEMA TP 2 are too crowded with information. As a result, the graphics and print symbols are too small, some to the point of being unreadable. The proposed test procedure seeks to improve the value of the diagrams, by incorporating four simplified diagrams instead of two.

(3) Table 3 of NEMA TP 2 lacks a descriptive title, the title of Table 3's first column should be ''Resistance to be Measured,'' and the titles of the remaining three columns should each be followed by the word ''Method.'' In addition, Table 3's identification of the ranges covered by various methods does not reflect the capabilities of modern instruments. Resistance meters are available to measure resistances on a four-terminal basis below 10 ohms, and voltmeter-ammeter methods are useable above 100 ohms. Hence, today's proposed rule does not contain a table that is a counterpart to Table 3, and but instead sets forth in narrative form the approximate ranges for the use of each method.

(4) Equation (2) for phase angle correction, in section 4.1.4 of NEMA TP 2, is incorrect. The equation should be $Pc = Pm - VmAm\,(Wd - Vd + Cd)\sin f$, where $f = \cos^{-1}(Pm/VmAm)$. Also, NEMA TP 2 fails to define the polarities of the phase angle errors. For example, Wd is positive if the phase angle between the voltage and current phasors as sensed by the wattmeter is smaller than the true phase angle. The Department believes that today's proposed test procedure correctly addresses these points based on the provisions of IEEE C57.12.90 and C57.12.91. The Department also notes that, although equation (4–3) in section 4.5.3.2 of the proposal does not appear in the IEEE standards, it provides information similar to that in Table 1 of

[4] This discussion does not address section 7 of NEMA TP 2, ''Demonstration of Compliance,'' which is discussed in section II–D.

the IEEE C57.12.90 as to whether phase angle correction is required.

(5) Section 4.3.4.2 of NEMA TP 2 lacks some of the steps needed to calculate the load loss from the previously measured quantities. The test procedure proposed in today's notice includes all of the necessary steps.

2. Reference Conditions

To establish a standard basis for test results, today's proposed test procedure specifies reference conditions for testing and rating the efficiency of distribution transformers. In particular, the test procedure would require that equipment efficiencies be rated at the loading levels of 35 percent for low-voltage, dry-type models and 50 percent for medium-voltage, dry-type and all liquid-immersed models, as specified in NEMA TP 2.

The Department recognizes that considerations other than efficiency commonly require manufacturers to test transformers at 100 percent of their rated load. Today's proposed test procedure includes analytical techniques that a manufacturer could use, where it has tested a transformer at 100 percent of its rated load, to calculate the transformer's efficiency at the loading point specified in the test procedure. Thus, the manufacturer would not have to test the transformer at both the loading point prescribed in the test procedure and at 100 percent of its rated load. Moreover, once today's test procedure has been implemented, should experience indicate that the loading levels specified in the test procedure are not appropriate for rating some distribution transformers, the Department would consider adopting different loading levels for those types of transformers.

B. Transformers Subject to the Test Procedure

1. Background

In essence, section 346 of EPCA directs the Department to consider whether an energy conservation program for ''distribution transformers'' is warranted. (42 U.S.C. 6317(a)(1)) However, the statute does not define ''distribution transformer.'' In the Determination notice, the Department interpreted the term ''distribution transformer'' in section 346 of EPCA to mean ''all transformers with a primary voltage of 480 V to 35 kV, a secondary voltage of 120 V to 480 V, and a capacity of either 10 to 2500 kVA for liquid-immersed transformers or 0.25 kVA to 2500 kVA for dry-type transformers,'' except for transformers which are not continuously connected to a power distribution system as a distribution transformer. 62 FR at 54811. The 1998 proposal proposed to adopt essentially this same definition, except that the upper limit on secondary voltage was increased from 480 V to 600 V because the Department learned that industry typically classifies transformers with a secondary voltage up to 600 V as distribution transformers. 63 FR 63370 (November 12, 1998).

The primary reason for defining distribution transformer in this rulemaking is to identify the transformers to which the Department's test procedure would apply. As indicated above, initially the test procedure would apply only to those transformers that the Department is evaluating for standards. Thus, the issue of which products should be within today's proposed definition of distribution transformer is identical to the issue of which products the Department will evaluate for standards. As the following discussion indicates, in developing this definition, the Department has considered information received in its rulemaking on transformer standards. The Department has also based the proposed definition on consideration of the nature of transformers that are commonly understood to be ''distribution transformers,'' and of whether energy conservation standards for such a transformer would result in significant energy savings.

2. Changes to, and Retention of, Provisions in the 1998 Poposed Rule

Today's proposal eliminates from the definition of distribution transformer the 1998 proposed rule's lower limits on primary voltage and secondary voltage of 480 V and 120 V, respectively. In the 1999 reopening notice, the Department stated that it did not intend to increase the lower limit on primary voltage to 600 V. 64 FR at 33432–33. In the proceedings on the development of standards, NEMA strongly advocated that the Department have no lower limits on the primary and secondary voltages of the transformers it evaluates for standards, reflecting the coverage of NEMA TP 1. (NEMA, No. 35 at p. 4 and No. 36 at p.2) [5] Consistent with NEMA's position, the Department is concerned that defining a distribution transformer as having a minimum primary and/or secondary voltage may result in eliminating distribution transformers from consideration in the standards rulemaking. The Department also believes that it can include other elements in its definition of ''distribution transformer'' to ensure that its test procedures and standards for transformers would cover only products that are truly ''distribution transformers.'' Therefore, in accordance with its planned approach in the standards rulemaking, and to ensure that its test procedure will apply to all distribution transformers evaluated for standards, the Department has removed the lower bounds on primary and secondary voltage from the definition of distribution transformer that the Department is proposing today.

With regard to the 1998 proposed rule's capacity criteria for defining a distribution transformer (10 kVA to 2500 kVA for liquid-immersed units and 0.25 kVA to 2500 kVA for dry-type units), the 1999 reopening notice stated the Department's intent to increase the lower capacity limit for dry-type units to either 1, 5, 10 or 15 kVA. 64 FR at 33433. The Department understands, based on information it has received in the course of its work on the standards rulemaking, that 5 and 10 kVA dry-type transformers are normally not used in the distribution of electric energy. Therefore, today's definition of distribution transformer proposes a lower capacity limit for dry-type units of 15 kVA. The Department, however, is still considering in the standards rulemaking whether to evaluate for standards dry-type transformers with ratings of 5 and 10 kVA. Therefore, DOE seeks comment in the instant rulemaking on whether such transformers are properly classified as distribution transformers, and whether it should adopt one of these levels as the lower capacity limit for dry-type units in the definition of distribution transformer, instead of the 15 kVA level in today's proposed rule.

The 1998 proposed rule's definition also excluded ''transformers which are not designed to be continuously connected to a power distribution system as a distribution transformer * * * [such as certain specifically identified types of transformers] and other transformers which are not designed to transfer electrical energy from a primary distribution circuit to a secondary distribution circuit, or within a secondary distribution circuit, or to a consumer's service circuit.'' 63 FR at 63370. The Department is concerned that these criteria may be too vague and imprecise, and subject to misinterpretation, and may fail to establish clearly which transformers are and are not covered under EPCA as

[5] No. 35 and No. 36 refer to the numbers of the written comments and supporting documents included or referenced in the docket for this rulemaking (Docket Number EE–TP–98–550). Numbers 4 and 2 refer to the cited page numbers in those written comments.

distribution transformers. This would be particularly true for parties that work with distribution transformers in non-utility related applications, where much of the terminology in these criteria—for example, phrases like ''to a consumer's service circuit''—is inapplicable and may be meaningless. In the standards rulemaking, NEMA has advocated that the Department adopt a definition of distribution transformer that aligns with the scope of NEMA TP 1. (NEMA No. 35 at p. 4) The scope provision of NEMA TP 1 states that the standard applies to transformers meeting numerical criteria of the types discussed above—for example, capacity in kVA—and then lists specific types of transformers to which the standard does not apply. (NEMA TP 1 at p. 1)

Today's proposed rule follows this approach in defining distribution transformer and is similar to the scope provision of NEMA TP 1. In addition to having numerical criteria, the proposed definition lists types of transformers that are made for applications unrelated to the distribution of electricity, or for which standards would not produce significant energy savings, and provides that they are not ''distribution transformers.'' Such a definition is clearer, more precise and less subject to misinterpretation than the 1998 proposed rule's definition. Although the list of excluded transformers is quite similar to that in NEMA TP 1, DOE has modified it slightly.[6] The proposed rule also contains a definition for each of these excluded transformers.

The 1998 proposed rule identified the following transformers as not being distribution transformers: grounding transformers, machine-tool (control) transformers, regulating transformers, testing transformers, and welding transformers. 63 FR at 63370. They were not addressed further in either the comments DOE received in this rulemaking or the 1999 reopening notice and they are listed as exclusions in the scope provision of NEMA TP 1. For all of these reasons, they are excluded from being ''distribution transformers'' in today's proposed rule.

The 1998 proposed rule also excluded ''converter and rectifier transformers with more than two windings per phase'' from the definition of distribution transformer, and provided definitions for these transformers. 63 FR at 63370. Comments on the 1998 proposed rule and the 1999 reopening notice supported these exclusions, as well as the exclusion of rectifier transformers with less than three windings. (Alexander D. Kline, P.E., No. 14 at pp.1–2; NEMA, No. 15 at p. 2, No 21 at p. 5, and No. 28 at p. 5; Howard Industries, Inc., No. 18 at p. 3 and No. 27 at p. 2) The Department now believes that exclusion of converter transformers is unnecessary. Today's proposed definition of distribution transformer has an upper limit on capacity of 2500 kVA, and it is the Department's understanding that a transformer connected to a converter, *i.e.*, a converter transformer, always has a capacity far above this level. Thus, their capacity automatically excludes them from the definition, and they need not be specifically excluded. Rectifier transformers, however, often have a capacity below 2500 kVA, but they are not connected to electric distribution systems and cannot be readily tested for losses. *See* 64 FR at 33433 (and comments cited there) and 63 FR at 63363. Therefore, in today's proposed rule they are in the list of products not included as distribution transformers. The Department is also proposing to adopt the definition of ''rectifier transformer'' that was recently incorporated into IEEE C57.12.80–2002, clause 3.379, rather than the definition proposed in the 1998 proposed rule. The Department believes the IEEE definition will be more widely understood and accepted, without any loss of technical precision.

3. Exclusions Discussed in the 1999 Reopening Notice

The 1999 reopening notice stated that the Department was also inclined to exclude autotransformers, and transformers with tap ranges greater than 15 percent, from the definition of distribution transformer. 64 FR at 33433–34. The notice identified comments on the 1998 proposed rule that advocated these exclusions and the Department's reasons for favoring them. Some of the comments in response to the reopening notice supported the exclusions and none opposed them. Therefore these exclusions are included in today's proposed rule.

The Department also discussed in the 1999 reopening notice whether it should exclude sealed or non-ventilated transformers, special impedance transformers, and harmonic transformers from the definition of distribution transformer. 64 FR at 33433–34. Each of these types of transformer can be a distribution transformer. The Department stated that it did not find persuasive the reasons commenters had advanced for excluding these products, and that it intended to include them unless it received information justifying their exclusion. As to non-ventilated or sealed transformers, in response to the 1999 reopening notice NEMA indicated that the unique features of these transformers could pose a hardship for some manufacturers in testing them, and that they are a small part of the market for distribution transformers. (NEMA, No. 28 at p. 5) Given their small market share, it appears that adopting standards for non-ventilated or sealed transformers would not result in significant energy savings. For these reasons, the Department has excluded them from today's proposed definition of distribution transformer. DOE specifically requests comment, however, on whether such exclusion is warranted.

With respect to special impedance distribution transformers, NEMA states that they have much higher load losses than standard impedance distribution transformers, and are designed to meet unusual performance functions. (NEMA, No. 28 at p. 5) It also asserts that, because they are relatively expensive to build, a lack of Federal efficiency standards for these products would not cause them to be manufactured and sold in increased volumes as substitutes for standard distribution transformers that were subject to standards. (NEMA, No. 15 at p. 2) The Department agrees with these points, and believes that the market for these products is small and therefore regulating them would not result in significant energy savings. For these reasons, today's proposed rule excludes special impedance transformers from the definition of distribution transformer.

DOE questions, however, the validity of NEMA's claim that any transformer with an impedance outside the range of four to eight percent is a special impedance transformer. (NEMA, No. 15 at p. 2) To address this issue, the Department is proposing a definition for

[6] Today's proposed definition of ''distribution transformer'' excludes almost verbatim 13 of the 17 types of transformers specifically excluded from NEMA TP 1. (The list of exclusions from TP 1 appears on page one of TP 1.) NEMA TP 1, however, also excludes ''transformers designed for high harmonics'' and ''harmonic transformers,'' but today's proposed definition addresses these transformers by excluding ''harmonic mitigating transformers'' and certain ''K-factor'' (harmonic tolerating) transformers. In addition, although TP 1 excludes ''retrofit transformers'' and ''regulation transformers,'' the proposed rule excludes neither—the former for reasons discussed in section II–B–3 in the text and the latter because DOE believes they are more accurately described as ''regulating transformers,'' which are already in the list of exclusions in NEMA TP 1 and the proposed rule. In addition, NEMA TP 1 excludes ''non-distribution transformers, such as UPS [uninterruptible power supply] transformers.'' Although the proposed definition excludes uninterruptible power supply transformers, the remainder of this exclusion is vague, and the Department believes that including it in the regulations would undercut the precision achieved by listing specific types of transformers as being excluded from the definition of ''distribution transformer.''

''special impedance transformer'' that incorporates tables which set forth the normal impedance range at each standard kVA rating for liquid-immersed and dry-type transformers. DOE would consider any transformer built with an impedance rating outside the ranges defined as normal to be considered special impedance, and would exclude it from the definition of distribution transformer. The Department specifically requests comments on the normal impedance ranges shown in Tables 1 and 2 of today's proposed definition of ''special impedance transformer.''

Concerning harmonic distribution transformers, the Department understands that there are two types of such transformers, those that correct harmonics (harmonic mitigating transformers) and those that simply tolerate, and do not correct, harmonics (called harmonic tolerating or K-factor transformers). NEMA appears to assert that neither type can be accurately tested to measure its efficiency. (NEMA, No. 28 at p. 5) Although the Department has doubts about the validity of this assertion, it agrees that harmonic mitigating transformers are a special type of transformer. Furthermore, DOE believes that few of them exist in the distribution system, regulating them would save little energy, and they are sufficiently expensive to manufacture that excluding them would be unlikely to result in a loophole if DOE adopted standards for other transformers. DOE is, therefore, excluding harmonic mitigating transformers from coverage in today's proposed rule.

The situation with harmonic tolerating (K-factor) transformers is not so clear cut. These transformers are designed for use in industrial situations where electronic apparatus can cause transformer losses that are much higher than normal, and they are designed to accommodate such losses without excessive temperature rise. But apparently it is economically viable to use K-factor distribution transformers that have low K-factors and relatively low efficiencies, in standard applications, instead of regular distribution transformers with higher efficiencies. The Department understands that, after the State of Minnesota began to require that dry-type distribution transformers installed in the state meet NEMA TP 1 efficiency levels, with an exemption for K-factor and other transformers excluded from NEMA TP 1, the installation of K–4 transformers increased substantially. These K–4 transformers had efficiencies that were not only below the levels mandated by NEMA TP 1, they were also below the prevailing efficiency levels of conventional distribution transformers that had been installed in Minnesota prior to the State's adoption of NEMA TP 1. As the K rating of K-factor transformers increases, however, they become increasingly sophisticated and expensive to produce, and their market share decreases. Thus, the risk that they would be used in place of more efficient transformers declines, and the potential energy savings from regulating them becomes insignificant.

The Department believes that K–13 is a reasonable demarcation between K-factor distribution transformers that should be evaluated for standards, and those for which standards appear to be unwarranted. Above the K–4 rating, K–9 and K–13 are the next higher standard K-factor rated transformers. The Department believes that while K–9 products are a small part of the market, it is uncertain whether, absent standards for them, K–9 distribution transformers would be substituted for transformers that are subject to standards (as happened in Minnesota with K–4 transformers). The Department is aware that K-factor transformers at K–13 and higher are significantly more expensive than conventional transformers, and believes it is very unlikely they would be purchased in place of distribution transformers subject to standards. Thus, today's proposed definition excludes transformers with a K-factor rating of K–13 or higher from the definition of a distribution transformer. The definition includes K-factor transformers with lower standard K-factors (K–4 and K–9), and DOE is evaluating them for standards during its rulemaking on transformer standards. The Department specifically invites comments on this issue.

Finally, information developed thus far in this proceeding indicates that ''retrofit distribution transformer'' refers to any transformer that replaces an existing distribution transformer. The Department understands, however, that the term also may refer more specifically to a transformer used in a distribution substation between primary and secondary switchgear 30 to 50 years old, which must be designed so that terminations are compatible with existing switchgear and for which other features must differ from present-day designs. Comments on the 1998 proposed rule asserted that the Department's exclusions from the definition of distribution transformer should provide for situations where existing distribution transformers cannot be replaced with more efficient retrofit transformers, which generally would be larger than, or configured differently from, the existing transformers. (NEMA, No. 21 at pp. 5–6) In the 1999 reopening notice the Department requested further, more detailed information on this issue. 64 FR at 33434. The Department has not received such information. Clearly retrofit distribution transformers are distribution transformers, and the Department lacks a basis for creating an exclusion for them in today's rule. In the standards rulemaking, however, the Department intends to gather information on the nature of, and dimensional restrictions for, these transformers, in order to decide whether to treat them separately, as for example by excluding them, by creating a separate class(es) or both, if the Department adopts energy conservation standards for distribution transformers.

4. Additional Exclusions Drawn From NEMA TP 1

In addition to excluding from its scope the types of transformers discussed in sections II–B–2 and 3, NEMA TP1 also excludes drive (isolation), traction-power, and uninterruptible power supply transformers. Drive or isolation transformers are a type of distribution transformer that is specially designed to accommodate added loads of drive-created harmonics, and mechanical stresses caused by an alternating current or direct current motor drive. Although intrinsically they have higher losses than conventional distribution transformers, DOE understands that they also have low sales volumes. Therefore, the Department believes standards for this product would not result in significant energy savings and is proposing to exclude them from the definition of distribution transformer. In addition, the Department notes that there are many kinds of drive transformers, and development of the varied test methods and multiple standard levels that would be necessary to achieve even the limited energy savings possible for this product would be a complex undertaking.

As to traction-power transformers, these are designed to supply power to railway trains or municipal transit systems, at frequencies of 16⅔ or 25 Hz in an alternating current circuit or as a rectifier transformer. These transformers are excluded from today's proposed definition of distribution transformer by provisions discussed above that exclude both transformers operating at these low frequencies as well as rectifier transformers. Therefore, DOE need not consider whether to specifically exclude them.

Finally, an uninterruptible power supply transformer is not a distribution transformer. It does not have as one of its functions stepping down voltage, but rather it is a transformer that is a system conditioning device. It is used as part of the electric supply system for sensitive equipment that cannot tolerate system interruptions or distortions, and counteracts such irregularities. Therefore, it is excluded from the definition of distribution transformer in today's proposed rule.

5. Definitions of Excluded Transformers

As noted above, today's proposed rule includes definitions for the transformers DOE is proposing to exclude from today's rule. This will help to make clear exactly which transformers the proposed rule covers. For the following excluded transformers, DOE has taken the definitions from IEEE C57.12.80–2002: autotransformers, grounding transformers, machine-tool (control) transformers, non-ventilated transformers, rectifier transformers, regulating transformers, and sealed transformers. For K-factor transformers, DOE took the definition from Underwriters Laboratories (UL) UL1561 and UL1562.

C. Basic Model

It is common for a manufacturer to make numerous models of a product covered by EPCA, and under the Act each model is potentially subject to testing for energy efficiency. In order to lessen the burden of testing, the Department allows manufacturers to group product models having essentially identical characteristics with respect to energy consumption into a single family of models. The Department has used the term ''basic model'' to represent such a family of models, consisting of models of a product that are essentially the same in some or all of the following respects: performance, physical, mechanical, electrical and functional characteristics. For each type of product, the Department's regulations set forth which of these characteristics applies in identifying basic models. Each manufacturer can then test a sufficient, representative sample of units of each basic model it manufactures, and derive an efficiency rating for each basic model that would apply to all models subsumed by that basic model. 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.

At the 1998 workshop, DOE presented a basic model definition for distribution transformers that incorporated these concepts. All groups and individuals who participated in that workshop opposed DOE's proposed definition because distribution transformers, unlike consumer appliances, are not produced in large numbers of virtually identical units. NEMA advocated at the workshop that DOE define basic model to include all transformers having the same nominal power (kVA) rating, the same insulation type (liquid immersed or dry-type), and the same number of phases (single or three), and operating within the same voltage range. (Public Workshop Tr., No. 2GG at pp. 54–55) [7] The Department proposed such a definition in the 1998 proposed rule. 63 FR at 63369. As the Department pointed out in the 1999 reopening notice, however, it later realized that this approach would allow a single basic model to include models of transformers that have significantly different utility or performance-related features that affect their efficiency. This would be inconsistent with the nature of the groupings that the ''basic model'' concept is meant to permit, since all models within a basic model should be in the same product class. 64 FR at 33435.

All of the comments to the 1999 reopening notice that addressed the basic model definition supported the approach in the 1998 proposed rule, but none addressed DOE's concern that the 1998 proposed rule definition would permit inclusion of models with different energy consumption characteristics in any particular basic model. One comment stated that the proposed definition would be a sound way to reduce the testing burden on manufacturers. (Howard Industries, No. 27 at p. 3) DOE continues to believe that any definition of basic model under its regulations must require that all of the models included in a basic model have similar energy consumption characteristics and be within the same product class. This is necessary to assure that the efficiency rating derived for the basic model would accurately represent the efficiency of all of these models. The Department is therefore proposing a definition of basic model for distribution transformers that includes essentially the same criteria 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.''

Today's proposed definition includes two editorial modifications to the criteria included in the 1998 proposed rule definition. First, the proposed definition omits the provision that transformers within a basic model must ''operate within the same voltage range.'' This criterion need not be stated explicitly in the proposed definition because it is embodied in the new proposed requirement that transformers cannot have differentiating electrical features that affect energy consumption. Second, the provision in the 1998 proposed rule that all transformers in a basic model must ''have a comparable nominal output power (kVA) rating'' is replaced in today's proposed rule with language that they have ''the same standard KVA rating.'' Use of the word ''same'' instead of ''comparable'' better achieves the Department's intent in the 1998 proposed rule to require that all transformers in a basic model have the same standard kVA rating, an approach supported in comments on the 1998 proposed rule and 1999 reopening notice. (NEMA, No. 28 at p. 7; Howard Industries, No. 18 at p. 3 and No. 27 at p. 3) In addition, the Department's understanding is that ''standard kVA rating'' means the same thing as ''nominal output power (kVA) rating.'' The former terminology is proposed here because it is more succinct and straightforward.

Regarding the term ''standard kVA rating,'' the transformer industry normally groups transformers based on apparent power rating and over the years has developed a set of standard ratings, ANSI/IEEE C57.12.00–2000 for liquid-immersed transformers and ANSI/IEEE C57.12.01–1998 for dry-type transformers. These standard ratings are set forth in the table that follows, and are the ratings that the Department refers to when it uses the term ''standard kVA rating'' in today's proposed basic model definition. Thus, under today's proposal, grouping of distribution transformers into basic models would be based in substantial part on groupings already used by the transformer industry.

[7] ''Public Workshop Tr., No. 2GG at pp. 54–55'' refers to the page number of the transcript of the ''Workshop on Test Procedures for Distribution Transformers'' held in Washington, DC on February 10, 1998.

STANDARD kVA RATINGS FOR DISTRIBUTION TRANSFORMERS*
[kVA]

Single phase	
10**	167
15	250
25	333
37.5	500
50	667
75	833
100	....
Three phase	
15	300
30	500
45	750
75	1000
112.5	1500
150	2000
225	2500

* The Department anticipates that it will subdivide the kVA ratings for the medium-voltage dry-type distribution transformers by basic impulse insulation level (BIL) rating during the standards rulemaking process, and develop separate efficiency ratings for each BIL rating associated with each kVA rating for these transformers. This would not affect manufacturers' basic model delineations under today's proposed definition of basic model. By providing that a basic model cannot include transformers that have differentiating electrical features, the proposed definition would already require that transformers with different BIL ratings be separated into different basic models.

** 10 kVA is a standard rating for liquid-immersed distribution transformers, but not necessarily for dry-type transformers.

The Department recognizes that any given manufacturer would likely have more basic models under today's proposed definition of basic model than under the 1998 proposed rule's definition. Potentially, this could increase the manufacturers' test burden. The Department believes, however, that this potential would be more than offset by its proposal, discussed below, to allow manufacturers to determine the efficiencies of a substantial number of their basic models by using alternative efficiency determination methods, instead of testing these basic models.

D. Manufacturer's Determination of Efficiency

In developing proposed requirements for distribution transformers, the Department initially examined as a model its regulations for consumer appliances in 10 CFR part 430, and later also examined its regulations for electric motors in 10 CFR part 431, after it adopted them in late 1999. Under both parts 430 and 431, each manufacturer must determine the efficiency rating for each of its basic models, to a substantial extent from testing the model. (Such testing is commonly referred to as ''compliance testing.'') As just discussed, use of the ''basic model'' concept is one means for reducing the potential compliance testing burden on manufacturers. The Department also reduces the compliance testing burden by allowing manufacturers to test a sample of units of each basic model. For each type of product, the regulations prescribe a statistical sampling plan designed to give a reasonable assurance that on average the performance of all units manufactured and sold of each basic model complies with (*i.e.*, equals or exceeds) the manufacturer's rating for the model and the applicable energy conservation standard mandated under EPCA.

In the 1998 proposed rule, the Department proposed to use part 430's sampling approach for compliance testing, with numerical criteria geared to distribution transformers and a minimum sample size of five units. 63 FR at 63366–67. But this approach is not well suited to situations where only a very small test sample (fewer than five units, for example) is available, and therefore it could be problematic for some distribution transformers.[8] Although some basic models of transformers are mass-produced, many are custom-designed with production runs of as few as one unit. Consequently, in the 1998 proposed rule the Department sought comment on three alternative approaches for basic models with limited production. 63 FR at 63366–67.

In response to the 1998 proposed rule, industry representatives commented that the proposed sampling plan might require manufacturers to do a large amount of testing, and, as DOE had indicated in the 1998 proposed rule, the plan appears unsuitable for basic models with small production volumes. (Public Meeting Tr., No. 11DD at p. 174; Howard Industries, No. 18 at p.5)[9] None of the comments, however, addressed the alternatives DOE had presented for dealing with these small production models. See 64 FR at 33434. NEMA advocated that DOE adopt the sampling plan set forth in NEMA TP 2, significant elements of which are (1) on-going testing during 180-day periods of either 100 percent of the units manufactured or a random sample of a statistically valid number of units (but not less than five per month), (2) discarding or reworking all tested units that exceed losses allowed under the applicable standard by more than eight percent,[10] and (3) for each 180-day period, aggregating the test results of different basic models (comprising all or a portion of a manufacturer's production) to determine their collective compliance with the applicable standards.

In the 1999 reopening notice, the Department expressed concern about aggregation as used in NEMA TP 2, particularly for basic models produced in relatively large volumes (50 or more in a six-month period). In DOE's view, compliance of the large volume models could be demonstrated without aggregation. But the Department stated that aggregation combined with testing all of the units of a basic model has some merit, particularly for limited production models. Therefore, DOE identified for consideration several alternatives to the proposal in the 1998 proposed rule, including variations on NEMA TP 2 that would allow manufacturers to demonstrate the compliance of aggregations of basic models subject to certain conditions. 64 FR at 33434–35. The goal of these alternatives was to provide a reasonable statistical method for deriving efficiency ratings from test results that would minimize the risk of false negatives for small volume basic models, *i.e.*, would make it unlikely that a manufacturer would determine a complying basic model to be out of compliance. The Department indicated, however, that although some of these options may be sufficient to assure compliance with efficiency standards by basic models that are included in aggregations, they may not be adequate to establish the validity of the represented efficiency level for particular basic models.

The comments on the 1999 reopening notice generally supported DOE's adoption of the sampling plan in NEMA TP 2, with Howard Industries urging DOE to adopt an approach that would minimize the number of units that a manufacturer must test. (American Council for an Energy-Efficient Economy, No. 29 at p. 3; Howard Industries, No. 27 at pp. 2–3; NEMA, No. 28 at pp. 6–7). None of the comments, however, addressed the

[8] The operating characteristics of the proposed compliance plan were examined and reported in National Institute of Standards and Technology (NIST) Technical Note (TN) 1427, ''An Analysis of Efficiency Testing under the Energy Policy and Conservation Act: A Case Study with Application to Distribution Transformers'' (NIST TN 1427). NIST TN 1427 noted for example that for a test sample of two units of a basic model that is designed and performing at a given rated value, and has a standard deviation of three percent, the probability of demonstrating compliance with that rated value is only about 0.12, and the probability of a false conclusion of noncompliance is about 0.88.

[9] ''Public Workshop Tr., No. 11DD at pp. 54–55'' refers to the page number of the transcript of the ''Public Hearing on Energy Efficiency Test Procedures—Distribution Transformers'' held in Washington, DC on January 6, 1999.

[10] For transformers, the industry practice is to measure power loss and evaluate performance in terms of such losses. Performance is expressed in terms of efficiency only at the final stage of rating the product.

alternatives DOE had presented in the reopening notice that would allow for aggregation of basic models. NEMA essentially reiterated its view that the Department should adopt the sampling plan in NEMA TP 2, but asserted in addition that the approach proposed in the 1998 proposed rule had only a 50-percent probability of accurately representing the mean efficiency level of all units of a basic model and was statistically unsound. (NEMA, No. 28 at pp. 6–7)

Upon consideration of the comments in this proceeding, and a further review of the sampling plan in NEMA TP 2, the Department continues to believe that NEMA TP 2's sampling plan is inappropriate for adoption as a DOE requirement. DOE has done considerable analysis of this issue since issuing the 1998 proposed rule. The Department's key concern regarding NEMA TP 2's sampling plan is the aggregation of test results. NEMA TP 2 allows a manufacturer to aggregate the test results of all or any portion of its basic models to determine their compliance with applicable standards. (The NEMA TP 2 sampling plan could also be used to determine compliance with rated efficiencies.) All of the basic models included in an aggregate grouping would be deemed to be in compliance (with applicable rated efficiencies and/or standards) so long as their weighted average efficiency measured from testing is equal to or larger than the weighted average rated efficiency or standard that applies to them. Thus, in a group of basic models found in compliance under NEMA TP 2's sampling plan, some of the basic models could have efficiencies below their applicable levels so long as other models exceed their levels. The Department recognizes that NEMA TP 2's eight percent limitation on total losses for individual tested units would encourage manufacturers to produce each basic model at or above the applicable efficiency level, and would provide some assurance that each basic model complies with that level. However, given the variability inherent in the manufacture of distribution transformers, the Department believes such assurance would be of limited value.

This approach is unacceptable to DOE for several reasons. First, the Department believes EPCA contemplates that each basic model of a distribution transformer must comply with the efficiency standard applicable to it, not that all or some other disparate grouping of models will comply on average with the applicable standards. Section 346(a) of EPCA directs DOE to prescribe energy conservation standards for those distribution transformers for which the Department determines standards would save significant amounts of energy and would be technologically feasible and economically justified. (42 U.S.C. 6317(a)) And section 346(f) in effect bars distribution of any transformer that does not conform to the standard applicable to it. (42 U.S.C. 6317(f)) The Department believes these provisions preclude it from mandating use of the sampling plan in NEMA TP 2, under which a manufacturer could determine all or groups of its basic models to be in compliance on average with applicable standards, with limited assurance that any particular basic model complies.

Second, NEMA TP 2's sampling plan does not provide a sufficient basis for a manufacturer to make representations as to the efficiency of individual basic models. Section 346(d) of EPCA requires the Department to prescribe efficiency labeling requirements for the distribution transformers for which DOE prescribes standards. (42 U.S.C. 6317(d)) Although the statute does not specify the content of such requirements, for other products the statute requires: (1) Efficiency labels that are based on or include the energy efficiency of the model on which the label appears, (see 42 U.S.C. 6293(b)(4), 6294(c), and 6315(d)–(e)) and (2) that any energy use or efficiency representation by a manufacturer or other distributor ''fairly discloses'' the results of testing the product under the DOE test procedure (42 U.S.C. 6293(c) and 6314(d)). In addition, for consumer products and electric motors, DOE requires manufacturers to certify to the Department the efficiency or energy use of particular basic models that are covered by energy conservation standards. 10 CFR 430.62 and 431.123. In 10 CFR 430.24 and 431.24, DOE provides the basis for manufacturers to comply with these requirements, by prescribing sampling plans and other methods for manufacturers to rate each basic model they produce. As indicated above, however, because of the aggregation of test results it contemplates, the sampling plan in NEMA TP 2 could not be used to establish the efficiency of any particular basic model. If the Department were to prescribe this sampling plan for distribution transformers, it would in effect be precluded from adopting for this product labeling and other energy representation requirements based on the energy use or efficiency of particular basic models, since no uniform basis would exist for assuring the accuracy of such representations. This would represent a considerable departure from the requirements for other products, and the Department believes it would be inconsistent with the intent of EPCA's labeling requirements.

Third, the NEMA TP 2 sampling provisions are problematic when one considers the enforcement of efficiency standards and of labeling requirements. On the one hand, in an enforcement action the Government assesses whether a basic model is out of compliance with its labeled efficiency or the applicable standard. NEMA TP 2 contemplates, however, that a manufacturer could distribute a non-compliant basic model provided the manufacturer included other ''overly compliant'' models in an aggregation with the non-compliant model. The Department believes this inconsistency in approaches is unacceptable. On the other hand, it could be argued that DOE should align the enforcement provisions for distribution transformers with NEMA TP 2's sampling plan. This would mean that any enforcement action would have to concern all of the basic models included in an aggregation that the manufacturer had used to establish compliance, possibly including the manufacturer's entire line of products. The Department strongly believes that such an approach would be untenable, and that it should address its enforcement efforts to individual basic models alleged to be out of compliance, not batches of basic models.

Finally, NEMA TP 2 contemplates more compliance testing than either part 430 or part 431. The sampling plan under part 430 prescribes no minimum size for a test sample, and the minimum sample size under part 431 is five units. Under NEMA TP 2, a manufacturer must do continuous testing either of 100 percent of the units it manufactures or of a random sample of a statistically valid number of units (but not less than five per month). Manufacturers are of course free to voluntarily do any amount of testing they deem necessary to meet their own contractual and other business requirements. DOE is reluctant, however, to require this amount of testing, and to impose this burden as a legal mandate.

For the foregoing reasons, the Department is not proposing to adopt the sampling plan in NEMA TP 2. Nevertheless, the Department agrees with NEMA that the sampling plan proposed in the 1998 proposed rule, using a methodology similar to that in 10 CFR part 430, could impose a significant risk of false negatives, *i.e.*, compliant basic models found to be non-compliant. The Department recognizes that there are inherent differences between the products regulated in part 430 and distribution transformers, and that these differences warrant a sampling plan for distribution transformers that is different from that in part 430. Manufacturers of electric motors had similar concerns, and DOE adopted a new sampling plan for determining a motor's efficiency in 10 CFR part 431.

DOE is proposing today to adopt both a sampling plan and alternative methods (other than actual testing) for manufacturers to use to determine the efficiency of distribution transformers, which are similar to requirements that DOE has prescribed for electric motors. Today's proposals are a substantial departure from the approaches proposed in the 1998 proposed rule and 1999 reopening notice. The Department believes they would require manufacturers to do substantially less testing than contemplated either by the earlier proposals or by NEMA TP 2, while at the same time ensuring that products comply with applicable efficiency standards.

Today's proposed sampling plan is designed to have a significantly higher probability than the 1998 proposed rule proposal that a basic model would be found in compliance with its rated value where it is in fact manufactured at that value, without incurring a probability for significant false positives, *i.e.*, non-complying models being found in compliance. Similar to the sampling plan for motors, today's proposal is predicated on the principle that the mean power loss of the sample must be equal to or smaller than the rated loss plus five percent of the rated loss divided by the square root of the number of units in the sample. This translates into the ''Represented Efficiency'' expression in today's proposed section 432.12. The tolerance of the motors plan is constant, however, while that of today's proposed plan decreases with increases in the sample size. The motors plan also has an additional requirement that the power loss of a single unit in the sample must not exceed the rated loss by more than 15 percent. Today's plan includes no such provision in large part because the tolerance in today's proposal decreases with increased sample size. The proposed plan provides the same probability of demonstrating compliance for all sample sizes for a basic model that is manufactured at the rated efficiency. Finally, because the confidence limit varies with the standard deviation of the population, under the proposed plan a very high probability exists that complying basic models that have relatively small variabilities would pass compliance testing, *i.e.*, be found in compliance with their rated values. For example, there is a 96.8 percent probability that a complying basic model with a standard deviation of 2.7 percent would pass compliance testing. Therefore, the manufacturer of such a basic model could design and manufacture the product at very close to its rated value, with little risk that it would fail compliance testing. A more thorough analysis of today's proposed sampling plan is set forth in NIST Technical Note 1456, ''Operating Characteristics of the Proposed Sampling Plans for Testing Distribution Transformers,'' 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*.

Today's proposed sampling plan also would limit the testing burden on manufacturers. As with the motors plan, it prescribes a minimum test sample size of five units except when fewer than that number of units is manufactured in a 180-day period. It also handles samples as small as one.

The key element that limits the test burden on manufacturers in today's proposed rule, however, is the proposal to allow manufacturers of distribution transformers to determine the efficiency of some of their transformers through use of alternative efficiency determination methods (AEDMs). An AEDM is a predictive mathematical model, developed from engineering analyses of design data and substantiated by actual test data, that represents the energy consumption characteristics of one or more basic models. Under today's proposal, after it substantiates the accuracy of an AEDM, the manufacturer can apply it to basic models to determine their efficiencies without testing them. The manufacturer would, however, have to determine the efficiency of at least five of its basic models, selected in accordance with criteria specified in the rule, through actual testing. The proposal would not permit a manufacturer to use the AEDM to rate any model that it had tested.

Today's proposal requires a manufacturer to substantiate an AEDM based on actual testing of at least five basic models. (These could be the same five basic models just referred to.) The manufacturer would have to apply the AEDM to these basic models, and could use the AEDM to determine the efficiency of other basic models only if, (1) the predicted total power loss for each of these basic models, calculated by applying the AEDM, is within five percent of the mean total power loss determined from the testing of that basic model, and (2) the average of the predicted total power loss for the tested basic models, calculated by applying the AEDM, is within three percent of the average of the total power loss determined from testing these basic models. In making this second determination, the manufacturer would calculate the average predicted power loss of each basic model as a percentage of the average measured power loss, which in turn it would treat as 100 percent. This expression of power losses as percentages is necessary in order for the manufacturer to assign equal weight to each basic model used to substantiate the AEDM.

The Department selected the above tolerances because the power loss predicted from an AEDM will differ from that predicted from testing sample units of a basic model, due to the variability of units within each model. The magnitude of such differences depends on the degree of variability, quantified as the standard deviation, and the sample size. As the number of units in each sample and the number of samples increases the difference between the calculated and measured values should decrease, but as a practical matter it never disappears. DOE understands that a difference on the order of one to three percent is the minimum that can be achieved. The maximum difference of plus or minus three percent proposed in today's rule is appropriate for populations consisting of at least five basic models with at least five units in each. This allowable difference is equal to the allowable measurement error in the test procedure specified in proposed section 432.11. The higher five-percent tolerance permitted for any single basic model allows for situations where units of a basic model have unusually high variability resulting in a relatively high standard deviation of four percent. This can result from factors such as variation in the materials used to produce the basic model and variability in the manufacturing process. Such factors can affect an entire production run for the basic model.

E. Enforcement Procedures

As it did in developing proposals for manufacturers to rate the efficiency of distribution transformers, DOE reviewed the provisions of 10 CFR parts 430 and 431 in formulating proposed enforcement procedures for this product. Parts 430 and 431 contain enforcement provisions that apply when DOE examines whether a basic model of a covered product complies with efficiency requirements set forth in those parts. Each part allows for enforcement testing where necessary, and each includes a sampling plan for such testing. Neither the 1998 proposed rule nor the 1999 reopening notice addressed enforcement. The Department believes, however, that it is desirable to consider methods for manufacturers to use to rate their distribution transformers, and methods for enforcement testing, in conjunction with one another. Therefore, today's proposal includes proposed enforcement procedures, including a sampling plan and other provisions for enforcement testing. Substantial elements of these procedures are drawn from part 431 and their application to distribution transformers should not be controversial, but the Department nevertheless welcomes comment on them. However, the provisions as to the number of units to be tested and the number of tests to be performed are not drawn from part 431, and the sampling plan was developed specifically for application to distribution transformers. These provisions reflect the fact that some basic models of distribution transformers are produced in limited quantities. The Department is particularly interested in receiving comments on these provisions.

The proposed enforcement sampling plan establishes detailed procedures for an enforcement action, and is similar to the enforcement sampling plans established in parts 430 and 431. All of these plans are based on a well established statistical method for obtaining a confidence interval on a mean, which first originated in Charles Stein, *A Two-sample Test For a Linear Hypothesis Whose Power is Independent of Variance*, 16 Annals of Mathematical Statistics 243–258 (1945). This procedure is discussed in Peter J. Bickel and Kjell A. Doksum, *Mathematical Statistics: Basic Ideas and Selected Topics* 158–159 (1977), for example. The sampling plan for enforcement testing included in part 430 covers both efficiency and energy consumption, and it is general. The enforcement sampling plan proposed here, in Appendix B to proposed part 432, has been adapted from part 430, but has been simplified to address only efficiency testing. It also includes provisions to allow tests of very small samples. These provisions assure consistency with today's proposed sampling plan for compliance testing, discussed above.

The proposed enforcement sampling plan is based on a *t*-test. The Department believes that the *t*-test is well suited for use in enforcement testing in that: (1) The *t*-test is insensitive to the exact nature of the distribution of performance of the item being evaluated, and (2) the risk of a false finding against a manufacturer can be set, by design, to a negligible level.

The nature of the distribution of efficiency performance may be at issue for some basic models of distribution transformers. Some of them are produced in small quantities, and it is difficult to establish with confidence an accurate distribution of efficiency performance for very small test samples. Moreover, even some basic models produced in relatively large quantities may not have a normally distributed efficiency performance. Although the *t*-test assumes a normal distribution, it is insensitive to departures from that assumption. The *t*-test is a test on a sample mean that is an average of independent values obtained from a random sample. Since sums of arbitrary, independent random values tend to have a distribution that is almost normal, *i.e.* is very close to normal, even if the values themselves are not normally distributed, the *t*-test is not strongly influenced by the exact form of the underlying distribution of these values (in this case transformer efficiencies).

Under parts 430 and 431, the test results obtained during enforcement testing may result in serious adverse actions against a manufacturer. For example, the manufacturer must cease distribution and sale of any basic model that the Department finds to be out of compliance, and the Department can assess a civil penalty for such noncompliance. Thus, the risk to a manufacturer of a false determination of noncompliance during an enforcement action is set, by design, to a negligible level. Today's proposed sampling plan for enforcement is based on a 97.5 percent statistical confidence, resulting in a risk of a false determination of noncompliance of not greater than 2.5 percent.

As mentioned above, some basic models of distribution transformers may have limited production, and thus, few units may be available for testing. The proposed sampling plan for compliance testing contemplates that a basic model would be in compliance with its rated efficiency so long as the mean, measured efficiency of the compliance test sample of the basic model meets the following test:

$$\overline{X} \geq \frac{100}{1+\left(1+\frac{0.05}{\sqrt{n}}\right)\left(\frac{100}{RE}-1\right)}$$

where RE is the rated efficiency and *n* is the number of units tested. Thus, the Department could find a basic model in compliance with its rated efficiency even if the mean efficiency of the test sample is less than the rated efficiency. This "threshold efficiency" establishes a reasonable lower control limit for compliance testing when very few units are available for testing.

Under the proposed plan for enforcement testing, DOE would test a random sample and would calculate the mean, $\bar{X}$, standard deviation, S, standard error in the mean, SE($\bar{X}$), and a sample size discount, SSD(m). In determining compliance with a rated efficiency, DOE would assume that the tested units are drawn from a population of transformers for which the mean efficiency is equal to or greater than the rated efficiency. Using the value for t at the 97.5 percentile of the t-distribution for n tests, that is for n–1 degrees of freedom, the probability of obtaining a mean efficiency

$$\overline{X} \geq RE - tSE(\overline{X})$$

is not less than 97.5 percent. The procedure recommends a lower control limit,

$$LCL = SSD(m) - tSE(\overline{X})$$

where the sample size discount,

$$SSD(m) = \frac{100}{1+\left(1+\frac{.05}{\sqrt{m}}\right)\left(\frac{100}{RE}-1\right)}$$

is included to be consistent with the provisions, just discussed, of the proposed plan for compliance testing. Here m is the number of units available for testing, which may not exceed 20 and can range between 1 and 20 under the proposed provisions for enforcement testing. Provided the mean efficiency obtained from the random sample is not less than the lower control limit and the condition

$$n \geq \left[\frac{tS(105-0.05RE)}{RE(5-0.05RE)}\right]^2$$

holds, the product is compliant.

In any statistical test there is some probability of a false conclusion. Under the proposed sampling plan for enforcement, the probability that the mean efficiency for a random sample drawn from a compliant population of transformers would fall below the lower control limit, and hence the risk of incorrectly concluding that the basic model is in noncompliance, is not greater than 2.5 percent. Furthermore, if both the proposed compliance and enforcement plans were applied to the same sample test units, the risk of a false determination of noncompliance with a represented efficiency under the proposed enforcement testing plan is not greater than 2.5 percent for units tested and found to be in compliance with that same represented efficiency under the compliance testing plan. Finally, as in parts 430 and 431, today's proposed rule provides that after DOE determines a basic model to be in noncompliance through testing under the enforcement sampling plan, DOE will conduct additional testing if the manufacturer so requests, and such testing could result in a determination of compliance. This testing over and above that required under the enforcement sampling plan would further reduce the likelihood of a false determination of noncompliance and would thus allow a manufacturer to reduce the risk of a false conclusion.

F. New Part 432

Section 346 of EPCA, 42 U.S.C. 6317, addresses energy conservation requirements for distribution transformers, high-intensity discharge lamps and small electric motors. As set forth in the 1998 proposed rule, 63 FR at 63367, the Department is proposing to add a new Part 432 which would include efficiency regulations the Department adopts for these products. In this notice, the Department is proposing to adopt, and place in Part 432, regulations as to efficiency testing for distribution transformers. At such time as the Department adopts energy conservation standards and other requirements for distribution transformers, or requirements for high-intensity discharge lamps or small electric motors, it also intends to place them in Part 432.

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

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). DOE has made its procedures and policies available on the Office of General Counsel's Web site: *http://www.gc.doe.gov*.

DOE reviewed today's rule under the provisions of the Regulatory Flexibility Act and the procedures and policies published on February 19, 2003, and, for reasons that follow, certifies that the proposed rule, if adopted as a final rule, will not impose a significant economic impact on a substantial number of small entities.

In another rulemaking, the Department is in the early stages of considering the adoption of mandatory energy conservation standards for distribution transformers. Today's proposed rule would prescribe test procedures that will be used to determine what standards, if any, DOE would adopt in that rulemaking, and it also contains certain related provisions. The proposed rule would likely become generally applicable only upon adoption of standards. Unless and until DOE adopts such standards, the Department anticipates that manufacturers will use the test procedures to voluntarily test their transformers and provide to DOE efficiency information about their products. But until energy conservation standards are adopted, no entities, small or large, would be required to comply with these test procedures, or with the other parts of today's proposed rule. Therefore, DOE believes today's proposed rule would not have a ''significant economic impact on a substantial number of small entities,'' and the preparation of a regulatory flexibility analysis is neither required nor warranted at this point.

If the Department adopts standards for distribution transformers, DOE's regulations would require manufacturers to produce transformers that meet the standards. That requirement would have the effect of also requiring manufacturers to comply with the provisions in today's proposed rule (if it is subsequently adopted as a final rule), with respect to the distribution transformers that are subject to the standards. At that point, today's proposed rule would become binding on, and could have an economic impact on, small entities. But the nature and extent of any such impact cannot be assessed until the Department develops standards. Until then, neither the identity nor the proportion of distribution transformers covered by standards can be known. Since today's proposed rule would only be mandatory as to transformers covered by standards, only when that information is known will it be possible to determine what if any burdens the proposed rule would impose on small entities. In light of these circumstances, at an appropriate point in conjunction with the standards rulemaking, the Department will conduct further review under the Regulatory Flexibility Act.

Accordingly, DOE has not prepared a regulatory flexibility analysis for this rulemaking. DOE will transmit 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

Today's proposed rule contains certain record-keeping requirements. For example, proposed § 432.12(a)(4)(ii) would require manufacturers to have records as to AEDMs available for DOE inspection, and proposed § 6.0 of Appendix A to Subpart B would require maintenance of calibration records. But for the reasons explained in Section III. B. above, unless and until the Department requires manufacturers to comply with energy conservation standards for distribution transformers, no manufacturer would be required to comply with these record-keeping provisions. Therefore, today's notice of proposed rulemaking would not impose any new reporting requirements requiring clearance by OMB under the Paperwork Reduction Act, 44 U.S.C. 3501 *et seq.*

The Department recognizes, however, that if it adopts standards for distribution transformers, once the standards become operative manufacturers will become subject to the record-keeping requirements in today's proposed rule (if it has been adopted in a final rule). Prior to that time, therefore, these requirements, if covered by the Paperwork Reduction Act, must be reviewed and approved by OMB. In addition, in conjunction with proposing any standards for transformers, the Department may propose additional reporting and/or record-keeping requirements for this product that are similar to requirements already in place for consumer products in 10 CFR 430.62 and for electric motors in 10 CFR 431.123 and 431.124. Any such additional requirements also may be subject to clearance under the

Paperwork Reduction Act. The Department anticipates a Paperwork Reduction Act submission that will cover any such additional requirements and the information collection requirements in today's proposed rule.

For these reasons, the Department will 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. DOE nonetheless invites public comment on the collections of information proposed today.

D. Review Under the National Environmental Policy Act

In this rulemaking, DOE proposes to adopt test procedures and related provisions for distribution transformers. The test procedures would be used initially for the purpose of considering the adoption of energy conservation standards for transformers, and DOE would require their use only if standards are subsequently adopted. The proposed test procedures will not affect the quality or distribution of energy and, therefore, will not result in any environmental impacts. DOE, therefore, 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. More specifically, today's rule 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 proposed 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 proposed 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 (Pub. L. 104–4) (UMRA) requires each Federal agency to assess the effects of Federal regulatory actions on State, local, and tribal governments and the private sector. With respect to a proposed regulatory action that may result in the expenditure by State, local and tribal governments, in the aggregate, or by the private sector of $100 million or more (adjusted annually for inflation), section 202 of UMRA requires a Federal agency to publish estimates of the resulting costs, benefits, and other effects on the national economy. (2 U.S.C. 1532(a), (b)) 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*). The proposed rule published today does not provide for any Federal mandate likely to result in an aggregate expenditure of $100 million or more. Therefore, the UMRA does not require a cost benefit analysis of today's proposal.

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

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

I. Review Under Executive Order 12630

DOE has determined pursuant to Executive Order 12630, "Governmental Actions and Interference with Constitutionally Protected Property Rights," 53 FR 8859 (March 18, 1988) that this proposed rule 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

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). DOE has reviewed today's notice 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. Today's regulatory action is not a significant regulatory action under Executive Order 12866. Moreover, it would not have a significant adverse effect on the supply, distribution, or use of energy. Therefore, it is not a significant energy action, and 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 of Energy must comply with section 32 of the Federal Energy Administration Act of 1974, as amended by the Federal Energy Administration Authorization Act of 1977. (15 U.S.C. 788) Section 32 provides in part that, where a proposed rule contains or involves use of commercial standards, the rulemaking must inform the public of the use and background of such standards.

The rule proposed in this notice incorporates testing methods contained in the following commercial standards: (1) IEEE Standard 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 Standard C57.12.91–2001, ''IEEE Standard Test Code for Dry-Type Distribution and Power Transformers,'' (3) IEEE Standard C57.12.00–2000, ''IEEE Standard General Requirements for Liquid-Immersed Distribution, Power and Regulating Transformers,'' (4) IEEE Standard 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,'' and (5) NEMA Standards Publication No. TP 2–1998, ''Standard Test Method for Measuring the Energy Consumption of Distribution Transformers.'' The Department has evaluated these standards and is unable to conclude whether they fully comply with the requirements of section 32(b) of the Federal Energy Administration Act, *i.e.*, they were developed in a manner that fully provides for public participation, comment and review.

As required by section 32(c) of the Federal Energy Administration Act, of 1974, as amended, DOE will consult with the Attorney General and the Chairman of the Federal Trade Commission, prior to prescribing a final rule, concerning the impact on competition of requiring use of methods contained in these standards to test distribution transformers.

IV. Public Participation

A. Attendance at Public Meeting

The time and date of the public meeting are listed in the DATES section at the beginning of this notice of proposed rulemaking. The public meeting will be held at the U.S. Department of Energy, Forrestal Building, Room 1E–245, 1000 Independence Avenue, SW., Washington, DC, 20585. To attend the public meeting, please notify Ms. Brenda Edwards-Jones at (202) 586–2945. Foreign nationals visiting DOE Headquarters are subject to advance security screening procedures, requiring a 30-day advance notice. Any foreign national wishing to participate in the meeting should advise DOE of this fact as soon as possible by contacting Ms. Brenda Edwards-Jones to initiate the necessary procedures.

B. Procedure for Submitting Requests To Speak

Any person who has an interest in today's notice, or who is a representative of a group or class of persons that has an interest in these issues, may request an opportunity to make an oral presentation. Such persons may hand-deliver requests to speak, along with a computer diskette or CD in WordPerfect, Microsoft Word, PDF, or text (ASCII) file format to the address shown in the **ADDRESSES** section at the beginning of this supplemental notice of proposed rulemaking between the hours of 9 a.m. and 4 p.m., Monday through Friday, except Federal holidays. Requests may also be sent by mail or e-mail to: *Brenda.Edwards-Jones@ee.doe.gov.*

Persons requesting to speak should briefly describe the nature of their interest in this rulemaking and provide a telephone number for contact. The Department requests persons selected to be heard to submit an advance copy of their statements at least two weeks before the public meeting. At its discretion, DOE may permit any person who cannot supply an advance copy of their statement to participate, if that person has made advance alternative arrangements with the Building Technologies Program. The request to give an oral presentation should ask for such alternative arrangements.

C. Conduct of Public Meeting

The Department will designate a DOE official to preside at the public meeting and may also use a professional facilitator to aid discussion. The meeting will not be a judicial or evidentiary-type public hearing, but DOE will conduct it in accordance with 5 U.S.C. 553 and section 336 of EPCA. A court reporter will be present to record the proceedings and prepare a transcript. The Department reserves the right to schedule the order of presentations and to establish the procedures governing the conduct of the public meeting. After the public meeting, interested parties may submit further comments on the proceedings as well as on any aspect of the rulemaking until the end of the comment period.

The public meeting will be conducted in an informal, conference style. The Department will present summaries of comments received before the public meeting, allow time for presentations by participants, and encourage all interested parties to share their views on issues affecting this rulemaking. Each participant will be allowed to make a prepared general statement (within time limits determined by DOE), before the discussion of specific topics. The Department will permit other participants to comment briefly on any general statements.

At the end of all prepared statements on a topic, DOE will permit participants to clarify their statements briefly and comment on statements made by others. Participants should be prepared to answer questions by DOE and by other participants concerning these issues. Department representatives may also ask questions of participants concerning other matters relevant to this rulemaking. The official conducting the public meeting will accept additional comments or questions from those attending, as time permits. The presiding official will announce any further procedural rules or modification of the above procedures that may be needed for the proper conduct of the public meeting.

The Department will make the entire record of this proposed rulemaking, including the transcript from the public meeting, available for inspection at the U.S. Department of Energy, Forrestal Building, Room 1J–018 (Resource Room of the Building Technologies Program), 1000 Independence Avenue, SW., Washington, DC 20585, (202) 586–9127, between 9 a.m. and 4 p.m., Monday through Friday, except Federal holidays. Any person may buy a copy of the transcript of the public hearing proceedings from the transcribing reporter.

D. Submission of Comments

The Department will accept comments, data, and information regarding the proposed rule before or after the public meeting, but no later than the date provided at the beginning of this notice of proposed rulemaking. Please submit comments, data, and information electronically. Send them to the following e-mail address: *DistTransformersTP-SNOPR@ee.doe.gov.* Submit electronic comments in WordPerfect, Microsoft Word, PDF, or text (ASCII) file format and avoid the use of special characters or any form of encryption. Comments in electronic format should be identified by the docket number EE-TP–98–550 and/or RIN number, and wherever possible carry the electronic signature of the author. Absent an electronic signature, comments submitted electronically must be followed and authenticated by submitting the signed original paper document. No telefacsimiles (faxes) will be accepted.

According to 10 CFR 1004.11, any person submitting information that he or she believes to be confidential and exempt by law from public disclosure should submit two copies: one copy of the document including all the information believed to be confidential, and one copy of the document with the information believed to be confidential deleted. The Department of Energy will make its own determination about the confidential status of the information and treat it according to its determination.

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

List of Subjects in 10 CFR Part 432

Administrative practice and procedure, Energy conservation, Distribution transformers.

The Secretary of Energy has approved publication of today's rule.

Issued in Washington, DC on May 26, 2004.

David K. Garman,

Assistant Secretary, Energy Efficiency and Renewable Energy.

For the reasons set forth in the preamble, Chapter II of Title 10, Code of Federal Regulations, is proposed to be amended by adding a new Part 432 to read as set forth below.

PART 432—ENERGY CONSERVATION PROGRAM FOR DISTRIBUTION TRANSFORMERS

Subpart A—General Provisions

Subpart B—Distribution Transformers

Subpart C—[Reserved]

Subpart D—[Reserved]

Authority: 42 U.S.C. 6317.

Subpart A—General Provisions

§ 432.1 Purpose and scope.

This part contains energy conservation requirements that the Department has promulgated pursuant to section 346 of EPCA, 42 U.S.C. 6317.

§ 432.2 Definitions.

The following definitions apply for purposes of this part:

Act means the Energy Policy and Conservation Act of 1975, as amended, 42 U.S.C. 6291–6317.

DOE or *the Department* means the Department of Energy.

EPCA means the Energy Policy and Conservation Act of 1975, as amended, 42 U.S.C. 6291–6317.

Secretary means the Secretary of the Department of Energy.

Subpart B—Distribution Transformers

§ 432.10 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 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.

Distribution transformer means a transformer with a primary voltage of equal to or less than 35 kV, a secondary voltage equal to or less than 600 V, a frequency of 55–65 Hz, and a capacity of 10 kVA to 2500 kVA for liquid-immersed units and 15 kVA to 2500 kVA for dry-type units, and does not include the following types of transformers:

(1) Autotransformer;
(2) Drive (isolation) transformer;
(3) Grounding transformer;
(4) Harmonic mitigating transformer;
(5) K-Factor Transformer;
(6) Machine-Tool (Control) Transformer;
(7) Non-ventilated Transformer;
(8) Rectifier Transformer;
(9) Regulating Transformer;

(10) Sealed Transformer;
(11) Special-Impedance Transformer;
(12) Testing Transformer;
(13) Transformer with Tap Range greater than 15 percent;
(14) Uninterruptible Power Supply Transformer; or
(15) 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.

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.

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) An autotransformer with a zig-zag winding arrangement.

Harmonic mitigating transformer means a transformer designed to cancel or reduce the harmonics drawn by computer equipment and other non-linear power electronic loads.

K-Factor transformer means a transformer with a K-Factor of 13 or greater that is designed to tolerate the additional eddy-current losses resulting from harmonics drawn by non-linear loads, usually when the ratio of the non-linear load to the linear load is greater than 50 percent.

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. It does not include no-load losses.

Low-voltage distribution transformer means a dry-type distribution transformer with a rated primary voltage of 600 V or less.

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 distribution transformer means a dry-type distribution transformer with rated primary voltage between 601 V and 35 kV.

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

Non-ventilated 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 liquid-immersed distribution transformers at 50% load, and 75 °C for both low-voltage and medium-voltage dry-type distribution transformers, at 35% load and 50% 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. This type of transformer is also commonly known as an Instrument Transformer.

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

Transformer means a static electric device consisting of a winding or two or more coupled windings, with a magnetic core, for introducing mutual coupling between electric circuits.

Transformer with Tap Range greater than 15 percent means a transformer with a tap range in the primary winding greater than the range accomplished with six, 2.5-percent taps, 3 above and 3 below the rated primary voltage (e.g., 6 times 2.5 percent = 15 percent).

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.

§ 432.11 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 (''Appendix A'').

§ 432.12 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 § 432.13 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 § 432.11 of this part and paragraph (b)(2) 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.

(2) *Alternative efficiency determination method.* A manufacturer may apply an AEDM to a basic model 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) In applying the AEDM to distribution transformers, the manufacturer uses the AEDM only for one or more of its basic models in one of the following groups of distribution transformers: low-voltage dry-type transformers, medium-voltage dry-type transformers, and liquid-immersed 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 shall periodically select basic models representative of those to which it has applied an AEDM, and for each basic model selected shall either:

(A) Subject a sample of at least five units to testing in accordance with the applicable test procedure and paragraph (b)(2) of this section by an independent testing laboratory; or

(B) Have an independent state-registered professional engineer, who is qualified to perform an evaluation of distribution transformer efficiency in a highly competent manner and who is not an employee of the manufacturer, review the manufacturer's representations and certify that the results of the AEDM accurately represent the total power loss and efficiency of the basic model.

(ii) 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 paragraphs (a)(3) and (a)(4)(i) 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.

(iii) 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 a sample of units at random and test them. The sample shall be comprised of production units of the basic model, or units that are representative of such production units. The sample size shall be not fewer than five units, except that when the manufacturer would produce fewer than five 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 or verify an AEDM pursuant to paragraphs (a)(3) or (a)(4) of this section. 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:

$$\bar{X} \geq \frac{100}{1 + \left(1 + \frac{0.05}{\sqrt{n}}\right)\left(\frac{100}{RE} - 1\right)}$$

where RE is the represented efficiency.

[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.

§ 432.13 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 § 432.12(a)(4)(iii) 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 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 the 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 his expense a reasonable number of units of a basic model specified in such test notice to a testing laboratory designated by the Department. The number of units of a 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 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.

(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.

Appendix A to Subpart B of Part 432—Uniform Test Method for Measuring the Energy Consumption of Distribution Transformers

1.0 Definitions

The definitions contained in §§ 432.2 and 432.10 are applicable to this Appendix A.

2.0 Accuracy Requirements

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

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

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

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

Record the winding temperature (T_{dc}) of liquid-immersed transformers as the average of top and bottom thermocouples or other temperature sensing devices applied to the outside of the transformer tank. The top sensor should be located at the level of the oil and the bottom sensor should be near the tank bottom or at the lower radiator header if applicable.

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 ventilated dry-type transformers as the average of readings of four or more thermometers, thermocouples, or other suitable temperature sensors inserted within the coils. Sensing points of the measuring devices must be placed as close as possible to the winding conductors.

For sealed units such as epoxy-coated or epoxy-encapsulated distribution transformers, the temperature of the windings must be recorded as either:

(1) The average of four or more temperature sensors located on the enclosure and cover as close to different parts of the winding assemblies as possible; or

(2) After allowing a stabilizing interval with no excitation and no current in the windings for at least 24 hours, the ambient temperature of the test area.

The following conditions must be met immediately before taking cold-resistance measurements:

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

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

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

(d) Neither voltage nor current has been applied to the unit under test for 24 hours. In addition, the period since application of voltage or current must exceed 24 hours 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 added 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

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.

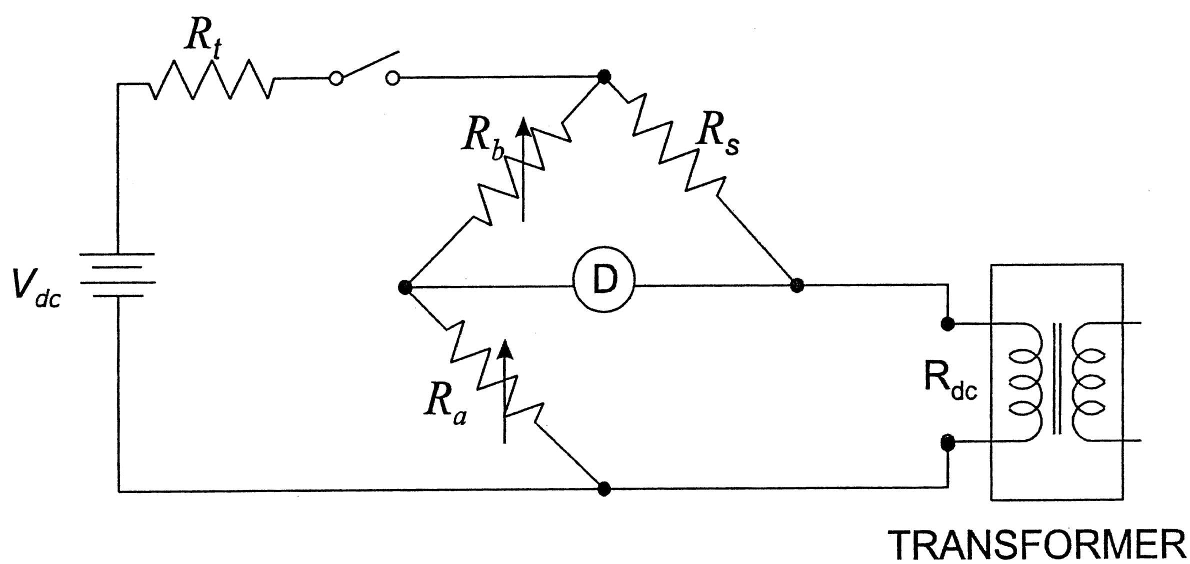

Figure 3.1 Wheatstone Bridge

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.

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:

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

3.3.1.2 Kelvin Bridge

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.

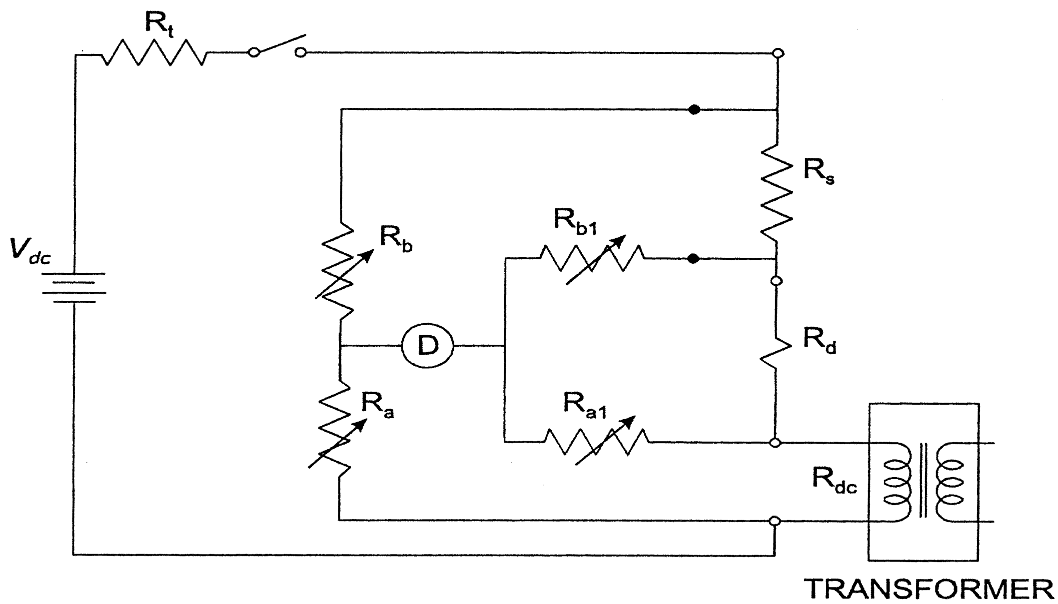

Figure 3.2 Kelvin Bridge

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:

$R_{dc} = R_s (R_a/R_b)$ (3–2),

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

$(R_a/R_b) = (R_{a1}/R_{b1})$ (3–3)

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

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% of the winding current. Connect the transformer winding under test to the circuit shown in Figure 3.3.

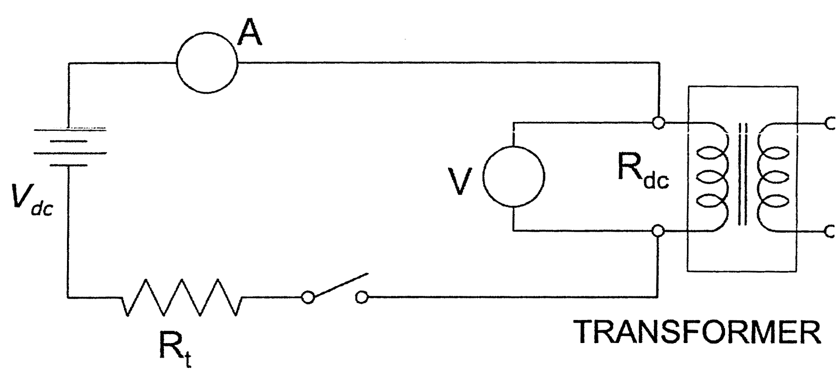

Figure 3.3 Voltmeter-Ammeter Method

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.

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:

$R_{dc} = (V_{mdc}/I_{mdc})$ (3–4)

Where:

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

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

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. A particular meter may be used to measure a transformer's winding resistance only if the meter's specifications for resistance range, current range, and ability to measure highly inductive resistors 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

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:

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:

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

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}.

Because R_{tc} is in the denominator of the expression for the time constant, increasing the size of resistor R_{tc} will decrease the time constant. If the time constant in a given test circuit is too high 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

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.

Correct measurement temperatures to the DOE reference temperature using equation 3–6 as follows:

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

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. Where copper and aluminum windings are employed in the same transformer, use 229 °C.

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 functionally identical test sets. The measured quantities will need correction for instrumentation losses and may need corrections for known phase angle errors in measuring equipment and for the wave form 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.

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

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

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 in place of an instrument to measure current or voltage where the current or voltage of the transformer under test exceeds the measurement capability of such instrument. 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 single-phase test set without an instrument transformer is shown in Figure 4.1.

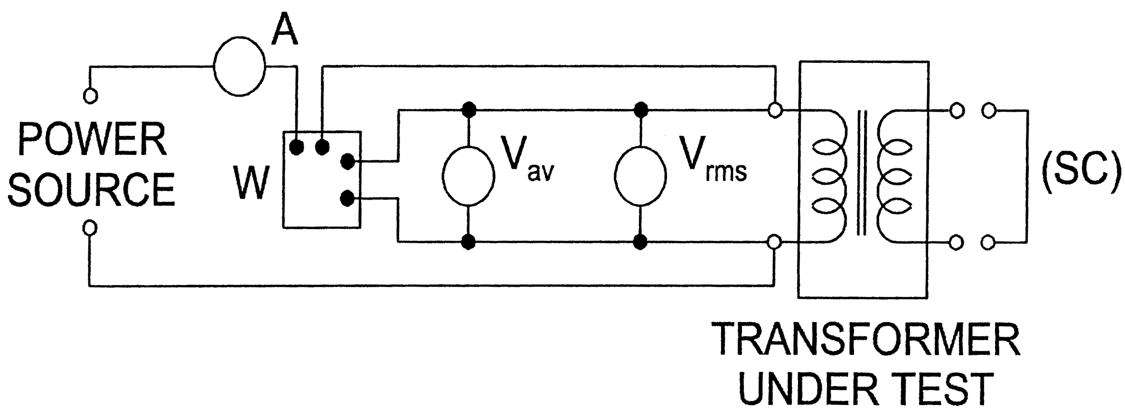

Figure 4.1 Single-Phase Test Set Without Instrument Transformers

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.

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.

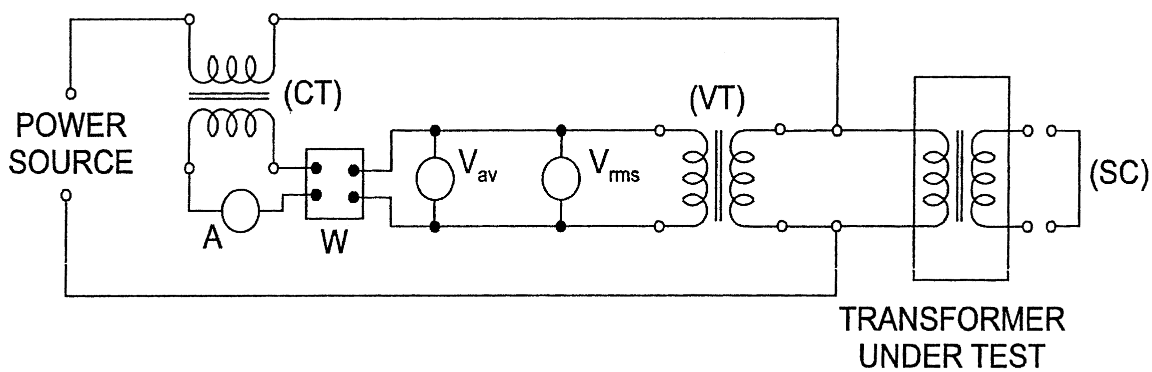

Figure 4.2 Single-Phase Test Set With Instrument Transformers

4.3.2 Three-Phase Test Sets

Use these for testing three-phase distribution transformers.

4.3.2.1 Without Instrument Transformers

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.

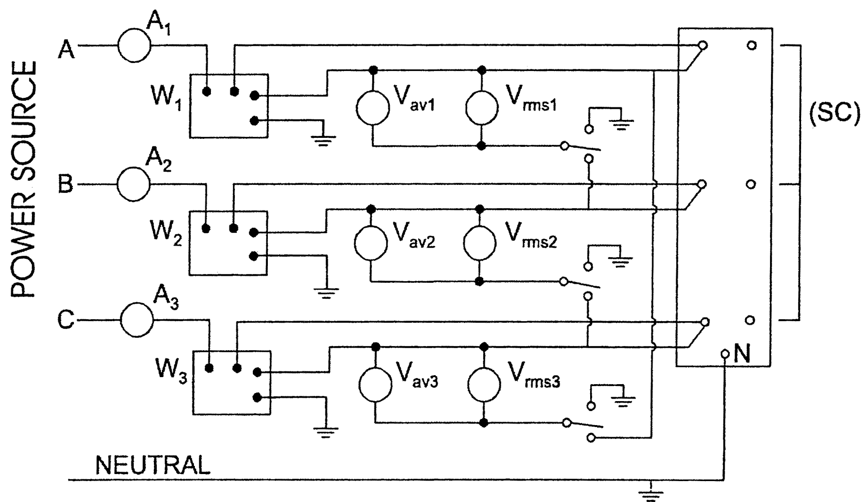

Figure 4.3 Three-Phase Test Set Without Instrument Transformers

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.

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.

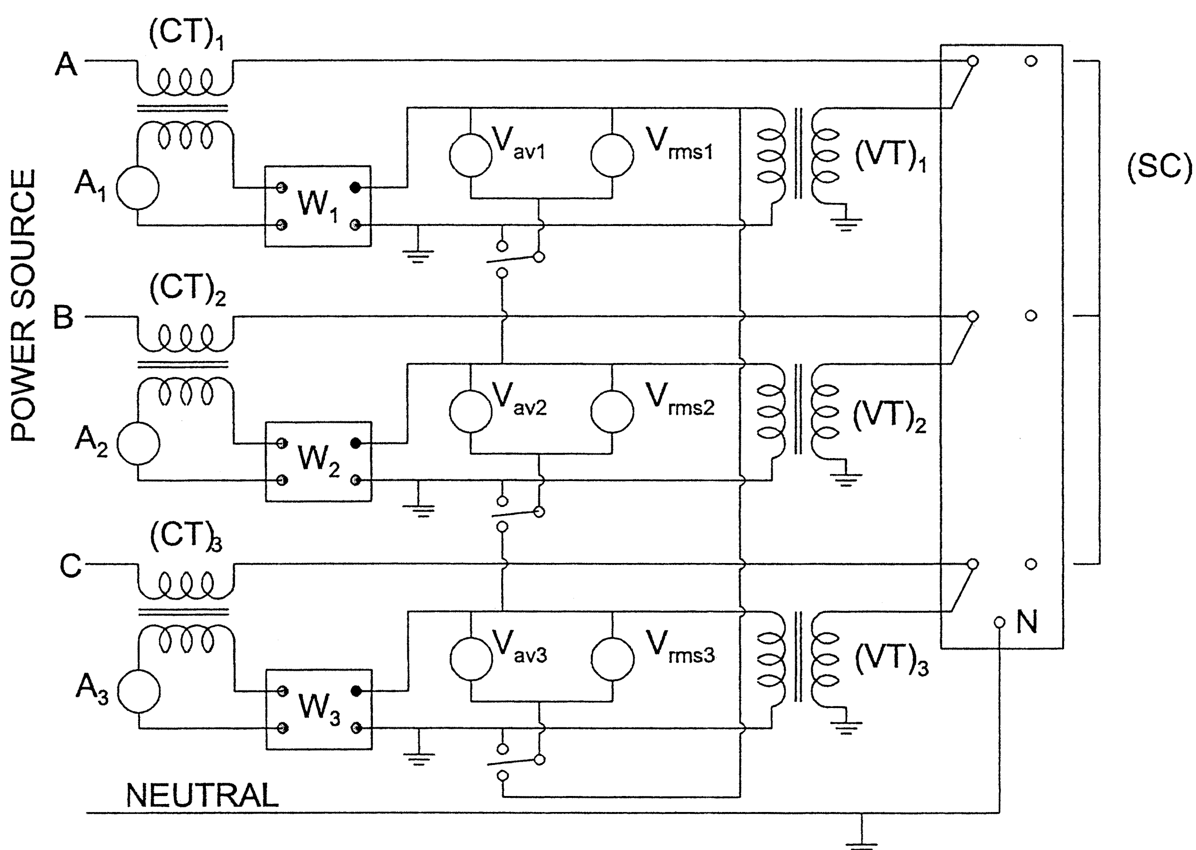

Figure 4.4 Three-Phase Test Set with Instrument Transformers

4.3.3 Test Set Neutrals

A four-wire, three-wattmeter test circuit must be used in making measurements. For delta-wound transformers, a neutral deriving transformer must be used to obtain neutral and ground for the test.

4.4 No-Load Losses: Measurement and Calculations

4.4.1 General Considerations

Make measurement corrections:

(1) For instrumentation losses;

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

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

4.4.2 No-Load Loss Test

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 precaution (b) below. 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 precautions (a), (b), and (c) below:

(a) 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.

(b) Energized windings. Either the high voltage or the low voltage winding of the transformer under test may be energized. Energize not less than 25 percent of the winding.

(c) 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, unless otherwise specified.

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

Determine the losses attributable to the voltmeters, ammeter, and wattmeter, and to the instrument transformers if they are used, and deduct these losses from the measurement of total no-load losses.

4.4.3.2 Correction for Non-Sinusoidal Applied Voltage

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%. In such a case, no correction is required.

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

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.

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:

$$P_{nc} = P_{ncl}\,[(1 + 0.00065\,(T_{nm} - T_{nr})] \qquad (4\text{–}2)$$

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

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.

For a transformer with a tap changer, the test must be conducted at the rated current and voltage of the nominal tap position.

4.5.2 Tests for Measuring Load Losses

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).

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

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

(b) The conductors used to short-circuit the windings must have a cross-sectional area equal to, or greater than, the corresponding transformer leads.

(c) 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 Instrumentation Losses

Determine the losses attributable to the voltmeters, ammeter, wattmeter and short-circuiting conductor (SC), and to the instrument transformers if they are used, and deduct these losses from the measurement of total load losses.

4.5.3.2 Correction for Phase Angle Errors

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:

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

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.

If the correction for phase angle errors is to be applied, first examine the total system phase angle (β_w–β_v+β_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:

$$P_{lc1} = P_{lm} - V_{lm} I_{lm} (\beta_w - \beta_v + \beta_c) \sin\phi \qquad (4\text{-}4)$$

$$P_{lc1} = V_{lm} I_{lm} \cos(\phi + \beta_w - \beta_v + \beta_c) \qquad (4\text{-}5)$$

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,

$$PF = \frac{P_{lm}}{V_{lm} I_{lm}} \text{ is the measured power factor of the load loss impedance,}$$

$$\phi = \cos^{-1} \frac{P_{lm}}{V_{lm} I_{lm}} \text{ is the measured phase angle between } V_{lm} \text{ and } I_{lm},$$

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.

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

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.

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

$$\begin{aligned} P_e &= P_{e(p)} + P_{e(s)} \\ &= I^2_{lm(p)} R_{dc(p)} \frac{T_{k(p)} + T_{lm}}{T_{k(p)} + T_{dc}} + I^2_{lm(s)} R_{dc(s)} \frac{T_{k(s)} + T_{lm}}{T_{k(s)} + T_{dc}} \\ &= I^2_{lm(p)} \left[R_{dc(p)} \frac{T_{k(p)} + T_{lm}}{T_{k(p)} + T_{dc}} + \left[\frac{N_1}{N_2} \right]^2 R_{dc(s)} \frac{T_{k(s)} + T_{lm}}{T_{k(s)} + T_{dc}} \right] \qquad (4\text{-}6) \end{aligned}$$

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

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

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:

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

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

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

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:

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

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

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

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.

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 output power (name plate),

P_{os} is the specified energy efficiency load level, where 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) at specified energy efficiency load level, P_{os}, by using equation 5–3 as follows:

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

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

6.1 Test Equipment

Test equipment and measuring instruments must be maintained properly, and calibration records must be maintained. The calibration of the test set shall confirm the accuracy of the test set to that specified in section 2.0.

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 B of Part 432—Sampling Plan for Enforcement Testing

Step 1. The number of units in the sample (m_1) shall be in accordance with §§ 432.13(a)(4), 432.13(a)(5), 432.13(a)(6) and 432.13(a)(7) and shall not be greater than twenty. The number of tests in the first sample (n_1) shall be in accordance with § 432.13(a)(8) and shall be not fewer than four.

Step 2. Compute the mean ($\bar{X}_1$) 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:

$$SSD(m_1) = \frac{100}{1 + \left(1 + \frac{.05}{\sqrt{m_1}}\right)\left(\frac{100}{RE} - 1\right)} \qquad (4)$$

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:

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

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:

$$n = \left[\frac{tS_1(105 - 0.05RE)}{RE(5 - 0.05RE)}\right]^2 \qquad (6)$$

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

$$\frac{105 - 0.05RE}{RE(5 - 0.05RE)}$$

is based on a 5-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,

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

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.

Subpart C—[Reserved]

Subpart D—[Reserved]

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