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Energy Conservation Program for Consumer Products: Test Procedures for Residential Furnaces and Boilers; Final Rule

## DEPARTMENT OF ENERGY

## 10 CFR Parts 429 and 430

[Docket No. EERE-2012-BT-TP-0024]

RIN 1904-AC79

**Energy Conservation Program for Consumer Products: Test Procedures for Residential Furnaces and Boilers**

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

**ACTION:** Final rule.

**SUMMARY:** The U.S. Department of Energy (DOE) amends its test procedure for residential furnaces and boilers established under the Energy Policy and Conservation Act. This rulemaking will fulfill DOE's obligation to review its test procedures for covered products at least once every seven years. The revisions include: Clarifying the components included in the burner electrical power input term (PE); adopting a method for determining whether a minimum draft factor can be applied, and how the conditions are to be verified; allowing optional measurement of condensate collection during establishment of steady state; updating references to the applicable installation and operating manual and providing clarifications when the installation and operation (I&O) manual does not specify test setup; clarifying the testing of units intended to be installed without a return duct; adopting a provision clarifying the testing of multi-position units; revising the required reporting precision for annual fuel utilization efficiency (AFUE); and adopting a verification method for determining whether a boiler incorporates an automatic means for adjusting water temperature and whether this design requirement functions as required.

**DATES:** The effective date of this rule is February 16, 2016. The final rule changes will be mandatory for representations made on or after July 13, 2016. The incorporation by reference of certain material listed in this rule is approved by the Director of the Federal Register as of February 16, 2016.

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

A link to the docket Web page can be found at: <http://www.regulations.gov/#!docketDetail;D=EERE-2012-BT-TP-0024>. This Web page contains a link to the docket for this final rule on the [www.regulations.gov](http://www.regulations.gov) site. The [www.regulations.gov](http://www.regulations.gov) Web page contains simple instructions on how to access all documents, including public comments, in the docket.

For further information on how to review the docket, contact Ms. Brenda Edwards at (202) 586-2945 or by email: [Brenda.Edwards@ee.doe.gov](mailto:Brenda.Edwards@ee.doe.gov).

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**SUPPLEMENTARY INFORMATION:** This final rule incorporates by reference into part 430 the following industry standard: ASTM D2156-09 (Reapproved 2013) ("ASTM D2156R13"), *Standard Test Method for Smoke Density in Flue Gases from Burning Distillate Fuels*, approved October 1, 2013.

Copies of ASTM D2156R13 can be obtained from ASTM, American Society of Testing and Materials, ASTM Headquarters, 100 Barr Harbor Drive, P.O. Box C700, West Conshohocken, PA 19428-2959, (877) 909-2786 or (610) 832-9585, or by going to <http://www.astm.org>. See section IV.M for further discussion of this standard.

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**I. Authority and Background**

Title III, Part B<sup>1</sup> of the Energy Policy and Conservation Act of 1975 ("EPCA" or "the Act"), Public Law 94-163 (42 U.S.C. 6291-6309, as codified) sets forth a variety of provisions designed to improve energy efficiency and established the Energy Conservation Program for Consumer Products Other Than Automobiles.<sup>2</sup> These products include residential furnaces and boilers, the subject of this notice.<sup>3</sup>

Under EPCA, DOE's energy conservation program generally consists of four parts: (1) Testing; (2) labeling; (3) Federal energy conservation standards; and (4) certification and enforcement procedures. The testing requirements consist of test procedures that manufacturers of covered products must

<sup>1</sup> For editorial reasons, Part B was codified as Part A in the U.S. Code.

<sup>2</sup> All references to EPCA in this document refer to the statute as amended through the Energy Efficiency Improvement Act of 2015, Public Law 114-11 (Apr. 30, 2015).

<sup>3</sup> Under 42 U.S.C. 6292(a)(5), the statute establishes "furnaces" as covered products, and 42 U.S.C. 6291(23) defines furnaces as inclusive of boilers.

use as the basis for: (1) Certifying to DOE that their products comply with the applicable energy conservation standards adopted pursuant to EPCA, and (2) making other representations about the efficiency of those products. (42 U.S.C. 6293(c); 42 U.S.C. 6295(s)) Similarly, DOE must use these test procedures to determine whether the products comply with any relevant standards promulgated under EPCA. (42 U.S.C. 6295(s))

EPCA sets forth the criteria and procedures that DOE must follow when prescribing or amending test procedures for covered products. EPCA provides, in relevant part, that any test procedures prescribed or amended under this section shall be reasonably designed to produce test results which measure energy efficiency, energy use, or estimated annual operating cost of a covered product during a representative average use cycle or period of use, and shall not be unduly burdensome to conduct. (42 U.S.C. 6293(b)(3))

In addition, if DOE determines that a test procedure amendment is warranted, it must publish proposed test procedures and offer the public an opportunity to present oral and written comments on them. (42 U.S.C. 6293(b)(2)) Finally, in any rulemaking to amend a test procedure, DOE must determine to what extent, if any, the proposed test procedure would alter the product's measured energy efficiency as determined under the existing test procedure. (42 U.S.C. 6293(e)(1))

EISA 2007 amended EPCA to require that, at least once every 7 years, DOE must review test procedures for all covered products and either amend the test procedures (if the Secretary determines that amended test procedures would more accurately or fully comply with the requirements of 42 U.S.C. 6293(b)(3)) or publish a notice in the **Federal Register** of any determination not to amend a test procedure. (42 U.S.C. 6293(b)(1)(A)) Under this requirement, DOE must review the test procedure for residential furnaces and boilers not later than December 19, 2014 (*i.e.*, 7 years after the publication of EISA 2007 on December 19, 2007).

DOE's current energy conservation standards for residential furnaces and boilers are expressed as minimum annual fuel utilization efficiency (AFUE). AFUE is an annualized fuel efficiency metric that accounts for fuel consumption in active, standby, and off modes. The following discussion provides a brief history of the rulemakings underlying the existing test procedure for residential furnaces and boilers.

The existing DOE test procedure for determining the AFUE of residential furnaces and boilers is located at 10 CFR part 430, subpart B, appendix N, *Uniform Test Method for Measuring the Energy Consumption of Furnaces and Boilers*. The existing DOE test procedure for residential furnaces and boilers was established by a final rule published in the **Federal Register** on May 12, 1997, and it incorporates by reference the American National Standards Institute/American Society of Heating, Refrigerating, and Air-Conditioning Engineers (ANSI/ASHRAE) Standard 103–1993, *Method of Testing for Annual Fuel Utilization Efficiency of Residential Central Furnaces and Boilers* (ASHRAE 103–1993). 62 FR 26140, 26157 (incorporated by reference at 10 CFR 430.3(f)(10)). On October 14, 1997, DOE published an interim final rule in the **Federal Register** to revise a provision concerning the insulation of the flue collector box in order to ensure the updated test procedure would not affect the measured AFUE of existing furnaces and boilers. 62 FR 53508. This interim final rule was adopted without change in a final rule published in the **Federal Register** on February 24, 1998. 63 FR 9390.

On October 20, 2010, DOE amended its test procedure for furnaces and boilers to establish a method for measuring the electrical energy use in standby mode and off mode for gas-fired and oil-fired furnaces and boilers, as required by EISA 2007. 75 FR 64621. These test procedure amendments incorporated by reference, and were based primarily on, provisions of the International Electrotechnical Commission (IEC) Standard 62301 (First Edition), *Household electrical appliances—Measurement of standby power*. On December 31, 2012, DOE published a final rule (December 2012 final rule) in the **Federal Register** that updated the incorporation by reference of the standby mode and off mode test procedure provisions to refer to the latest edition of IEC Standard 62301 (Second Edition). 77 FR 76831. On July 10, 2013, DOE published a final rule (July 2013 final rule) in the **Federal Register** that amended its test procedure for residential furnaces and boilers by adopting needed equations that allow manufacturers the option to omit the heat-up and cool-down tests and still generate a valid AFUE measurement. 78 FR 41265. On August 30, 2013, DOE published a correction to the July 2013 final rule that corrected errors in the redesignations of affected subsections within section 10 of appendix N. 78 FR 53625.

On January 4, 2013, DOE initiated this rulemaking to examine all aspects of the DOE test procedure by publishing a request for information (RFI) (January 2013 RFI) in the **Federal Register**. 78 FR 675. On March 11, 2015, DOE published a notice of proposed rulemaking (NOPR) (March 2015 NOPR) in the **Federal Register** to amend the test procedure for residential furnaces and boilers. 80 FR 12876. In the March 2015 NOPR, DOE proposed to amend the residential furnaces and boilers test procedure by incorporating by reference ANSI/ASHRAE Standard 103–2007 (ASHRAE 103–2007) in place of ASHRAE 103–1993, which currently is referenced in the existing test procedure. In addition, the March 2015 NOPR proposed to adopt modifications that would establish revised test procedures for two-stage and modulating products, as well as for boilers with long post-purge times that would not otherwise be included in the incorporation by reference of ASHRAE 103–2007.

DOE also proposed to amend the test procedure to: (1) Allow the measurement of condensate during the establishment of steady-state rather than require an additional 30 minutes of testing after steady-state conditions are established; (2) revise annual electricity consumption equations to account for additional electrical components; (3) revise test procedure references to “manufacturer recommendations” or “manufacturer’s instructions” that do not explicitly identify the source of the recommendations or instructions; (4) include a test protocol for determining the functionality of the automatic means for adjusting water temperature; (5) include a test method to indicate the absence or presence of air flow to determine whether the minimum default draft factor may be used; (6) revise the required reporting precision for AFUE; (7) specify testing requirements for units that are installed without a return duct; and (8) specify testing requirements for units with multi-position configurations. 80 FR 12876.

## II. Summary of the Final Rule

The final rule amends the existing DOE test procedure for residential furnaces and boilers to improve the consistency and accuracy of test results generated using the DOE test procedure and to reduce test burden. In particular, these modifications include: (1) Clarifying the definition of the electrical power term PE; (2) adopting a smoke stick test for determining use of minimum default draft factors; (3) allowing for the measurement of condensate under steady-state

conditions; (4) referencing the manufacturer's installation and operation (I&O) manual and providing clarifications when the I&O manual does not specify test setup; (5) specifying ductwork requirements for units that are installed without a return duct; (6) specifying testing requirements for units with multi-position configurations; and (7) revising the AFUE reporting precision. DOE has also revised the definitions of several terms in the test procedure and added an enforcement provision to provide a method of test for DOE to determine compliance with the automatic means design requirement mandated by EISA 2007.

DOE has withdrawn or modified all test procedure amendment proposals in the March 2015 NOPR for which stakeholders expressed concern regarding the effect of the proposed amendments on the measured energy efficiency of residential furnaces and boilers when compared to the current test procedure. In particular, as discussed in section III.C, DOE has withdrawn its proposal to incorporate by reference ASHRAE 103–2007.

### III. Discussion

The following sections discuss the products within the scope of this rulemaking, the test procedure amendments, other test procedure considerations, test burden, measured energy use, and changes to certification and enforcement provisions.

In response to the March 2015 NOPR, the following twelve interested parties submitted written comments: The American Gas Association (AGA); the Air-Conditioning, Heating and Refrigeration Institute (AHRI); Burnham Holdings, Inc. (Burnham); Carrier Corporation (Carrier); John Cockerill (Cockerill); Goodman Global, Inc. (Goodman); Lennox Industries Inc. (Lennox); Lochinvar, LLC (Lochinvar); Rheem Manufacturing Company (Rheem); Ingersoll Rand Residential Solutions (Ingersoll Rand); Laclede Group; and Weil-McLain. Interested parties provided comments on a range of issues, including those DOE identified in the March 2015 NOPR, as well as issues related to the proposed test procedure changes. The issues on which DOE received comments, as well as DOE's responses to those comments and the resulting changes to the test procedure proposals presented in the NOPR, are discussed in the subsequent sections. A parenthetical reference at the end of a comment quotation or

paraphrase provides the location of the item in the public record.<sup>4</sup>

#### A. Products Within Scope of the Final Rule

The test procedure amendments apply to products that meet the definitions for residential furnaces and boilers (see DOE's regulations at 10 CFR 430.2). A "furnace" is defined as a product that: (1) Utilizes only single-phase electric current, or single-phase electric current or direct current (DC) in conjunction with natural gas, propane, or home heating oil; (2) is designed to be the principal heating source for the living space of a residence; (3) is not contained within the same cabinet with a central air conditioner whose rated cooling capacity is above 65,000 Btu per hour; (4) is an electric central furnace, electric boiler, forced-air central furnace, gravity central furnace, or low pressure steam or hot water boiler; and (5) has a heat input rate of less than 300,000 Btu per hour for electric boilers and low pressure steam or hot water boilers and less than 225,000 Btu per hour for forced-air central furnaces, gravity central furnaces, and electric central furnaces.<sup>5</sup>

The individual products within the scope of this test procedure and the definition of each (see DOE's regulations at 10 CFR 430.2) are listed below:

(1) Electric boiler means an electrically powered furnace designed to supply low pressure steam or hot water for space heating application. A low pressure steam boiler operates at or below 15 pounds per square inch gauge (psig) steam pressure; a hot water boiler operates at or below 160 psig water pressure and 250 °F water temperature.

(2) Electric central furnace means a furnace that is designed to supply heat through a system of ducts with air as the heating medium, in which heat generated by one or more electric resistance heating elements is circulated by means of a fan or blower.

(3) Forced-air central furnace means a furnace that burns gas or oil and is designed to supply heat through a system of ducts with air as the heating medium. The heat generated by

<sup>4</sup> The parenthetical reference provides a reference for information located in the docket of DOE's rulemaking to amend the test procedures for residential furnaces and boilers. (Docket No. EERE-2012-BT-TP-0024, which is maintained at <http://www.regulations.gov/#!docketDetail;D=EERE-2012-BT-TP-0024>). The references are arranged as follows: (commenter name, comment docket ID number, page of that document).

<sup>5</sup> The definition of "furnace" currently in the CFR at 10 CFR 430.2 mistakenly repeats the terms "gravity central furnaces, and electric central furnaces" at the end of the definition. In this final rule, DOE is correcting this error to remove the duplicative language.

combustion of gas or oil is transferred to the air within a casing by conduction through heat exchange surfaces and is circulated through the duct system by means of a fan or blower.

(4) Gravity central furnace means a gas-fueled furnace which depends primarily on natural convection for circulation of heated air and which is designed to be used in conjunction with a system of ducts.

(5) Low pressure steam or hot water boiler is an electric, gas, or oil-burning furnace designed to supply low pressure steam or hot water for space heating applications. A low pressure steam boiler operates at or below 15 psig steam pressure; a hot water boiler operates at or below 160 psig water pressure and 250 °F water temperature.

(6) Mobile home furnace means a direct vent furnace that is designed for use only in mobile homes.

(7) Outdoor furnace or boiler is a furnace or boiler normally intended for installation out-of-doors or in an unheated space (such as an attic or a crawl space).

(8) Weatherized warm air furnace or boiler means a furnace or boiler designed for installation outdoors, approved for resistance to wind, rain, and snow, and supplied with its own venting system.

#### B. General Comments

Stakeholders submitted general comments regarding the test procedure and parallel energy conservation standards rulemaking timeline and the availability of data related to this proceeding. DOE discusses and responds to these comments in the following subsections.

##### 1. Statutory Deadline

As noted in section I, EISA 2007 requires that DOE must review test procedures for all covered products and amend the test procedures or publish a notice in the **Federal Register** of any determination not to amend test procedures at least once every seven years. (42 U.S.C. 6293(b)(1)(A)).

AHRI asserted that the start date for the obligation to review efficiency test procedures at least once every seven years has been reset by the July 2013 Final Rule. And, therefore, by its estimation, DOE has approximately five more years to review and amend, as needed, the test procedures for residential furnaces and boilers. AHRI added that this would be ample time to manage DOE's rulemaking activities such that proposed revisions to efficiency standards and test procedures are not considered concurrently. (AHRI, No. 36 at p. 2)

DOE notes that the July 2013 Final Rule was limited in scope and only intended to remedy a specific concern articulated by stakeholders. Specifically, the July 2013 Final Rule adopted needed equations to allow manufacturers the option to omit the heat up and cool down tests and still generate a valid AFUE measurement for certain condensing products. 78 FR 41265, 41266. DOE considers the seven year look back provision to include a comprehensive review of the entire test procedure. (42 U.S.C. 6293(b)(1)(A)) DOE did not conduct a comprehensive review for the July 2013 Final Rule. Furthermore, DOE stated in the July 2013 Final Rule that it was initiating a separate rulemaking that was broader in scope to examine all aspects of the DOE test procedure for residential furnaces and boilers. 78 FR 41265, 41266. Therefore, DOE maintains that the July 2013 final rule did not meet the requirements outlined in 42 U.S.C. 6293(b)(1)(A). In contrast, DOE has conducted a comprehensive review as part of the current rulemaking, which satisfies the requirements of 42 U.S.C. 6293(b)(1)(A).

## 2. Simultaneous Changes in Test Procedure and Standards

Several stakeholders cited legal and practical concerns regarding the timing of proposed revisions to the test procedures and standards for residential furnaces and boilers. Stakeholders requested that DOE delay any further work on the rulemakings to amend efficiency standards for these products until after the finalization of the test procedure. (AHRI, No. 36 at p. 1; Weil-McLain, No. 31 at p. 2; Ingersoll Rand, No. 37 at p. 5)

AHRI stated that it believes the non-final status of the test procedure inhibits stakeholders' fair evaluation of the standard. AHRI stressed the importance of having a known efficiency test procedure. AHRI noted that when a test procedure is in flux, manufacturers must spend resources collecting potentially unusable data which undermines their ability to provide input on the proposed efficiency standards. Similarly, AHRI added that when a test procedure is not finalized, a manufacturer has no way of determining whether the test procedure will affect its ability to comply with a proposed revised standard. AHRI noted that DOE is required to give stakeholders the opportunity to provide meaningful comments and asserted that the joint proposal of test procedures and standards diminishes that opportunity (see 42 U.S.C. 6295(p)(2), 6306(a)). (AHRI, No. 36 at p. 1)

In response to AHRI, DOE does not believe that the timing of the test procedure and standards rulemakings has negatively impacted stakeholders' ability to provide meaningful comment on this test procedure rulemaking. DOE allowed four months for public comment on the test procedure NOPR. Additionally, DOE's original proposal included an update to the latest industry standard (*i.e.*, ASHARE 103–2007), which was developed by a consensus-based ASHRAE process, and was released in 2007. DOE believes that industry was involved in developing that standard and had experience with the changes in the 2007 version of ASHRAE Standard 103. Lastly, stakeholders provided detailed, insightful comments on all aspects of the proposal, including submitting select test data in response to DOE's proposal, which shows that industry was able to carefully consider the proposed method and how it compared to the current Federal method of test. In addition, DOE has taken AHRI's concerns regarding the potential impact of test procedure changes on measured energy use into account in its determinations of which test procedure proposals to finalize in this rulemaking.

AHRI and Goodman stated that by publishing the March 2015 NOPR within weeks of the proposed efficiency standard, DOE has failed to abide by the procedures located at 10 CFR part 430, subpart C, appendix A (7)(b). (AHRI, No. 36 at p. 2; Goodman, No. 33 at p. 2) AHRI stated that the Administrative Procedure Act (APA) requires agencies to abide by their policies and procedures, especially where those rules have a substantive effect. AHRI asserted that the non-final test procedure has the substantive effect of increasing costs to stakeholders and diminishing their ability to comment on the efficiency standards. (AHRI, No. 36 at p. 2; Weil-McLain, No. 31 at p. 7)

In response to the comments from AHRI and Goodman asserting that DOE has failed to abide by its procedures at 10 CFR 430, subpart C, appendix A (7)(b), DOE notes that appendix A establishes procedures, interpretations, and policies to guide DOE in the consideration and promulgation of new or revised appliance efficiency standards under EPCA. (See section 1 of 10 CFR part 430, subpart C, appendix A) Those procedures are a general guide to the steps DOE typically follows in promulgating energy conservation standards. The guidance recognizes that DOE can and will, on occasion, deviate from the typical process. Accordingly, DOE has concluded that there is no basis to either: (1) Delay the final rules

adopting standards for residential furnaces and boilers; or (2) suspend the test procedure rulemaking until the standards rulemaking has been completed.

Ingersoll Rand and Goodman stated their concern that two-stage, condensing furnaces that would meet the March 12, 2015 furnace proposed rule of 92-percent AFUE under the current test procedure would not meet the 92-percent AFUE standard under the proposed DOE test procedure. Ingersoll Rand noted that the two test procedures were assumed to be identical in the March 12, 2015 residential furnace standard NOPR technical support document. (Ingersoll Rand, No. 37 at p. 2; Goodman, No. 33 at p. 1) Similarly, Weil-McLain suggested that the uncertainty caused by the simultaneous test procedure rulemaking amplifies venting issues present in the residential boiler standards NOPR. (Weil-McLain, No. 31 at p. 3)

In response to Ingersoll Rand and Goodman, as discussed in section III.C, DOE declines to adopt the latest industry standard of ASHRAE 103–2007, which is the only amendment proposed in the March 2015 NOPR that manufacturers claimed could alter the AFUE for two-stage and modulating condensing products. In response to Weil-McLain, DOE notes that none of the proposed test procedure provisions that had the potential to result in a change in measured AFUE are adopted in this test procedure final rule, as discussed in section III.G.

## 3. Lack of Data Availability

In response the March 2015 NOPR, interested parties submitted comments regarding lack of data availability. For example, the March 2015 NOPR included several references to a testing report. 80 FR 12876, 12878. Burnham stated that in spite of requests from commenters, the testing report was not available in the public docket as of July 8, 2015. Burnham added that the lack of access to the testing report has made it impossible to properly review the impact of ambient conditions on AFUE during the public comment period. Burnham requested that the comment period be extended to allow comment on this document which should be disclosed immediately. (Burnham, No. 35 at p. 7)

DOE made the test results available during the test procedure public meeting.<sup>6</sup> The slide deck presented at

<sup>6</sup> Test results included in the slide deck for the public meeting include those for proposed changes related to AFUE determination for two-stage/

the public meeting was posted to the docket on March 26, 2015, along with the transcript of the public meeting. (Public Meeting Presentation Slides, No. 21) Therefore, stakeholders were presented with an opportunity to review and discuss the data with the Department at the public meeting and to review the results during the comment period, which was open until July 10, 2015.

### C. Proposed Incorporation by Reference of ASHRAE Standard 103–2007

In the March 2015 NOPR, DOE proposed amendments to reduce variability, eliminate ambiguity, and address discrepancies between the test procedure and actual field conditions, and DOE requested comment on its proposals. 80 FR 12876, 12902. One of these proposals was to update its incorporation by reference of the industry test standard ASHRAE 103–1993 to ASHRAE 103–2007.

DOE received several comments in response to its proposal to update the incorporation by reference in the DOE test procedure to ASHRAE 103–2007. Lochinvar and AGA responded to the NOPR in favor of adopting ASHRAE 103–2007 provided that DOE make adequate allowances for the resulting test burden and the impact that the change would have on existing efficiency claims. (Lochinvar, No. 29 at p. 1; AGA, No. 27 at p. 4) Similarly, Burnham stated that they are not opposed to the update provided test burden is reduced. (Burnham, No. 35 at p. 3)

Ingersoll Rand and Rheem stated their support only for certain provisions of ASHRAE 103–2007. Specifically, Ingersoll Rand supported requiring only reduced fire testing (and not high-fire testing) when the calculated balance point temperature is less than or equal to five degrees. (Ingersoll Rand, No. 37 at p. 4) Rheem stated their support for the elimination of table 8 and the average design heating requirements in ASHRAE 103–1993. (Rheem, No. 30 at p. 2)

Lennox and Weil-McLain suggested DOE not update to ASHRAE 103–2007 at this time. (Lennox, No. 32 at p. 2; Weil-McLain, No. 31 at p. 7) AHRI and Weil-McLain suggested that DOE wait to modify the test procedure until ASHRAE 103–2016 is issued. (AHRI, No. 36 at p. 8; Weil-McLain, No. 31 at

p. 7) Carrier suggested that DOE not update to ASHRAE 103–2007, but change the AFUE metric for forced-air furnaces to be based on the steady-state operation, as discussed in section III.E.4. (Carrier, No. 34 at p. 2)

Several commenters suggested that that the updating to ASHRAE 103–2007 would result in more significant changes to AFUE ratings than suggested by DOE in the March 2015 NOPR. (Burnham, No. 35 at p. 3; Lennox, No. 32 at p. 2; AGA, No. 27 at p. 4; AHRI, No. 36 at p. 4; Ingersoll Rand, No. 37 at p. 2) Of these commenters, only AHRI provided test data, which indicated small changes in AFUE as a result of changes to the cyclical condensate test for modulating condensing boilers. (AHRI, No. 36 at p. 17)

Burnham and Ingersoll Rand suggested that the impact to AFUE resulting from the changes in cycle times is still uncertain. Therefore, it is not possible to conclude that the effect of this proposed change to the procedure is insignificant. (Burnham, No. 35 at p. 3; Ingersoll Rand, No. 37 at p. 2) Ingersoll Rand noted that as a result of adopting ASHRAE 103–2007, two-stage and modulating non-condensing furnaces will have a higher AFUE rating, and condensing furnaces will have lower AFUE ratings. Ingersoll Rand noted that the changes in AFUE are higher than the uncertainty of the test procedure reported by DOE and therefore this change to the test procedure cannot be considered *de minimis*. Ingersoll Rand also noted that the test results are limited and have high variability. Ingersoll Rand suggested that the change not be adopted until the variability is better understood. (Ingersoll Rand, No. 37 at p. 2) AGA suggested that the Department substantially increase the amount of testing using the modified test procedure to ensure that the resulting efficiency rating for both furnaces and boilers are accurate and repeatable. (AGA, No. 27 at p. 4)

Similarly, Ingersoll Rand suggested the calculation to account for post purge times longer than three minutes not be adopted without test data indicating the adjustment to AFUE that would result from this update. Ingersoll Rand stated that without test data they cannot determine if the new readings would be representative of a unit's performance. (Ingersoll Rand, No. 37 at p. 4)

In response to the March 2015 NOPR, Ingersoll Rand requested that DOE not adopt the proposed changes to the calculation of annual auxiliary electrical energy consumption ( $E_{AE}$ ) caused by the update to ASHRAE 103–2007. Ingersoll Rand stated that the calculation of  $E_{AE}$

proposed in the March 2015 NOPR changes the value of  $E_{AE}$  substantially from  $-8.5$  percent to  $+13.5$  percent. Ingersoll Rand noted that this change, along with the proposal to include the electrical consumption of additional components is significant enough that all current furnaces would have to be retested and recertified. Ingersoll Rand requested that DOE reconsider its finding that the amended test procedure would have a "*de minimis* impact on the products' measured energy use" and instead find that the proposed test procedure amendment has a significant impact on measured electricity consumption. (Ingersoll Rand, No. 37 at p. 5)

Several commenters stated that the changes to AFUE caused by updating to ASHRAE 103–2007 would lead to additional testing burden. (Burnham, No. 35 at p. 3; Lennox, No. 32 at p. 2; AHRI, No. 36 at p. 4) AHRI stated that the change to use calculated values for  $t_{ON}$  and  $t_{OFF}$  will at a minimum require retesting for any step-modulating models at the reduced input rate and for many two stage models at both the maximum and reduced input rates. (AHRI, No. 36 at p. 4)

Given this expected test burden, Lochinvar argued that if DOE is to adopt ASHRAE 103–2007, DOE must declare in writing that products certified according to ASHRAE 103–1993 that were on the market prior to updating the test procedure are not required to be retested and recertified unless the design is changed in a way that affects efficiency. Lochinvar suggested that future audit tests of pre-existing products could still be conducted according to ASHRAE 103–2007 but that manufacturers should not be required to do new tests on existing models for certification reporting to DOE's Compliance Certification Management System (CCMS). (Lochinvar, No. 29 at p. 1)

Burnham also commented that their efforts to explore the impact of adoption of ASHRAE 103–2007 have been hampered by the lack of generally available, National Institute of Standards and Technology (NIST) validated software tools for calculating AFUE (and intermediate values) based on ASHRAE 103–2007. Burnham argued that the lack of software is a significant departure from past practice during comparable rulemakings. Burnham also asserted that this constituted a lack of transparency that would violate basic administrative law precepts and would be arbitrary and capricious. (Burnham, No. 35 at p. 3)

After considering these comments, DOE agrees that further evaluation is

modulating products, measurement of condensate under steady state conditions, electric consumption of components, and verification test for automatic means for adjusting the water temperature in boilers. DOE did not provide test results for ambient conditions or other testing for which no changes were proposed in the NOPR.

needed to determine the impact of adopting ASHRAE 103–2007 on the AFUE ratings of residential furnace and boiler models currently distributed in commerce. As a result, DOE does not adopt ASHRAE 103–2007 in this final rule. Instead, DOE retains the reference in the existing test procedure to ASHRAE 103–1993, both related to AFUE and  $E_{AE}$ . However, DOE believes ASHRAE 103–2007 better accounts for the operation of two-stage and modulating equipment and may further evaluate adoption of ASHRAE 103–2007, or a successor standard, in future rulemakings. In addition to retaining the reference to ASHRAE 103–1993, DOE revises the list of excluded ASHRAE 103–1993 sections to reflect test procedure amendments (as discussed in section III.D) and to more accurately identify the excluded sections.

DOE does not agree with Burnham's assertion that the lack of an automated software program implementing the equations presented in DOE's proposal hampered stakeholder's ability to comment on the practicability and the impact of the adoption of ASHRAE 103–2007. DOE does not endorse specific calculations tools commonly developed by industry or third-party test laboratories that automate the equations provided in DOE's regulations. Furthermore, DOE does not need to provide software for interested parties to be able to perform the calculations in proposed test procedure amendments and believes the simplified equations provided in the proposed rule can be easily implemented through a desktop-software calculation tool such as a commonly available spreadsheet application. Lastly, DOE disagrees with Burnham's assertion that the proposed rule was not sufficiently clear to provide an opportunity for interested parties to understand the proposal and provide meaningful comment because each of the equations utilized was presented in the regulatory text within the proposed rule in a step-by-step fashion.

#### D. Test Procedure Amendments

In response to the March 2015 NOPR, DOE received input on a variety of test procedure issues beyond incorporation of ASHRAE 103–2007, including: (1) Electrical power of additional components; (2) smoke stick test for determining use of minimum default draft factors; (3) measurement of condensate under steady-state conditions; (4) I&O manual reference and proposed clarifications when the I&O manual does not specify test setup; (5) specifying ductwork requirements for units that are installed without a return duct; (6) specifying testing

requirements for units with multi-position configurations; (7) AFUE reporting precision; (8) room ambient temperature and humidity ranges; (9) full-fuel-cycle (FFC) energy metrics in the AFUE test; (10) oversize factor values; (11) alternative methods for furnace and boiler efficiency determination; and (12) test method for combination appliances. DOE amends the test procedure for residential furnaces and boilers regarding issues (1)–(7), which are addressed in further detail below. Issues (8)–(12), for which DOE does not amend the test procedure in this final rule, are discussed in section III.E. DOE also received comments on the verification test for automatic means for adjusting water temperature, which are discussed in section III.H.1.

#### 1. Electrical Power of Components

In the January 2013 RFI and March 2015 NOPR, DOE noted that the specific method of electrical measurement prescribed in the existing DOE test procedure does not explicitly capture the electrical power associated with all auxiliary components. The method identifies PE as the electrical power used to operate the burner but only explicitly mentions measurements of the power supplied to the power burner motor, the ignition device, and the circulation water pump, but does not explicitly identify other devices that use power during the active mode, such as the gas valve, safety and operating controls, and a secondary pump for boilers (*i.e.*, boiler pump) used to maintain a minimum flow rate through the boiler heat exchanger, which is most typically associated with condensing boiler designs. 78 FR 675, 678; 80 FR 12876, 12882. In response to the January 2013 RFI, several stakeholders, including Lennox, Rheem, and AHRI, stated that manufacturers already measure all electrical power associated with the additional components DOE listed in the January 2013 RFI. (Lennox, No. 6 at p. 3; Rheem, No. 12 at p. 10; AHRI, No. 13 at p. 6) Therefore, to clarify which components are included in the power measurements, in the March 2015 NOPR DOE proposed to add two new terms to the calculations of the average annual auxiliary electrical energy consumption ( $E_{AE}$ ) to capture the electrical power of the boiler pump ( $BE_S$ ) and the gas valve and controls ( $E_O$ ), if present. DOE requested comment on these proposed amendments. 80 FR 12876, 12902.

AHRI expressed the view that the proposed changes over-complicate this issue and that the proposed measurements will change the

measurement of  $E_{AE}$ . AHRI stated that the typical gas burner will not operate unless both the ignition system and gas control (*e.g.*, automatic valves) are energized, which DOE acknowledges by including the power of the energized electric ignition device in the definition of PE. AHRI stated that the definition of PE should be clarified to include all electrical energy consumption that relates to the functions of igniting and operating the burner during the on cycle. (AHRI, No. 36 at p. 5)

Burnham supported DOE's proposal to measure all electrical consumption associated with operating the burner (PE), which should include the power consumption of any additional pump which is needed to provide adequate flow through the boiler itself without also providing significant flow through the heating system. (Burnham, No. 35 at p. 4)

Lochinvar stated that, in its experience, all electrical power consumption measurements made during an AFUE test are made at the power supply connection to the boiler and account for all auxiliary components. (Lochinvar, No. 29 at p. 2) Lochinvar stated that while the proposed change in the measurement of electrical consumption seems unnecessary, it does not object to the revision.

After reviewing the comments on the March 2015 NOPR, DOE agrees with the alternative approach suggested by AHRI to make explicit that all of the electrical energy provided to the burner is captured in the  $E_{AE}$  measurement. Rather than including the additional terms in the equation for  $E_{AE}$  as proposed in the NOPR, DOE clarifies the definition of PE to include all of the electrical power that relates to burner operation, including energizing the ignition system, controls, gas valve or oil control valve, and draft inducer, if applicable.<sup>7</sup> In addition, DOE agrees with Burnham that the electrical power of the boiler pump, if present, should be accounted for in the electrical measurements for boilers. Therefore, DOE further amends the definition of PE for boilers to include the electrical power of the boiler pump. In cases where the boiler pump power might not be captured in the electrical power measurement because it is not operating at that time, DOE will require the nameplate power to be added to PE, and if nameplate power is not available, then manufacturers must include a

<sup>7</sup> The existing DOE test procedure states in section 10.4.1 that PE is the "burner electrical power input at full load steady-state operation, including electrical ignition device if energized, as defined in 9.1.2.2 of ASHRAE 103–1993."



default value of 0.13 kW. This is the same as the current default value for a circulating water pump, and DOE understands that the power of the boiler pump is similar to that of a typical circulating water pump. DOE revises sections 8.1, 8.2, and 10.4 of appendix N to subpart B of 10 CFR part 430 to reflect the clarification of the definition of PE.

The revised section 2 of appendix N defines the individual components that are measured as part of PE:

- Control means a device used to regulate the operation of a piece of equipment and the supply of fuel, electricity, air, or water.
- Draft inducer means a fan incorporated in the furnace or boiler that either draws or forces air into the combustion chamber.
- Gas valve means an automatic or semi-automatic device consisting essentially of a valve and operator that controls the gas supply to the burner(s) during normal operation of an appliance. The operator may be actuated by application of gas pressure on a flexible diaphragm, by electrical means, by mechanical means or by other means.
- Oil control valve means an automatically or manually operated device consisting of an oil valve for controlling the fuel supply to a burner to regulate burner input.
- Boiler pump means a pump installed on a boiler that maintains adequate water flow through the boiler heat exchanger and that is separate from the circulating water pump.

Although these definitions were not explicitly proposed in the NOPR, they provide additional clarity about the definition of PE, consistent with the proposal in the NOPR to improve the regulatory text to reflect that PE includes the electrical power of all auxiliary components.

Carrier noted that DOE in the past had held to the policy of not making changes that will negatively impact present ratings. The electrically-efficient furnaces ratio, known as “e”, will increase with the additional requirement, making some products lose their ENERGY STAR® qualification. Carrier stated that including additional electrical components along with the blower electrical consumption is equivalent to changing the ENERGY STAR qualifying standard without justifying the value. (Carrier, No. 34 at p. 4)

In response to Carrier’s concerns, DOE notes that the definition of PE has always been the electrical energy input to the burner and that the amendments adopted in this rule merely make explicit additional components that are

commonly incorporated into burners. Further, as noted in many other stakeholder comments, most manufacturers already measure the electrical power of all the auxiliary components that are listed in the revised definition of PE. Therefore, clarifying the additional components in the definition of PE will not affect ENERGY STAR ratings for most furnaces. Furthermore, the clarification of the definition of PE ensures more accurate and consistent reporting of energy consumption in the residential furnaces and boilers market.

Weil-McLain stated that the new electrical testing requirements would not allow the manufacturer to interpolate results from tests because the electrical load will not scale in the same manner as other aspects of a boiler. This means hundreds of new tests will need to be run, imposing substantial cost and burden. (Weil-McLain, No. 31 at p. 6)

In response to Weil-McLain’s comment, DOE notes that only cast iron sectional boilers may be certified based on linear interpolation, as specified in 10 CFR 429.18(b)(3). As stated previously, the amendment of the definition of PE will not impose additional burden because it does not change the definition but merely clarifies the components included in measurement of PE. In addition, DOE’s understanding is that cast iron sectional boilers are typically non-condensing models that do not have boiler pumps.

Burnham recommended that DOE provide regulatory provisions to ensure that electrical consumption is measured with the controls normally shipped with the boiler. Such provisions are required because in many cases it is impossible to perform the AFUE test using controls having an automatic means of adjusting water temperature, making replacement of the standard controls during the AFUE test mandatory. (Burnham, No. 35 at p. 4) DOE notes that the electrical power measurement during the steady-state test does not account for electrical power outside of normal steady-state operation. Therefore, any controls operation outside of the steady-state test, such as automatic means for adjusting water temperature, are not included in the electrical power measurement.

## 2. Smoke Stick Test for Determining Use of Minimum Default Off-Cycle and Power Burner Draft Factors

In the March 2015 NOPR, DOE proposed to leave the default draft factor values for furnaces and boilers unchanged from the existing text procedure. 80 FR 12876, 12885. DOE

did not receive any comments on this issue, and does not amend the default draft factor values for this final rule.

In addition, to determine if a unit has no measureable airflow through the heat exchanger such that manufacturers may use the minimum default draft factors, DOE proposed in the March 2015 NOPR to incorporate a test based on the use of a smoke stick to establish the absence of flow through the heat exchanger. DOE requested input on whether, in addition to the proposed smoke stick test, other options exist for indicating the absence of flow through the heat exchanger. 80 FR 12876, 12902.

Lochinvar stated that it appreciates and supports the DOE’s affirmation of the use of smoke for visual determination of no-flow conditions in the vent. (Lochinvar, No. 29 at p. 4) Similarly, Rheem stated that although the proposed procedure is not quantitative, it is more definitive than “absolutely no chance of airflow through the combustion chamber and heat exchanger when the burner is off.” (Rheem, No. 30 at p. 3)

Ingersoll Rand and Carrier stated that the proposed procedure requires a detailed definition of the “smoke stick device” and test method to be created and made available. (Ingersoll Rand, No. 37 at p. 5; Carrier, No. 34 at p. 5) Ingersoll Rand stated that the test method and materials to be used need to be explicitly documented to ensure that all test labs generate repeatable and reproducible test results. (Ingersoll Rand, No. 37 at p. 5) Carrier also requested additional information as to where smoke sticks can be obtained commercially. (Carrier, No. 34 at p. 5)

DOE agrees with Rheem that the test procedure is not quantitative; however, the purpose of the test is to provide a visual assessment of no airflow, not a quantitative measure of airflow. Regarding the Ingersoll Rand and Carrier request to provide a detailed definition of the smoke stick device, DOE notes that smoke sticks are commercially available and routinely used for visualization purposes, and DOE does not endorse a specific type of smoke stick device. In addition, DOE believes that the exact amount of smoke produced by the smoke stick is not essential to the reproducibility of the results.

Ingersoll Rand expressed concern about air flow in the lab and if manufacturers can fix their venting such that air does not flow through it. (Ingersoll Rand, Public Meeting Transcript, No. 23 at p. 117) Similarly, Carrier requested DOE to add clarification to the procedure to ensure that the smoke stick is not affected by



the ventilation system when used. Carrier also expressed concern about the use of a smoke-generating device in a lab area that is not appropriately ventilated. (Carrier, No. 34 at p. 5)

In response to Ingersoll Rand, DOE already specified that all air currents and drafts be minimized for the smoke stick test in the March 2015 NOPR. For this final rule, DOE explicitly states that ventilation should be turned off if the test area is mechanically ventilated, and to minimize air currents if there is no mechanical ventilation. To address Carrier's safety concerns, DOE clarifies that the smoke produced by the smoke stick must be non-toxic to the test personnel. DOE is confident that the smoke stick test as proposed in the NOPR and modified based on the clarifications recommended by stakeholders will ensure repeatable and reproducible test results. Therefore, DOE adopts the modified optional smoke stick test to determine the absence of flow through the heat exchanger.

In the March 2015 NOPR, DOE also proposed to include revisions to the requirements of sections 8.8.3 and 9.10 of ASHRAE 103–2007 to accommodate the use of the smoke stick test, and, to reduce redundancy, to eliminate use of the term “absolutely” from “absolutely no chance of airflow” in sections 8.8.3 and 9.7.4 of ASHRAE 103–2007. 80 FR 12876, 12902. DOE received no comment on these proposals. Even though DOE has decided not to adopt ASHRAE 103–2007 and instead retain reference to ASHRAE 103–1993, the relevant sections do not differ between the two versions. Therefore, DOE is adding sections 7.10 and 8.10 to appendix N and revising sections 10.2 and 10.3 of appendix N to accommodate the use of the smoke stick test and is eliminating the use of the term “absolutely” from “absolutely no chance of airflow” in sections 8.8.3 and 9.7.4 of ASHRAE 103–1993 (included as sections 7.10 and 8.9 of appendix N) for determining the use of the minimum default draft factors.

### 3. Condensate Collection During the Establishment of Steady State Conditions

In the March 2015 NOPR, DOE proposed to allow for the condensate mass to be measured during the establishment of steady-state conditions, rather than after steady-state has been achieved. 80 FR 12876, 12881. Section 9.2 of ASHRAE 103–1993 requires that the measurement of condensate shall be conducted during the 30-minute period after steady-state conditions have been established. For the March 2015 NOPR,

DOE investigated the difference in condensate mass collected and the rate of condensate production during the two separate periods (*i.e.*, during the establishment of steady-state conditions and after steady-state conditions have been reached) and determined that there is no significant difference in the mass of condensate collected or the rate of condensate production during the two separate timeframes.

In response to the March 2015 NOPR, Lennox, Lochinvar and AHRI stated their support for the allowance to measure condensate during the establishment of steady-state conditions. (Lochinvar, No. 29 at p. 2; Lennox, No. 32 at p. 3; AHRI, No. 36 at p.5; Ingersoll Rand, No. 37 at p. 5) However, Lennox, AHRI and Ingersoll Rand each noted that to avoid an unintended consequence of causing manufacturers to retest existing models, this change should be clearly identified as an option to the current procedure. (Lennox, No. 32 at p. 3; Lennox, No. 32 at p. 3; AHRI, No. 36 at p.5; Ingersoll Rand, No. 37 at p. 5) Carrier also agreed that the condensate collection can be done during the steady state period, so long as clarification is added to prevent testing with dry heat exchangers. (Carrier, No. 34 at p. 4)

On the other hand, Rheem did not support allowing the measurement of condensate during the establishment of steady state conditions. (Rheem, No. 30 at p.1) Rheem argued that condensate measurements have a significant impact on the final calculated AFUE value and that additional variation in the condensate measurement procedure will add variation to the test procedure. Rheem believes that the time spent to establish steady-state conditions is worthwhile and should not be eliminated. (Rheem, No. 30 at p.1)

DOE understands commenters' concerns regarding the test burden associated with the need to retest existing models to the new test procedure. Therefore, DOE has made the ability to measure condensate during the establishment of steady-state conditions an option, not a requirement. This change is incorporated in section 8.4 of appendix N.

In response to Rheem, DOE notes that test data indicate a similar rate of condensate mass production in both the establishment of steady-state, and measurement of condensate test intervals. Therefore, DOE does not expect any impact on AFUE to result from the allowance of this optional procedure.

### 4. Installation and Operation Manual Reference

The existing DOE test procedure language, which refers in some locations to “manufacturer recommendations” or “manufacturer instructions”, can lead to the use of ad hoc instructions derived solely for testing purposes. To clarify the test procedure language, DOE proposed in the March 2015 NOPR that testing recommendations should be drawn from each product's I&O manual. DOE also provided alternate instructions if the I&O manual did not contain the necessary testing recommendations. 80 FR 12876, 12883. Lastly, in the March 2015 NOPR, DOE proposed to require manufacturers to request a test procedure waiver from DOE when the DOE test procedure provisions and I&O manuals are not sufficient for testing a furnace or boiler. *Id.* These proposals, comments received, and responses are discussed in the following sub-sections.

#### a. Reference to I&O Manual

DOE did not receive any comments objecting to reference the manufacturer's I&O manuals instead of “manufacturer's instructions” or “manufacturer's recommendations.” Therefore, DOE replaces all references to “manufacturer's instructions” or “manufacturer's recommendations” in ASHRAE 103–1993 with “I&O manual” in appendix N.<sup>8</sup> However, in response to the March 2015 NOPR, Burnham suggested revising the definition of I&O manual in section 2.7 because many oil boilers do not carry a safety listing as a packaged unit; rather, they are comprised of separately listed components. (Burnham, No. 35 at p. 5) DOE agrees with Burnham that some boilers do not carry safety listings as packaged units and thus excludes the reference to the product's safety listing in the adopted definition of I&O manual in section 2 of appendix N.

#### b. Proposed Specific Instructions for Adjusting Combustion Airflow

In the NOPR, DOE proposed specific instructions for adjusting combustion airflow to achieve an excess air ratio, flue O<sub>2</sub> percentage, or flue CO<sub>2</sub> percentage to within the middle 30th percentile of the acceptable range specified in the I&O manual. AHRI stated that the specification of “the 30th percentile of the acceptable range” is confusing. The 30th percentile is a

<sup>8</sup> DOE replaced references in sections 7.1, 7.2.2.2, 7.2.2.5, 7.2.3.1, 7.8, 8.2.1.3, 8.3.3.1, 8.4.1.1, 8.4.1.1.2, 8.4.1.2, 8.4.2.1.4, 8.4.2.1.6, 8.7.2, and 9.5.1.1 of ASHRAE 103–1993 with sections 6.1, 6.2, 6.3, 6.4, 6.5, 7.1, 7.2, 7.3, 7.4, 7.5, 7.6, 7.7, 7.9, and 8.5 of appendix N, respectively.

single value so it is not clear what is meant by “the middle of the 30th percentile.” (AHRI, No. 36 at p. 3) Ingersoll Rand stated that the proposed burner adjustments are more restrictive than both the current test procedure and the specifications found in ASHRAE Standard 103–2007. (Ingersoll Rand, No. 37 at p. 6) Burnham stated that while it supports DOE’s effort to more closely tie air fuel ratio used during the test with what can be expected in the field, DOE needs to recognize that the industry practice has been to use the CO<sub>2</sub> at the top end of the range (or in some cases even higher) in the I&O manual. (Burnham, No. 35 at p. 4) Lochinvar objected to the proposed changes, stating that forcing boiler manufacturers to test at the maximum input rate and the middle air-fuel ratio is not typical of field installations, is inconsistent with past rating methods, and will force manufacturers to rerate boilers based on this test procedure change. Lochinvar suggested adopting language from section 5.3 of AHRI Standard 1500, which uses the CO<sub>2</sub> at the top of the manufacturer’s specified range, to provide improved clarity and specificity regarding the air-fuel adjustment and to be more consistent with current industry practice, with much less potential to force manufacturers to retest and rerate existing products.<sup>9</sup> (Lochinvar, No. 29 at pp. 2–3)

Lennox, AHRI, and Burnham noted that the proposed adjustment of the CO<sub>2</sub> percentage on gas- and oil-fired boilers would significantly affect AFUE. (Lennox, No. 32 at p. 3; AHRI, No. 36 at pp. 3–4; Burnham, No. 35 at pp. 2, 4) AHRI stated that the results of the testing of three residential boilers that it conducted at Intertek Testing Laboratories indicate that the proposed revised burner setup requirements change AFUE by 0.3 percent for each 1 percent difference in the CO<sub>2</sub> values. (AHRI, No. 36 at pp. 3–4) Burnham stated that based on test data that it provided, for an oil-fired hot water boiler with an 11.5 to 12.5 percent CO<sub>2</sub> adjustment range in the I&O manual, DOE’s proposed adjustment would reduce AFUE by as much as 1.0 percent compared to the rating under the existing test procedure. (Burnham, No. 35 at p. 2) Burnham stated that the proposed change to the requirements for adjusting CO<sub>2</sub> will have a significant impact on the existing ratings for many boilers, and that DOE needs to take this into account when evaluating the burden imposed by this rule, as well as

promulgating the parallel residential boiler standards rulemaking currently underway. (Burnham, No. 35 at p. 4)

Carrier, Ingersoll Rand, and Rheem stated that most modern furnaces do not have the capability to make combustion air adjustments because the practice of including primary air shutters is no longer widely used on modern gas furnaces with fan-assisted or power burners. (Carrier, No. 34 at pp. 3–4; Ingersoll Rand, No. 37 at p. 6; Rheem No. 30 at p. 3) AHRI and Burnham also stated that for many gas furnaces and boilers that use atmospheric burners or other equipment with no means of adjusting CO<sub>2</sub> in the field, these adjustments to the excess air ratio cannot be made. (AHRI, No. 36 at p. 3, Burnham, No. 35 at p. 4) Carrier, Ingersoll Rand, and Burnham stated that DOE needs to exclude from these requirements burners that have no capability to make combustion air adjustments. (Carrier, No. 34 at pp. 3–4; Ingersoll Rand, No. 37 at p. 6; Burnham, No. 35 at p. 4)

Burnham stated that some type of tolerance is needed for adjusting CO<sub>2</sub> when the I&O manual provides only a single or maximum value, as opposed to a range. To address this issue, Burnham suggested adopting the language in section 5.3 of AHRI Standard 1500, which essentially sets a fixed tolerance of  $\pm 0.1$  percent and uses the CO<sub>2</sub> at the top, as opposed to the middle, of the manufacturer’s specified range.<sup>10</sup> (Burnham, No. 35 at p. 4)

After reviewing stakeholders’ comments on the specific instructions for adjusting combustion airflow, DOE concurs that further study is needed to determine the impact on AFUE of the CO<sub>2</sub> percentage proposed in the March 2015 NOPR and the AHRI 1500 requirements suggested by certain stakeholders. As such, for this final rule, DOE does not adopt the specific instructions for adjusting combustion airflow to achieve an excess air ratio, flue O<sub>2</sub> percentage, or flue CO<sub>2</sub> percentage to within the middle 30th percentile of the acceptable range specified in the I&O manual. Instead, in sections 7.3 and 7.5 of appendix N, DOE retains the instructions in accordance with ASHRAE 103–1993 section 8.4.1.1 for gas burners to set the primary air shutters to give a good flame with no deposit of carbon during the test procedure, and section 8.4.1.2 for oil burners to give a CO<sub>2</sub> reading as specified in the I&O manual and an hourly Btu input within  $\pm 2\%$  of the

normal hourly Btu input rating as specified in the I&O manual. DOE understands from stakeholder comments that the instructions in the existing test procedure to adjust the primary air shutters for gas units are not applicable to many modern furnaces and boilers. However, DOE has determined that further investigation is required before amending these test procedure requirements.

#### c. Waiver Process for Additional Test Instructions

In response to DOE’s proposal that manufacturers request a test procedure waiver from DOE when the DOE test procedure provisions and I&O manuals are not sufficient for testing a furnace or boiler, Burnham stated that the proposed waiver process is unduly burdensome, given the use of increasingly complex control and burner systems. To reduce the frequency with which waivers are required, Burnham suggested that DOE adopt a repository for “special test instructions” similar to that which DOE currently has in place for commercial boilers. (Burnham, No. 35 at p. 5) Lennox and AHRI similarly stated that if DOE is concerned about the situation where the manufacturer does not provide any recommended settings in the I&O manual, DOE should allow manufacturer to provide information on unit setup for testing as part of the certification report as is done for commercial and industrial equipment. (Lennox, No. 32 at p. 3; AHRI, No. 36 at pp. 4, 6)

In response to stakeholders’ comments, DOE notes that manufacturers have control over what information is specified in the I&O manual. Furthermore, the test procedure provides defaults for most requirements that are based on the I&O manual. As such, DOE believes the instructions given in the test procedure and I&O manuals should be sufficient for testing in most cases. Therefore, DOE is not amending its certification provisions to permit manufacturers to report test-specific instructions as supplemental information in cases where the I&O manual does not provide instructions, and is implementing the requirement to request a waiver in section 6.1.a of appendix N. DOE also notes that the waiver procedure provides a feedback loop by which DOE learns of issues manufacturers are encountering with the test procedure and yields amendments to the test procedure through rulemaking to address those issues.

<sup>9</sup> AHRI Standard 1500 is available at <http://ahrinet.org/site/686/Standards/HVACR-Industry-Standards/Search-Standards>.

<sup>10</sup> AHRI Standard 1500 is available at <http://ahrinet.org/site/686/Standards/HVACR-Industry-Standards/Search-Standards>.

##### 5. Duct Work for Units That Are Installed Without a Return Duct

In the March 2015 NOPR, DOE proposed to add a provision in the test procedure clarifying that the return (inlet) duct is not required during testing for units that, according to the I&O manual, are intended to be installed without a return duct. 80 FR 12876, 12902–12903.

In response, Rheem, Carrier, and Ingersoll Rand agreed that a unit that is intended to be installed without a return duct should be tested without a return duct. (Rheem, No. 30 at p. 3; Carrier, No. 34 at p. 6; Ingersoll Rand, No. 37 at p. 5) In addition, Carrier recommended that DOE adopt figure 2 in exhibit 1 of Carrier's comment, which clarifies the use of a return duct for gas furnaces. (Carrier, No. 34 at p. 6)

DOE agrees with stakeholders and adopts the amendment clarifying that units intended to be installed without a return duct are not required to use the return (inlet) duct during testing. After reviewing the figure provided by Carrier, DOE believes that the language is sufficient and an additional figure is unnecessary.

##### 6. Testing Requirements for Multi-Position Configurations

In the March 2015 NOPR, DOE proposed to require that multi-position furnaces be tested using the least-efficient position.<sup>11</sup> DOE also proposed to explicitly allow manufacturers to test multi-position furnaces in other configurations and report the AFUE ratings for each position. 80 FR 12876, 12886.

In response, AHRI stated that they believe that manufacturers already test in the least-efficient configuration. (AHRI, Public Meeting Transcript, No. 23 at p. 123)

Carrier stated that in the past, it has tested and displayed the AFUE by orientation of installation; however, it no longer does so because the multiple ratings by position did not give customers any benefit. Because the setup requirements of the DOE test procedure already cause furnaces to operate at the lowest efficiency, thus making AFUE ratings conservative for the average installation, Carrier recommended that DOE drop the requirement to test in all positions and simplify the testing to be in the most commonly installed position of the furnace. If DOE were to require testing in all positions, Carrier proposed an

alternative to allow single rating that is weighted based on percent of applications by configuration and installation location to reduce sample testing burden and not confuse consumers with excess information. (Carrier, No. 34 at pp. 6–8)

Lennox disagreed with the testing requirements in multiple configurations because of the increased test burden and lack of improved test accuracy. (Lennox, No. 32 at pp. 3–4)

In response to Carrier's and Lennox's concerns about increased test burden if required to test in all configurations, DOE clarifies that in the March 2015 NOPR, DOE did not propose to require manufacturers to test in all positions, but rather to require testing only in the least efficient configuration while explicitly allowing manufacturers to test in multiple configurations if they wish. DOE notes that, as stated by AHRI, it is already common industry practice to test in the least efficient configuration; accordingly, DOE anticipates that there will be no additional test burden from the clarification to require testing in the least efficient configuration. Regarding Carrier's suggestion to test in the dominant installed position, DOE believes that testing in the least efficient position will provide ratings that are more comparable between different models because the dominant position may not be the least efficient configuration and may vary among models and among manufacturers. DOE believes that Carrier's suggestion of a weighted rating is not practicable because DOE is not requiring manufacturers to test in all configurations, only the least efficient one. Therefore, in section 6.1.b of appendix N and in 10 CFR 429.18, DOE amends its regulations to require testing and rating only in the least efficient configuration, while still allowing manufacturers the ability to test and rate in multiple configurations. In addition, DOE includes a definition for multi-position furnace in section 2 of appendix N.

In the March 2015 NOPR, DOE also proposed to allow testing of units configured for multiple position installations to use the blower access door as an option instead of one of the inlet openings. 80 FR 12876, 12886 (March 11, 2015). In response, Rheem stated that a furnace should not be tested in a configuration that is prohibited by the installation manual. For example, Rheem stated that its furnace installation manuals allow only bottom and side returns. A rear return and a return in place of the blower access door are not allowed. (Rheem, No. 30 at p. 4) Ingersoll Rand stated that

testing of multi-position units using the blower access door may not be feasible option for some furnaces, and the manufacturer should state whether this is an acceptable test method for the furnace model. (Ingersoll Rand, No. 37 at p. 6)

DOE agrees with Rheem and Ingersoll Rand that units should not be required to be tested using the blower access door if not allowed in the I&O manual or if not feasible. In an effort to ensure consistent and appropriate testing, DOE withdraws its proposal that would have explicitly allowed the use of the blower access door for testing of multi-position furnaces and boilers that are not shipped with an open inlet.

##### 7. AFUE Reporting Precision

DOE's existing furnaces and boilers test procedure specifies that the AFUE rating be rounded to the nearest whole percentage point. 10 CFR 430.23(n)(2). In the March 2015 NOPR, DOE sought comment on its proposal to report AFUE to the nearest tenth of a percentage point. 80 FR 12876, 12902.

AHRI, Lochinvar, Lennox, and Burnham support reporting of AFUE to the nearest tenth of a percentage point and noted that it reflects the current practice. (AHRI, No. 36 at p. 6; Lochinvar, No. 29 at p. 4; Lennox, No. 32 at p. 3; Burnham, No. 35 at p. 6) However, Burnham does not agree with the proposal to round to the nearest 0.1 percent, stating that it would be a direct violation of 10 CFR 429.18(a)(2)(i)(B) requiring any representative value of AFUE for which consumers would favor higher values to be less than or equal to the lower of the mean of the sample or the lower 97.5 percent confidence limit (LCL) of the true mean divided by 0.95. Burnham stated that rounding up would allow the representative value to potentially be higher than allowed by calculation mentioned. Burnham urged DOE to prescribe the current industry practice of truncating to 0.1 percent. (Burnham, No. 35 at pp. 6–7)

In contrast, Rheem stated that rating furnaces to the nearest tenth of a percentage point will give consumers the impression that one furnace is more efficient than another, while in actuality, the test procedure tolerances do not result in the proposed level of precision that should be required to support reporting AFUE to the nearest tenth of a percentage point. (Rheem, No. 30 at p. 3)

Ingersoll Rand stated that while DOE's CCMS can accommodate reporting AFUE to this level, any manufacturer that reports AFUE to the whole percentage point will have to submit new certification reports and

<sup>11</sup> A multi-position furnace is a furnace that can be installed in more than one airflow configuration (e.g., upflow or horizontal; downflow or horizontal; and upflow, downflow or horizontal).

relabel products. Ingersoll Rand stated that having to submit new certification reports and relabel products will cause an administrative burden and cost to manufacturers that was not addressed in the March 2015 NOPR. Ingersoll Rand requested that DOE consider setting the effective date of this requirement to coincide with the effective date of any amended energy conservation standard adopted under the March 12, 2015 energy conservation standards NOPR for residential furnaces. (Ingersoll Rand, No. 37 at p. 6)

AHRI stated that it reports to the nearest tenth to DOE for furnaces but not for boilers due to Environmental Protection Agency (EPA) and ENERGY STAR requirements. (AHRI, Public Meeting Transcript, No. 19 at p. 89) Burnham urged DOE to work with the EPA to simultaneously update the ENERGY STAR requirement of rounding to the nearest whole percentage point to avoid conflicting values on the DOE and ENERGY STAR Web sites. (Burnham, No. 35 at p. 7)

DOE understands that reporting AFUE values to the nearest tenth of a percentage point is currently industry practice. Based on 10 CFR 429.18(a)(2)(i)(B), DOE agrees with Burnham that AFUE should be truncated to the tenth of a percentage point. In response to Rheem's comment about the test procedure tolerances, DOE notes that in response to the January 2013 RFI, Rheem stated that this level of precision has been demonstrated to be statistically possible. (Rheem, No. 12 at p. 9). DOE also observes that Rheem, as well as many other manufacturers, reports AFUE to the tenth of a percentage point in DOE's Compliance Certification Database and the AHRI directory for some models. In response to Ingersoll Rand's comments, DOE notes that AHRI's certification directories for both furnaces and boilers as well as DOE's Compliance Certification Database already allow manufacturers to report AFUE to the nearest tenth of a percentage point. Therefore, DOE anticipates this clarification will not require changing the reported efficiency in manufacturer literature, nor will it cause significant manufacturer burden. Furthermore, in response to AHRI and Burnham, DOE notes that EPA must use the method of test, sampling plan, and representation requirements adopted by DOE. DOE will work with EPA to make sure the language in its specification is harmonized with federal regulations. Accordingly, DOE updates the existing requirement for residential furnaces and boilers in 10 CFR 430.23(n)(2) to truncate AFUE to the tenth of a

percentage point. DOE also clarifies in 10 CFR 429.18 that the represented value of AFUE based on the tested sample must be truncated to the tenth of a percentage point.

#### 8. Definitions and Other Changes

In this final rule, DOE revises the term "seasonal off switch" to "off switch" and revises the definitions of "off mode" and "standby mode" in section 2 of appendix N to reflect the updated definitions found in the second edition of IEC 62301, which was incorporated by reference in the December 2012 final rule. DOE also revises sections 8.1, 8.2, and 8.4 of the existing appendix N (sections 8.3, 8.5, and 8.7 of the amended appendix N) to clarify and improve the test instructions. DOE also revises sections 10.4, 10.5, 10.6, 10.7.3, 10.9, 10.9.1, and 10.11 of appendix N to improve grammar and consistency in formatting throughout the test procedure, and to include missing variable definitions. In addition, DOE incorporates the previously excluded section 9.7.1 of ASHRAE 103-1993 to include instructions on the setup of the tracer gas test. DOE updates the definition of "isolated combustion system" in section 2.5 of the existing appendix N (2.8 of the amended appendix N) to reflect the updated definition in ASHRAE 103-2007. Finally, DOE modifies section 8.3 of the existing appendix N (8.6 of the amended appendix N) to clarify that the referenced time delay is the blower delay  $t^*$ . DOE did not receive comment on any of these revisions where proposed in the NOPR.

#### E. Other Test Procedure Considerations

##### 1. Room Ambient Air Temperature and Humidity Ranges

In the March 2015 NOPR, DOE proposed not to change the test procedure regarding room ambient temperature and humidity conditions, neither by mathematical correction nor by limiting the existing ambient condition range, and requested input on this approach. 80 FR 12876, 12889.

Lochinvar and Lennox stated their support for DOE's proposal not to further restrict the ambient conditions due to the additional test burden it would cause. (Lochinvar, No. 29 at p. 4; Lennox, No. 32 at p. 4) Rheem stated that they believe that the ambient conditions range requires further study. Rheem noted that the room ambient air temperature and humidity ranges were developed based on 30-year-old laboratory conditions and that laboratory conditions may be more carefully controlled today compared to

the long past. (Rheem, No. 30 at p.1) AHRI noted that the new edition of ASHRAE-103-2016 will be issued for public review and one of the proposed amendments is to include changes to the definition of room ambient air operating conditions. (AHRI, No. 36 at p. 5)

Burnham stated that they disagree with DOE's assertion in the March 2015 NOPR that relative humidity (RH) has a minimal impact on the AFUE of condensing boilers and stated that the issue should be revisited. Burnham provided test data of a condensing boiler which shows a swing in AFUE of approximately 1.3 percent when the RH was changed from approximately 30 percent to 70 percent. Burnham stated that they expect the variation in AFUE as a function of RH to be at least as large for boilers as it is for furnaces. Burnham noted that the flue temperature of boilers is closely linked to the return water temperature during the test (120 °F), which is close to the typical dew point of natural gas flue products. Changes in RH may therefore have a large impact on where the temperature of the flue products falls below the dew point as they pass through the heat exchanger. Burnham stated that if ambient conditions have a significant impact on AFUE, DOE should tighten the tolerance for RH to conditions likely to be seen in the field, even if this results in an increased burden for manufacturers in the form of requiring conditioned lab facilities. (Burnham, No. 35 at p. 7)

DOE agrees with Rheem and Burnham that the impact of ambient conditions on AFUE warrants further study. However, at this time DOE does not have adequate data to justify the testing burden associated with the narrowing of ambient conditions. Therefore, DOE maintains the ambient conditions specified in the current test procedure.

##### 2. Full-Fuel-Cycle Energy Metrics

In the March 2015 NOPR, DOE stated that the test procedure rulemaking was not the appropriate vehicle for deriving an FFC energy descriptor for furnaces (and other products). Specifically, DOE noted that if a secondary FFC energy descriptor were included as part of the furnace and boiler test procedure, DOE would need to update the test procedure annually. DOE indicated its intent to estimate FFC energy savings in future energy conservation standards rulemakings for furnaces, and to take those savings into account in proposing and selecting amended standards. 80 FR 12876, 12896.

In response to the NOPR, AGA expressed their disagreement with

DOE's position, stating that the test procedure develops the energy efficiency rating for the product and is specifically the correct vehicle to be used for determining the FFC energy descriptor. AGA added that all that is needed is a mathematical adjustment to the site-based energy descriptor now determined by the test procedure. AGA requested that the Department reconsider its decision not to include provisions for an FFC energy descriptor and incorporate one in the test procedures for residential boilers and furnaces. (AGA, No. 27 at p. 3)

DOE maintains its position outlined in the NOPR that it does not believe that a mathematical adjustment to the test procedure to account for FFC is appropriate. As noted in the March 2015 NOPR, the mathematical adjustment to the site-based energy descriptor relies on information that is updated annually. If DOE were to include such an adjustment to the test procedure, DOE would be required to update the test procedure annually.

### 3. Oversize Factor Value

In the March 2015 NOPR, DOE proposed to maintain the existing oversize factor of 0.7 and sought comment on the appropriateness of this strategy.<sup>12</sup> 80 FR 12876, 12891.

Rheem stated that replacement furnaces are more likely to be oversized than a new construction furnace because the unit may not be resized when it is replaced with a more efficient unit. Rheem also noted that it is more likely for a furnace to be oversized in a climate with high variation in outdoor temperature, or if it is installed in an area with high airflow requirements for the cooling load. (Rheem, No. 30 at p. 4)

DOE agrees with Rheem that a variety of factors, including construction type and climate, may influence the magnitude of oversizing that occurs in a given installation. DOE did not receive any data supporting a change to the existing oversize factor of 0.7. DOE has determined the existing value of 0.7 continues to be representative of the oversized factor applicable to the average U.S. household and therefore maintains that value.

<sup>12</sup> The "oversize factor" accounts for the national average oversizing of equipment that occurs when a heating product is sized to satisfy more than the heating load of the household. This is typically done to size the equipment so that it is able to satisfy the days in which the house heating requirements might be exceeded and/or to take into account uncertainties regarding house heating load. For example, a 0.7 oversize factor is equivalent to 170-percent oversizing of the heating equipment (*i.e.*, 70 percent greater input capacity than is required).

### 4. Alternative Methods for Furnace/Boiler Efficiency Determination

In response to the March 2015 NOPR, Carrier questioned the need for a test method as precise as ASHRAE 103 due to the advances that have been made in reducing cyclical losses. Carrier noted that the difference between steady state efficiency and cyclical AFUE is less than 1 percent across all model types. Carrier suggested that DOE change the AFUE metric for forced-air furnaces to be based on the steady-state operation. (Carrier, No. 34 at p. 2) Carrier stated that this would simplify the test procedure and relieve significant burden from manufacturers. Carrier stated that the lab setup of gas furnaces during AFUE testing—including vent length, isolated combustion system (ICS) installation, off cycle times, and blower off delay time—rarely replicates the actual installation of condensing gas furnaces. (Carrier, No. 34 at p. 2)

DOE agrees that there have been significant advances in the minimization of cyclical losses since the inception of the AFUE metric. However, including cyclical losses, which are captured in the AFUE metric, still provides market differentiation for models that would yield the same steady-state values. Furthermore, DOE believes that the inclusion of cyclical losses in the AFUE metric has contributed to the increases in efficiency noted by Carrier. For these reasons, DOE declines to limit the calculation of AFUE to steady-state operation. DOE would be willing to work with industry to investigate this further to see if moving to a steady-state methodology has merit and meets the requirements of the statute.

### 5. Test Method for Combination Appliance

In the March 2015 NOPR, DOE discussed the possibility of creating a test procedure for determining the efficiency of combination products. Ultimately DOE did not propose to amend the test procedure to include a method of test for combination appliances choosing not to complicate the test procedure rulemaking. 80 FR 12876, 12894.

In response to the NOPR, Ingersoll Rand believes that EPCA anticipated products being capable of serving more than one function and expects DOE to set separate energy efficiency metrics for each major function. Ingersoll Rand noted that EPCA authorizes DOE to "set more than 1 energy conservation standard for each major function." (42 U.S.C. 6295(o)(5)) Ingersoll Rand suggested that establishing a

combination metric and setting a standard for a combination unit is contrary to EPCA. (Ingersoll Rand, No. 37 at p. 6)

DOE did not propose a combination metric in the NOPR, and does not amend the test procedure to include such a metric in this final rule.

### F. Test Burden

EPCA requires that the test procedures DOE prescribes or amends be reasonably designed to produce test results that measure the energy efficiency, energy use, water use (in the case of showerheads, faucets, water closets, and urinals) or estimated annual operating cost of a covered product during a representative average use cycle or period of use. These procedures must also not be unduly burdensome to conduct. (42 U.S.C. 6293(b)(3))

In response to the March 2015 NOPR, Ingersoll Rand stated that the testing and reporting burden from the proposals would be far greater than the average 20 hours per response that DOE estimates. (Ingersoll Rand, No. 37 at p. 9) Weil-McLain expressed concerns that the cost of the proposed test is grossly underestimated and that cost analysis for all of the testing is fundamentally flawed and incomplete. Weil-McLain stated that a more appropriate estimate for the cost to re-test all models in DOE's example of average small boiler business with 70 basic models would be more than twenty times the estimate shown for various reasons, such as the cost of set up for each test, test re-runs if parameters are not met, test recording, and analysis time. In addition, Weil-McLain stated that: (1) Only the incremental cost related to the changes in procedure have been captured when in all likelihood all products will have to be retested through the entire test procedure; (2) at least two tests per model are required for data submittal; (3) initial certification and annual audits require an additional witness test by a third-party lab; (4) engineering, facility, or other charges were not captured; (5) third-party test agency fees were not considered; and (6) the time required to test the number of models for the manufacturer and third-party test agency capacity were not considered. Weil-McLain also stated that retesting and re-rating would take substantially longer than 180 days. (Weil-McLain, No. 31 at pp. 6–7) Ingersoll Rand stated that to retest all of its current models will require more than six months of lab time with a cost of over \$400,000. (Ingersoll Rand, No. 37 at p. 9)

Weil-McLain questioned why DOE would impose the burden of conducting all of the new tests on manufacturers

when DOE stated that the results from using new test procedures will not change when compared to current procedure. (Weil-McLain, No. 31 at p. 2)

Several stakeholders requested more time to conduct re-testing after the issuance of the final rule. Weil-McLain stated that the process of conducting all the tests, analyzing information, and conducting re-certification through the certified labs for hundreds of models cannot be completed within 180 days of when the final rule is issued. (Weil-McLain, No. 31 at p. 7) Similarly, Burnham expressed concern that it has found it impossible to thoroughly evaluate the impact of this NOPR, as it asserted that DOE provided only a short amount of time and inadequate information and resources during the rulemaking process. (Burnham, No. 35 at p. 8) Goodman stated that the industry needs at least 6 months to assess the impact of the new test procedure on existing basic models. (Goodman, No. 33 at p. 2)

Ingersoll Rand argued that the fact that many of the current models may be removed from the market as a result of the separate energy conservation standards rulemakings, Fan Energy Rating (FER) standard effective in 2019 and AFUE proposed standard effective in 2021, makes this retesting effort even more burdensome, unnecessary and wasteful. (Ingersoll Rand, No. 37 at p. 9) Carrier also stated that recent rulemakings, such as the standby power ruling and the recent legislation for furnace fans, have increased the test burden for gas furnace compliance compared to when the complicated AFUE procedure was formulated and first implemented. (Carrier, No. 34 at p. 3)

The many comments from manufacturers regarding re-testing of all models currently in distribution were responding to DOE's proposals to incorporate by reference ASHRAE 103–2007 and adjust the CO<sub>2</sub> percentage. Under the amended test procedure, DOE is not incorporating by reference ASHRAE 103–2007 or adjusting of the CO<sub>2</sub> percentage, and so manufacturers will not need to re-test their entire model line-up, thereby alleviating the concerns expressed by manufacturers. DOE has assessed the test burden of the revisions to the test procedure it is adopting in this final rule, and has concluded that manufacturers will experience no additional burden when performing the AFUE test.

DOE believes that the clarification of the electrical power term PE will not add any additional burden on manufacturers, since this is what has been required under the existing test

procedure. In terms of the boiler pump, DOE included a default value in case manufacturers are not currently capturing this component, which will minimize test burden.

Many manufacturers currently perform the tracer gas test to determine whether the minimum default draft factor of 0.05 may be used. DOE expects that, when establishing the absence of flow through the heat exchanger, the use of the smoke stick test will reduce the test burden to manufacturers by eliminating, in some cases, the need for the tracer gas test.

The optional provision allowing for the measurement of condensate during the establishment of steady-state conditions will provide manufacturers of condensing furnaces and boilers time and labor savings.

The inclusion of references to the I&O manual will provide additional guidance and clarity to the test procedure. It does not impose additional test burden since the information is already available in the manufacturers' literature.

The amendment of the duct work setup for units that are installed without a return duct and the requirement to test multi-position units in the least efficient position only clarify the testing requirements. The duct work setup change reflect current industry practice and does not introduce new testing requirements. With respect to the multi-position unit testing, most manufacturers indicated that the change reflects their understanding and current practice. DOE notes that, although the test method did not describe the position for testing as the "least efficient position," in practice, if following the existing method for setup, manufacturers should have tested the least efficient position or all testing configurations. DOE also notes that AHRI commented that this reflects the common practice of its members, which is to test in the least efficient position. (AHRI, Public Meeting Transcript, No. 23 at p. 123) Therefore, DOE expects that there would be no additional test burden associated with these revisions.

The requirement to report AFUE to be truncated to the tenth of a percentage point and the requirement to report whether a boiler uses a burner delay automatic means control strategy will not introduce any additional test burden because they do not require retesting; however, they may impose a cost on either boiler manufacturers or manufacturers who do not currently report AFUE to a tenth of a percentage point, who must submit new certification reports and relabel their

products. DOE discusses this burden in section IV.B.

For these reasons, DOE concludes that the amended test procedure will not be unduly burdensome to conduct.

#### G. Measured Energy Use

When DOE modifies test procedures, it must determine to what extent, if any, the new test procedure would alter the measured energy efficiency or energy use of any covered product. (42 U.S.C. 6293(e)(1)) In the NOPR, DOE stated that the one amendment that might alter the AFUE of covered products is the incorporation by reference of ASHRAE 103–2007. 80 FR 12876, 12897.

As discussed in section III.C, based on stakeholder comments, DOE has declined to incorporate by reference ASHRAE 103–2007 in this final rule. Therefore, the amended test procedure will not alter measured AFUE ratings.

As discussed in section III.D.1, certain stakeholders commented that the proposed revision in the NOPR regarding the method for determining the electrical power consumption would change the power measurements. In response to comments, for the Final Rule, DOE decided not to change the method for calculating the electrical consumption and only clarified the definition of the PE term. This clarification will not alter measured AFUE ratings.

As discussed in section III.D.3, certain stakeholders expressed concern that allowing the measurement of condensate during the establishment of steady state conditions would have an impact on the final calculated AFUE value. In response to comments, DOE clarified for the final rule that this is an option rather than a requirement. DOE has found through its testing as shown in the test data presented at the NOPR public meeting indicating both options produce a similar rate of condensate mass production and therefore would have a *de minimis* impact on measured AFUE ratings.

As discussed in section III.D.4.b, certain stakeholders expressed concern that the proposed adjustment of the CO<sub>2</sub> percentage on gas- and oil-fired boilers would significantly affect AFUE. In response to comments, DOE has declined to adopt this proposal for the final rule.

DOE received no comment regarding the impact of measured energy use on the remaining test procedure amendments, including the smoke stick test, duct work for units that are installed without a return duct, and testing requirements for multi-position configurations. The smoke stick test serves to verify a condition and does not

impact ratings. The requirements for units installed without a return duct and for multi-position configurations only clarify the testing requirements, and therefore will not impact measured energy use or efficiency.

For these reasons, DOE has determined that none of the adopted test procedure amendments would alter the projected measured energy efficiency or energy use of the covered products that are the subject of this rulemaking.

#### H. Certification and Enforcement

##### 1. Verification Test for Automatic Means for Adjusting the Water Temperature in Boilers

In 2008, DOE published a technical amendment to the 2007 energy conservation standards final rule for residential furnaces and boilers that added design requirements for boilers consistent with the provisions of EISA 2007, including mandating, starting September 1, 2012, that all gas, oil, and electric hot water boilers (excluding those equipped with a tankless domestic water heating coil) be equipped with automatic means for adjusting the boiler water temperature (“automatic means”) to ensure that an incremental change in inferred heat load produces a corresponding incremental change in the temperature of water supplied (codified at 42 U.S.C. 6295(f)(3)).<sup>13</sup> 73 FR 43611 (July 28, 2008). EISA 2007 further specifies that for single-stage hot water boilers, the automatic means requirement may be satisfied by incorporating controls that allow the burner or heating element to fire only when the automatic means has determined that the inferred heat load cannot be met by the residual heat of the water in the system. When there is no inferred heat load, the automatic means limits the temperature of the water in the boiler to not more than 140 °F.

The existing DOE residential furnace and boiler test procedure does not include any method of test for determining compliance with these design requirements. In the March 2015 NOPR, DOE proposed the introduction of a new test method for the verification of the automatic means for adjusting the water temperature in boilers. DOE proposed the use of two test methods—one for single-stage boilers and one for two-stage/modulating boilers—for verification of the functionality of the automatic means for adjusting the water

temperature supplied by a boiler. The proposed test methods were based on draft testing methodologies provided by Natural Resources Canada (NRCAN), as well as the California mechanical codes section for non-residential boilers.<sup>14</sup> The two separate tests were developed to accommodate various boiler control strategies, including outdoor reset, inferred load, and thermal pre-purge (*i.e.*, burner delay).<sup>15</sup> The proposed test methods, as would be specified in 10 CFR 429.134, would be intended for use by DOE for assessment and enforcement testing to determine if a given basic model complies with the applicable design requirements. Therefore, boiler manufacturers would not be required to conduct this testing. 80 FR 12876, 12902.

Several stakeholders commented on the lack of compliance criteria for the automatic means test. Burnham asserted that it is legally unacceptable for DOE to not specify any objective criteria for demonstrating compliance and that DOE does not have authority to unilaterally create criteria to determine compliance with the automatic means test without notice and comment. (Burnham, No. 35 at p. 6) Weil-McLain stated that it is not clear what this required test criteria or procedure would be, but that, once defined, this test will require more time and resources to complete. Weil-McLain also asserted that the new requirement is arbitrary and capricious because it is so indefinite. (Weil-McLain, No. 31 p. 8)

DOE’s automatic means design requirement does not specify how a manufacturer must implement the automatic means and does not provide compliance criteria for the automatic means testing. DOE interprets the design requirement established by EISA 2007 as intending to allow manufacturers flexibility when designing control strategies to meet the design requirement. DOE believes that the requirement of an incremental change in inferred heat load that produces a corresponding incremental change in the temperature of water supplied is a sufficient metric for evaluation of the functionality of an automatic means for adjusting water temperature. DOE designed the tests, as noted in the March 2015 NOPR, to confirm whether the boiler supply water temperature responds to a change in inferred heat

load without specifying to what degree the temperature must change or for how long that change is present because such detail is not required for meeting the design requirement. DOE also designed the test methods to accommodate technological advancements in controls and designs. For these reasons, DOE does not agree with Burnham and Weil-McLain that establishing further criteria or thresholds is required beyond the general requirements set forth in the 2008 technical amendment to the furnace and boiler final rule.

Lochinvar stated that while it supports the use of automatic means as an effective method of energy conservation, it opposes testing controls for compliance for the following reasons: (1) The lack of compliance threshold; (2) no guarantee of repeatability or consistency in test method or results; (3) difficulty in reasonably measuring the effectiveness of different designs; (4) test method may be biased for or against certain control methods; and (5) a published simulation-type test will lead to manufacturers designing automatic means for the test compliance.

(Lochinvar, No. 29 at p. 3) AHRI stated that the criterion to confirm the functioning of the means is too vague to be meaningful, and that DOE should not finalize this proposed procedure and not pursue further the concept of adding a test to verify the functioning of the automatic means. (AHRI, No. 36 at p. 6)

Several stakeholders commented on technical issues regarding the proposed test method. Lochinvar and Burnham stated that single-stage products may use options other than “thermal purge.” (Lochinvar, No. 29 at p. 3; Burnham, No. 35 at p. 6) Lochinvar stated that if DOE chooses to require automatic means testing, single-stage boilers must be allowed to comply by meeting either the proposed test method in § 429.134(e)(1) or (e)(2). (Lochinvar, No. 29 at p. 3)

Lochinvar also stated that DOE incorrectly states that the automatic means will change the heat output of a boiler in response to the inferred heat load. Responding to DOE’s proposal in the March 31, 2015 notice of proposed rulemaking for energy conservation standards for boilers (“March 2015 ECS Boiler NOPR”), Lochinvar asserted that the automatic means would change the temperature of the water supplied, not necessarily the heat output. (Lochinvar, No. 29 at p. 4)

Burnham argued that the water temperatures specified are too low to necessarily cause a burner delay. Also responding to the March 2015 ECS Boiler NOPR, Burnham suggested that the proposed 10 CFR

<sup>13</sup> The automatic means requirement excludes boilers that are manufactured to operate without any need for electricity. EISA 2007 also prohibited constant-burning pilot lights for gas-fired hot water boilers and gas-fired steam boilers. 73 FR 43611, 43613 (July 28, 2008).

<sup>14</sup> California Energy Commission, “Reference Appendices for the 2008 Building Energy Efficiency Standards for Residential and Non-residential Buildings”, p. 332, (Available at: <http://www.energy.ca.gov/2008publications/CEC-400-2008-004/CEC-400-2008-004-CMF.PDF>) (Last accessed January 16, 2015).

<sup>15</sup> See the March 2015 NOPR for further description of the different control strategies.



429.134(e)(1)(iii)(C) seems to imply that a delay will always be present.

However, Burnham asserted that EISA only requires that the automatic means delay ignition above 140 °F until it has determined that the inferred heat load cannot be met by the residual heat in the boiler. (Burnham, No. 35 at p. 6)

Burnham stated that the proposed 10 CFR 429.134(e)(2)(ii)(B)(1) specifies that the supply water temperature be maintained at “the lowest supply water temperature ( $\pm 4$  °F),” which may not be possible if the boiler’s minimum input is greater than the corresponding load, resulting in burner cycling. Burnham stated that a similar problem is possible in the proposed 10 CFR

429.134(e)(2)(ii)(C)(2), where a “boost function” (a control strategy commonly used that shifts the y-intercept of the reset curve upward during extended calls for heat) might make it impossible to hold the required  $\pm 3$  °F tolerance for the boiler supply water temperature. (Burnham, No. 35 at p. 6)

Burnham stated that some of the control strategies currently in use require multiple burner cycles to determine the inferred heat load, which does not seem to be taken into account by DOE’s proposed verification method. (Burnham, No. 35 at p. 6)

DOE makes several changes to the proposed verification of automatic means tests to address the technical comments received from Lochinvar and Burnham. DOE revised the two tests for the verification of automatic means presented in the NOPR such that the test previously identified as the two-stage/modulating boilers test will apply to all boilers, with the exception of single-stage boilers that employ a burner delay control strategy. The test for all boiler products monitors water temperature settings from the inferential load controller and/or monitors supply water temperature to determine whether the supply water temperature changes in response to changes in the inferred load. This test method allows for establishing the necessary conditions that may lead to a change in inferred load, for example, a change in outdoor air temperature, a change in thermostat patterns, and/or a change in boiler cycling.

DOE is adopting the test previously identified as the single-stage boilers test as the test method for single-stage boilers that employ a burner delay control strategy to fulfill the automatic means design requirement as specified in 42 U.S.C. 6295(f)(3)(B)(ii). The test for single-stage boilers that employ a burner delay control strategy captures the delayed burner reaction following a call

for heating when residual heat is present within the boiler.

DOE agrees with Burnham and Lochinvar’s comments that help to clarify the test method and allow for accommodating variations in the control strategies. Therefore, DOE adopts revisions that include removing the minimum supply water temperature tolerance requirement to allow variations in temperature when burner cycling occurs; increasing the inlet water temperature from 120 °F ( $\pm 2$  °F) to 140 °F ( $\pm 2$  °F) for the test method for single-stage boilers that employ a burner delay control strategy so that it is high enough to cause burner delay; and making terminology related to inlet water consistent throughout the test method. However, DOE disagrees with Burnham’s comment that the tolerance range for determining a stabilized supply water temperature could not be met under a specific control strategy, such as the boost mode where an extended call for heating occurs until the heat demand is satisfied. In such a case, DOE’s test method would be implemented when either the heat demand is satisfied or the high boiler water temperature limit is reached.

As discussed in the March 2015 NOPR, DOE also adds a definition for “controlling parameter.” DOE has placed this definition in 10 CFR 430.2 rather than appendix N as it applies to DOE enforcement regulations rather than manufacturer testing. Controlling parameter is defined as a measurable quantity for a residential boiler (such as temperature or usage pattern) used for inferring heating load, which would then result in incremental changes in supply water temperature.

## 2. Compliance Dates for the Amended Test Procedure

This document amends 10 CFR 429.18, 10 CFR 429.134, 10 CFR 430.2, 10 CFR 430.3, 10 CFR 430.23, and 10 CFR part 430, subpart B, appendix N. When DOE modifies test procedures, it must determine to what extent, if any, the new test procedure would alter the measured energy efficiency or energy use of any covered product. (42 U.S.C. 6293(e)(1)) For the reasons described previously, DOE has determined that none of the test procedure amendments would alter the measured energy efficiency or energy use of the covered products that are the subject of this rulemaking. The changes made to appendix N through this final rule, as listed in section III.D, clarify the manner in which the test is conducted, or otherwise represent minor changes or additions to the test or reporting requirements that do not affect

measured energy use. Therefore, these amendments become effective 30 days after publication of this final rule in the **Federal Register**. Pursuant to 42 U.S.C. 6293(c)(2), 180 days after DOE prescribes or establishes a new or amended test procedure, manufacturers must make representations of energy efficiency, including certifications of compliance, using that new or amended test procedure.

## IV. Procedural Issues and Regulatory Review

### A. Review Under Executive Order 12866

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

### B. Review Under the Regulatory Flexibility Act

The Regulatory Flexibility Act (5 U.S.C. 601 *et seq.*, as amended by the Small Business Regulatory Fairness Act of 1996) requires preparation of an initial regulatory flexibility analysis (IRFA) 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 DOE rulemaking process. 68 FR 7990. DOE has made its procedures and policies available on the Office of the General Counsel’s Web site: <http://energy.gov/gc/office-general-counsel>.

DOE reviewed this final rule under the provisions of the Regulatory Flexibility Act and the procedures and policies published on February 19, 2003. 68 FR 7990. This final rule amends DOE’s test procedure by providing clarifications regarding relevant test procedure provisions and revising the definitions of some terms. DOE has concluded that this final rule will not have a significant impact on a substantial number of small entities. The factual basis for this certification is as follows:

The Small Business Administration (SBA) considers a business entity to be a small business if, together with its affiliates, it employs less than a threshold number of workers specified in 13 CFR part 121. These size standards and codes are established by the North American Industry Classification System (NAICS) and are available at [http://www.sba.gov/sites/default/files/files/Size\\_Standards\\_Table.pdf](http://www.sba.gov/sites/default/files/files/Size_Standards_Table.pdf). Residential boiler manufacturing is classified under NAICS 333414, "Heating Equipment (Except Warm Air Furnaces) Manufacturing," for which the maximum size threshold is 500 employees or fewer. Residential furnace manufacturing is classified under NAICS 333415, "Air-conditioning and warm air heating equipment and commercial and industrial refrigeration equipment manufacturing" for which the maximum size threshold is 750 employees or fewer. To estimate the number of companies that could be small business manufacturers of products covered by this rulemaking, DOE conducted a market survey using available public information to identify potential small manufacturers. DOE's research involved reviewing several industry trade association membership directories (e.g., AHRI<sup>16</sup>), SBA databases,<sup>17</sup> individual company Web sites, and marketing research tools (e.g., Hoovers<sup>18</sup> reports) to create a list of all domestic small business manufacturers of residential furnaces and boilers covered by this rulemaking.

After DOE identified manufacturers of residential furnaces and consumer boilers, DOE then consulted publically-available data and contacted companies, as necessary, to determine if they both meet the SBA's definition of a "small business" manufacturer and have their manufacturing facilities located within the United States. DOE screened out companies that did not offer products covered by this rulemaking, did not meet the definition of a "small business," or are foreign-owned and operated. Based on this analysis, DOE identified 9 small businesses that manufacture residential furnaces and 9 small businesses that manufacture residential boilers (two of which also manufacture residential furnaces), for a total of 16 small businesses potentially impacted by this rulemaking.

This document amends DOE's test procedure by incorporating several

changes that modify the existing test procedure or reporting requirements for furnaces and boilers. This includes the following changes that could potentially impact manufacturers: (1) Clarified definition of electrical power term PE; (2) a smoke stick method for determining whether the minimum default draft factor may be used; (3) a provision to allow for the measurement of condensate under steady-state conditions; (4) reference to manufacturers' I&O manuals; (5) specification of ductwork for units that are installed without a return duct; (6) specification of testing requirements for multi-position units; (7) revised reporting precision for AFUE to the nearest tenth of a percentage point; and (8) requirement to report the use of a burner delay automatic means control strategy in certification reports. The estimated costs of testing/rating and potential impact to manufacturer burden resulting from use of the amended test procedure are discussed subsequently. The estimated costs and potential impacts apply to all manufacturers, including the manufacturers identified as small businesses.

DOE believes that explicitly listing the components encompassed in the definition of PE does not change the definition of the electrical power term PE but rather only clarifies it, and will not impose any additional test burden.

The adoption of the smoke stick method for determining whether the minimum default draft factor may be used is intended to reduce the test burden to manufacturers. DOE estimated that the smoke stick method for determining the minimum default draft factor would reduce the overall duration of the test by about 15 minutes for units designed to have no flow through the heat exchanger. However, DOE does not have sufficient information to support estimating the fraction of units that have been designed such that there is no flow through the heat exchanger. Therefore, DOE has not included the cost savings associated with the smoke stick.

The addition of the optional provision to allow for the measurement of condensate prior to the establishment of steady state conditions will result in a lowering of test burden for manufacturers of condensing furnaces and boilers. Manufacturers of condensing furnaces and boilers will benefit from the time and labor savings attributed to the measurement of condensate during the establishment of steady-state conditions. However, DOE does not have sufficient information to support estimating the fraction of units

that would be tested under the optional provision. Therefore, DOE has not included the cost savings associated with the optional provision to allow for the measurement of condensate prior to the establishment of steady state conditions.

The clarification of duct work requirements for units that are installed without a return duct and clarification of the test requirements for multi-position units do not present any additional test burden to manufacturers, as the two amendments do not change the existing testing requirements or conflict with current industry practice.

Revision of AFUE reporting precision and the requirement to report the use of a burner delay automatic means control strategy in the certification report do not present any additional test burden to manufacturers, as the two amendments do not change testing requirements. However, both amendments may require some manufacturers to submit new certification reports and relabel their products. DOE estimates that for affected parties, submitting new certification reports and relabeling products will take 30 minutes per unit. At an assumed cost of \$40 per hour, the cost to recertify and relabel is \$20 per unit.

To determine the potential cost of the test procedure amendments on small furnace and boiler manufacturers, DOE estimated the cost of recertifying and relabeling per basic model and the savings from the optional provision to measure condensate during the establishment of steady state conditions, as described above. DOE estimated that on average, each furnace small business would have 51 basic models, and each boiler small business would have 70 basic models. Based on residential furnace and boiler model data, DOE assumed that approximately 70 percent of all furnace and 60 percent of all boiler manufacturers will need to recertify and relabel due to the revision of the AFUE reporting precision. Based on residential boiler model data, DOE assumed that about 75 percent of boilers are single-stage boilers; furthermore, DOE assumed that about two-thirds of single-stage boilers employ a burner delay automatic means control strategy. Thus, DOE assumed that half of all boiler models will employ a burner delay automatic means control strategy. The additional recertification and relabeling cost associated with the test procedure amendments was multiplied by the estimated fraction of affected basic models produced by a small manufacturer. DOE has estimated a total added cost from the test procedure amendments of \$714 per furnace

<sup>16</sup> For more information on the boiler and furnace directories, see <http://www.ahridirectory.org/ahridirectory/pages/home.aspx>.

<sup>17</sup> For more information see: [http://dsbs.sba.gov/dsbs/search/dsp\\_dsbs.cfm](http://dsbs.sba.gov/dsbs/search/dsp_dsbs.cfm).

<sup>18</sup> For more information see: <http://www.hoovers.com/>.

manufacturer and a total added cost of about \$1,120 per boiler manufacturer for manufacturers that currently do not report AFUE to the nearest tenth of a percentage point or for manufacturers of single-stage boilers that employ a burner delay automatic means control strategy.

For the reasons stated previously, DOE certifies that this rule will not have a significant economic impact on a substantial number of small entities.

#### *C. Review Under the Paperwork Reduction Act of 1995*

Manufacturers of residential furnaces and boilers must certify to DOE that their products comply with all applicable energy conservation standards. In certifying compliance with applicable performance standards, manufacturers must test their products according to the DOE test procedures for residential furnaces and boilers, including any amendments adopted for those test procedures. Manufacturers must also ensure their products comply with applicable design standards. DOE has established regulations for the certification and recordkeeping requirements for all covered consumer products and commercial equipment, including residential furnaces and boilers. *See generally* 10 CFR part 429. The collection-of-information requirement for certification and recordkeeping is subject to review and approval by OMB under the Paperwork Reduction Act (PRA). This requirement has been approved by OMB under OMB control number 1910-1400. Public reporting burden for the certification is estimated to average 30 hours per response, including the time for reviewing instructions, searching existing data sources, gathering and maintaining the data needed, and completing and reviewing the collection of information.

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

#### *D. Review Under the National Environmental Policy Act of 1969*

In this final rule, DOE amends its test procedure for residential furnaces and boilers. DOE has determined that this rule falls into a class of actions that are categorically excluded from review under the National Environmental Policy Act of 1969 (42 U.S.C. 4321 *et seq.*) and DOE's implementing regulations at 10 CFR part 1021. Specifically, this rule amends an

existing rule without affecting the amount, quality or distribution of energy usage, and, therefore, will not result in any environmental impacts. Thus, this rulemaking is covered by Categorical Exclusion A5 under 10 CFR part 1021, subpart D, which applies to any rulemaking that interprets or amends an existing rule without changing the environmental effect of that rule. Accordingly, neither an environmental assessment nor an environmental impact statement is required.

#### *E. Review Under Executive Order 13132*

Executive Order 13132, "Federalism," 64 FR 43255 (August 10, 1999) imposes certain requirements on agencies formulating and implementing policies or regulations that preempt State law or that have Federalism implications. The Executive Order requires agencies to examine the constitutional and statutory authority supporting any action that would limit the policymaking discretion of the States, and to carefully assess the necessity for such actions. The Executive Order also requires agencies to have an accountable process to ensure meaningful and timely input by State and local officials in the development of regulatory policies that have Federalism implications. On March 14, 2000, DOE published a statement of policy describing the intergovernmental consultation process it will follow in the development of such regulations. 65 FR 13735. DOE examined this final rule and determined that it will not have a substantial direct effect on the States, on the relationship between the national government and the States, or on the distribution of power and responsibilities among the various levels of government. EPCA governs and prescribes Federal preemption of State regulations as to energy conservation for the products that are the subject of this final rule. States can petition DOE for exemption from such preemption to the extent, and based on criteria, set forth in EPCA. (42 U.S.C. 6297(d)) No further action is required by Executive Order 13132.

#### *F. Review Under Executive Order 12988*

Regarding the review of existing regulations and the promulgation of new regulations, section 3(a) of Executive Order 12988, "Civil Justice Reform," 61 FR 4729 (Feb. 7, 1996), imposes on Federal agencies the general duty to adhere to the following requirements: (1) Eliminate drafting errors and ambiguity; (2) write regulations to minimize litigation; (3) provide a clear legal standard for affected conduct rather than a general

standard; and (4) promote simplification and burden reduction. Section 3(b) of Executive Order 12988 specifically requires that Executive agencies make every reasonable effort to ensure that the regulation: (1) Clearly specifies the preemptive effect, if any; (2) clearly specifies any effect on existing Federal law or regulation; (3) provides a clear legal standard for affected conduct while promoting simplification and burden reduction; (4) specifies the retroactive effect, if any; (5) adequately defines key terms; and (6) addresses other important issues affecting clarity and general draftsmanship under any guidelines issued by the Attorney General. Section 3(c) of Executive Order 12988 requires Executive agencies to review regulations in light of applicable standards in sections 3(a) and 3(b) to determine whether they are met or it is unreasonable to meet one or more of them. DOE has completed the required review and determined that, to the extent permitted by law, this final rule meets the relevant standards of Executive Order 12988.

#### *G. Review under the Unfunded Mandates Reform Act of 1995*

Title II of the Unfunded Mandates Reform Act of 1995 (UMRA) requires each Federal agency to assess the effects of Federal regulatory actions on State, local, and Tribal governments and the private sector. Public Law 104-4, sec. 201 (codified at 2 U.S.C. 1531). For a regulatory action resulting in a rule that may cause the expenditure by State, local, and Tribal governments, in the aggregate, or by the private sector of \$100 million or more in any one year (adjusted annually for inflation), section 202 of UMRA requires a Federal agency to publish a written statement that estimates the resulting costs, benefits, and other effects on the national economy. (2 U.S.C. 1532(a), (b)) The UMRA also requires a Federal agency to develop an effective process to permit timely input by elected officers of State, local, and Tribal governments on a proposed "significant intergovernmental mandate," and requires an agency plan for giving notice and opportunity for timely input to potentially affected small governments before establishing any requirements that might significantly or uniquely affect small governments. On March 18, 1997, DOE published a statement of policy on its process for intergovernmental consultation under UMRA. 62 FR 12820. (This policy is also available at <http://energy.gov/gc/office-general-counsel>). DOE examined this final rule according to UMRA and its statement of policy and determined that the rule

contains neither an intergovernmental mandate, nor a mandate that may result in the expenditure of \$100 million or more in any year, so these requirements do not apply.

*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 rule will 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*

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

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

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

*K. Review Under Executive Order 13211*

Executive Order 13211, “Actions Concerning Regulations That Significantly Affect Energy Supply, Distribution, or Use,” 66 FR 28355 (May 22, 2001), requires Federal agencies to prepare and submit to OMB, a Statement of Energy Effects for any 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 significant energy action, the agency must give a detailed statement of any adverse effects on energy supply, distribution, or use if the regulation is implemented, and of reasonable alternatives to the action and their expected benefits on energy supply, distribution, and use.

This 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, nor has it been designated as a significant energy action by the Administrator of OIRA. Therefore, it is not a significant energy action, and, accordingly, DOE has not prepared a Statement of Energy Effects.

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

Under section 301 of the Department of Energy Organization Act (Pub. L. 95–91; 42 U.S.C. 7101), DOE must comply with section 32 of the Federal Energy Administration Act of 1974, as amended by the Federal Energy Administration Authorization Act of 1977 (Pub. L. 95–70). (15 U.S.C. 788; FEAA) Section 32 essentially provides in relevant part that, where a proposed rule authorizes or requires use of commercial standards, the notice of proposed rulemaking must inform the public of the use and background of such standards. In addition, section 32(c) requires DOE to consult with the Attorney General and the Chairman of the Federal Trade Commission (FTC) concerning the impact of the commercial or industry standards on competition.

This final rule incorporates testing methods contained in the following commercial standard: ASTM D2156–09 (Reapproved 2013). While this test procedure is not exclusively based on this standard, the DOE test procedure adopts several provisions from this standard without amendment. DOE has evaluated this standard and is unable to conclude whether it fully complies with the requirements of section 32(b) of the FEAA (*i.e.*, that it was developed in a manner that fully provides for public participation, comment, and review). DOE has consulted with the Attorney General and the Chairwoman of the FTC concerning the impact of these test procedures on competition and has received no comments objecting to their use.

*M. Description of Materials Incorporated by Reference*

In this final rule, DOE incorporates by reference the ASTM test standard

“Standard Test Method for Smoke Density in Flue Gases from Burning Distillate Fuels,” ASTM D2156–09 (Reapproved 2013). ASTM D2156 is an industry accepted test procedure that establishes uniform test methods for the evaluation of smoke density in the flue gases from burning distillate fuels. The test procedure established in this final rule references ASTM D2156 in its entirety, which includes terminology, methods of testing, materials, apparatus, procedures, reporting, and precision and bias, to determine the allowable smoke in the flue of oil furnaces and boilers. ASTM D2156–09 is available on ASTM’s Web site at <http://www.astm.org/Standards/D2156.htm>.

*N. Congressional Notification*

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

**V. Approval of the Office of the Secretary**

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

**List of Subjects**

*10 CFR Part 429*

Confidential business information, Energy conservation, Household appliances, Imports, Reporting and recordkeeping requirements.

*10 CFR Part 430*

Administrative practice and procedure, Confidential business information, Energy conservation, Household appliances, Imports, Incorporation by reference, Intergovernmental relations, Small businesses.

Issued in Washington, DC, on December 29, 2015.

**Kathleen B. Hogan,**

*Deputy Assistant Secretary for Energy Efficiency, Energy Efficiency and Renewable Energy.*

For the reasons stated in the preamble, DOE amends parts 429 and 430 of chapter II, subchapter D of title 10, Code of Federal Regulations, as set forth below:

**PART 429—CERTIFICATION, COMPLIANCE, AND ENFORCEMENT FOR CONSUMER PRODUCTS AND COMMERCIAL AND INDUSTRIAL EQUIPMENT**

■ 1. The authority citation for part 429 continues to read as follows:

**Authority:** 42 U.S.C. 6291–6317.

■ 2. Amend § 429.18 by adding paragraphs (a)(2)(vii) and (b)(4) to read as follows:

**§ 429.18 Residential furnaces.**

(a) \* \* \*

(2) \* \* \*

(vii) *Reported values.* The represented value of annual fuel utilization efficiency must be truncated to the one-tenth of a percentage point.

(b) \* \* \*

(4) For multi-position furnaces, the annual fuel utilization efficiency (AFUE) reported for each basic model must be based on testing in the least efficient configuration. Manufacturers may also report and make representations of additional AFUE values based on testing in other configurations.

■ 3. Amend § 429.134 by adding paragraph (h) to read as follows:

**§ 429.134 Product-specific enforcement provisions**

\* \* \* \* \*

(h) *Residential boilers—test protocols for functional verification of automatic means for adjusting water temperature.* These tests are intended to verify the functionality of the design requirement that a boiler has an automatic means for adjusting water temperature for single-stage, two-stage, and modulating boilers. These test methods are intended to permit the functional testing of a range of control strategies used to fulfill this design requirement. Section 2, *Definitions*, and paragraph 6.1.a of appendix N to subpart B of part 430 of this chapter apply for the purposes of this paragraph (h).

(1) *Test protocol for all products other than single-stage products employing burner delay.* This test is intended to verify whether an automatic means for adjusting water temperature other than burner delay produces an incremental change in water supply temperature in response to an incremental change in inferred heat load.

(i) *Boiler setup—(A) Boiler installation.* Boiler installation in the test room shall be in accordance with the setup and apparatus requirements of section 6 of appendix N to subpart B of 10 CFR part 430.

(B) *Establishing flow rate and temperature rise.* Start the boiler without enabling the means for adjusting water temperature. Establish a water flow rate that allows for a water temperature rise of greater than or equal to 20 °F at maximum input rate.

(C) *Temperature stabilization.* Temperature stabilization is deemed to be obtained when the boiler supply water temperature does not vary by

more than  $\pm 3$  °F over a period of five minutes.

(D) *Adjust the inferential load controller.* (1) Adjust the boiler controls (in accordance with the I&O manual) to the default setting that allows for activation of the means for adjusting water temperature. For boiler controls that do not allow for control adjustment during active mode operation, terminate call for heat and adjust the inferential load controller in accordance with the I&O manual and then reinitiate call for heat.

(2) If the means for adjusting water temperature uses outdoor temperature reset, the maximum outdoor temperature setting (if equipped) should be set to a temperature high enough that the boiler operates continuously during the duration of this test (*i.e.*, if the conditions in paragraph (h)(1)(ii)(A) of this section equal room ambient temperature, then the maximum outdoor temperature should be set at a temperature greater than the ambient air temperature during the test).

(ii) *Establish low inferred load conditions at minimum boiler supply water temperature—(A) Establish low inferred load conditions.* (1) Establish the inferred load conditions (simulated using a controlling parameter, such as outdoor temperature, thermostat patterns, or boiler cycling) so that the supply water temperature is maintained at the minimum supply water temperature prescribed by the boiler manufacturer's temperature reset control strategy found in the I&O manual.

(2) The minimum supply water temperature of the default temperature reset curve is usually provided in the I&O manual. If there is no recommended minimum supply water temperature, set the minimum supply water temperature equal to 20 °F less than the high supply water temperature specified in paragraph (h)(1)(iii)(A) of this section.

(B) *Supply water temperature stabilization at low inferred load.* (1) Maintain the call for heat until the boiler supply water temperature has stabilized. Temperature stabilization is deemed to be obtained when the boiler supply water temperature does not vary by more than  $\pm 3$  °F over a period of five minutes. The duration of time required to stabilize the supply water, following the procedure in paragraph (h)(1)(ii)(A) of this section, is dependent on the reset strategy and may vary from model to model.

(2) Record the boiler supply water temperature while the temperature is stabilized.

(iii) *Establish high inferred load conditions at maximum boiler supply*

*water temperature—(A) Establish high inferred load conditions.* Establish the inferred load conditions so that the supply water temperature is set to the maximum allowable supply water temperature as prescribed in the I&O manual, or if there is no recommendation, set to a temperature greater than 170 °F.

(B) *Supply water temperature stabilization at high inferred load.* (1) Maintain the call for heat until the boiler supply water temperature has stabilized. Temperature stabilization is deemed to be obtained when the boiler supply water temperature does not vary by more than  $\pm 3$  °F over a period of five minutes. The duration of time required to stabilize the supply water, following the procedure in paragraph (h)(1)(iii)(A) of this section, is dependent on the reset strategy and may vary from model to model.

(2) Record the boiler supply water temperature while the temperature is stabilized.

(3) Terminate the call for heat.

(iv) [Reserved]

(2) *Test protocol for single-stage products employing burner delay.* This test will be used in place of paragraph (h)(1) of this section for products manufacturers have certified to DOE under § 429.18(b)(3) as employing a burner delay automatic means strategy. This test verifies whether the automatic means in single-stage boiler products establishes a burner delay upon a call for heat until the means has determined that the inferred heat load cannot be met by the residual heat of the water in the system.

(i) *Boiler setup—(A) Boiler installation.* Boiler installation in the test room shall be in accordance with the setup and apparatus requirements by section 6.0 of appendix N to subpart B of 10 CFR part 430.

(B) *Activation of controls.* Adjust the boiler controls in accordance with the I&O manual at the default setting that allows for activation of the means for adjusting water temperature.

(C) *Adjustment of water flow and temperature.* The flow and temperature of inlet water to the boiler shall be capable of being adjusted manually.

(ii) *Boiler heat-up—(A) Boiler start-up.* Power up the boiler and initiate a call for heat.

(B) *Adjustment of firing rate.* Adjust the boiler's firing rate to within  $\pm 5\%$  of its maximum rated input.

(C) *Establishing flow rate and temperature rise.* Adjust the water flow through the boiler to achieve a  $\Delta T$  of 20 °F ( $\pm 2$  °F) or greater with an inlet water temperature equal to 140 °F ( $\pm 2$  °F).

(D) *Terminate the call for heating.* Terminate the call for heat, stop the flow of water through the boiler, and record the time at termination.

(iii) *Verify burner delay*—(A) *Reinitiate call for heat.* Within three (3) minutes of termination (paragraph (h)(2)(ii)(D) of this section) and without adjusting the inlet water flow rate or temperature as specified in paragraph (h)(2)(ii)(C) of this section, reinitiate the call for heat and water flow and record the time.

(B) *Verify burner ignition.* At 15-second intervals, record time and supply water temperature until the main burner ignites.

(C) *Terminate the call for heat.*

(iv) [Reserved]

**PART 430—ENERGY CONSERVATION PROGRAM FOR CONSUMER PRODUCTS**

■ 4. The authority citation for part 430 continues to read as follows:

**Authority:** 42 U.S.C. 6291–6309; 28 U.S.C. 2461 note.

■ 5. Amend § 430.2 by adding in alphabetical order a definition of “Controlling parameter” and revising the definition of “Furnace” to read as follows:

**§ 430.2 Definitions.**

\* \* \* \* \*

*Controlling parameter* means a measurable quantity or an algorithm (such as temperature or usage pattern) used for inferring heating load to a residential boiler, which would then result in incremental changes in boiler supply water temperature.

\* \* \* \* \*

*Furnace* means a product which utilizes only single-phase electric current, or single-phase electric current or DC current in conjunction with natural gas, propane, or home heating oil, and which—

(1) Is designed to be the principal heating source for the living space of a residence;

(2) Is not contained within the same cabinet with a central air conditioner whose rated cooling capacity is above 65,000 Btu per hour;

(3) Is an electric central furnace, electric boiler, forced-air central furnace, gravity central furnace, or low-pressure steam or hot water boiler; and

(4) Has a heat input rate of less than 300,000 Btu per hour for electric boilers and low-pressure steam or hot water boilers and less than 225,000 Btu per hour for forced-air central furnaces, gravity central furnaces, and electric central furnaces.

\* \* \* \* \*

■ 6. Amend § 430.3 by revising paragraph (g)(11) and adding paragraph (j)(2) to read as follows:

**§ 430.3 Materials incorporated by reference.**

\* \* \* \* \*

(g) \* \* \*  
 (11) ANSI/ASHRAE Standard 103–1993, (“ASHRAE 103–1993”), Methods of Testing for Annual Fuel Utilization Efficiency of Residential Central Furnaces and Boilers, (with Errata of October 24, 1996), except for sections 7.1, 7.2.2.2, 7.2.2.5, 7.2.3.1, 7.8, 8.2.1.3, 8.3.3.1, 8.4.1.1, 8.4.1.1.2, 8.4.1.2, 8.4.2.1.4, 8.4.2.1.6, 8.6.1.1, 8.7.2, 8.8.3, 9.1.2.2.1, 9.1.2.2.2, 9.5.1.1, 9.5.1.2.1, 9.5.1.2.2, 9.5.2.1, 9.7.1, 9.7.4, 9.7.6, 9.10, 11.5.11.1, 11.5.11.2 and appendices B and C, approved October 4, 1993, IBR approved for § 430.23 and appendix N to subpart B.

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(j) \* \* \*  
 (2) ASTM D2156–09 (Reapproved 2013) (“ASTM D2156R13”), Standard Test Method for Smoke Density in Flue Gases from Burning Distillate Fuels, approved October 1, 2013, IBR approved for appendix N to subpart B.

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■ 7. Amend § 430.23 by revising paragraph (n)(2) to read as follows:

**§ 430.23 Test procedures for the measurement of energy and water consumption.**

\* \* \* \* \*

(n) \* \* \*  
 (2) The annual fuel utilization efficiency for furnaces, expressed in percent, is the ratio of the annual fuel output of useful energy delivered to the heated space to the annual fuel energy input to the furnace determined according to section 10.1 of appendix N of this subpart for gas and oil furnaces and determined in accordance with section 11.1 of the American National Standards Institute/American Society of Heating, Refrigerating, and Air-Conditioning Engineers (ANSI/ASHRAE) Standard 103–1993 (incorporated by reference, see § 430.3) for electric furnaces. Truncate the annual fuel utilization efficiency to one-tenth of a percentage point.

\* \* \* \* \*

■ 8. Revise appendix N to subpart B to read as follows:

**Appendix N to Subpart B of Part 430—Uniform Test Method for Measuring the Energy Consumption of Furnaces and Boilers**

**Note:** Prior to July 13, 2016, representations with respect to the energy use or efficiency of residential furnaces and

boilers, including compliance certifications, must be based on testing conducted in accordance with either this appendix as it now appears or appendix N as it appeared at 10 CFR part 430, subpart B revised as of January 1, 2016.

After July 13, 2016, representations with respect to energy use or efficiency of residential furnaces and boilers, including compliance certifications, must be based on testing conducted in accordance with this appendix.

1.0 *Scope.* The scope of this appendix is as specified in section 2 of ASHRAE 103–1993 (incorporated by reference, see § 430.3).

For purposes of this appendix, the Department of Energy incorporates by reference several industry standards, either in whole or in part, as listed in § 430.3. In cases where there is a conflict, the language of the test procedure in this appendix takes precedence over the incorporated standards.

2.0 *Definitions.* Definitions include those specified in section 3 of ASHRAE 103–1993 (incorporated by reference, see § 430.3) and the following additional and modified definitions.

2.1 *Active mode* means the condition in which the furnace or boiler is connected to the power source, and at least one of the burner, electric resistance elements, or any electrical auxiliaries such as blowers or pumps, are activated.

2.2 *Boiler pump* means a pump installed on a boiler and that is separate from the circulating water pump.

2.3 *Control* means a device used to regulate the operation of a piece of equipment and the supply of fuel, electricity, air, or water.

2.4 *Draft inducer* means a fan incorporated in the furnace or boiler that either draws or forces air into the combustion chamber.

2.5 *Gas valve* means an automatic or semi-automatic device consisting essentially of a valve and operator that controls the gas supply to the burner(s) during normal operation of an appliance. The operator may be actuated by application of gas pressure on a flexible diaphragm, by electrical means, by mechanical means or by other means.

2.6 *Installation and operation (I&O) manual* means instructions for installing, commissioning, and operating the furnace or boiler, which are supplied with the product when shipped by the manufacturer.

2.7 *Isolated combustion system* means a system where a unit is installed within the structure, but isolated from the heated space. A portion of the jacket heat from the unit is lost, and air for ventilation, combustion and draft control comes from outside the heated space.

2.8 *Multi-position furnace* means a furnace that can be installed in more than one airflow configuration (*i.e.*, upflow or horizontal; downflow or horizontal; upflow or downflow; and upflow, or downflow, or horizontal).

2.9 *Off mode* means a mode in which the furnace or boiler is connected to a mains power source and is not providing any active mode or standby mode function, and where the mode may persist for an indefinite time. The existence of an off switch in off position

(a disconnected circuit) is included within the classification of off mode.

2.10 *Off switch* means the switch on the furnace or boiler that, when activated, results in a measurable change in energy consumption between the standby and off modes.

2.11 *Oil control valve* means an automatically or manually operated device consisting of an oil valve for controlling the fuel supply to a burner to regulate burner input.

2.12 *Standby mode* means any mode in which the furnace or boiler is connected to a mains power source and offers one or more of the following space heating functions that may persist:

a. To facilitate the activation of other modes (including activation or deactivation of active mode) by remote switch (including thermostat or remote control), internal or external sensors, or timer;

b. Continuous functions, including information or status displays or sensor based functions.

2.13 *Thermal stack damper* means a type of stack damper that relies exclusively upon the changes in temperature in the stack gases to open or close the damper.

3.0 *Classifications*. Classifications are as specified in section 4 of ASHRAE 103–1993 (incorporated by reference, see § 430.3).

4.0 *Requirements*. Requirements are as specified in section 5 of ASHRAE 103–1993 (incorporated by reference, see § 430.3).

5.0 *Instruments*. Instruments must be as specified in section 6 of ASHRAE 103–1993 (incorporated by reference, see § 430.3).

6.0 *Apparatus*. The apparatus used in conjunction with the furnace or boiler during the testing must be as specified in section 7 of ASHRAE 103–1993 (incorporated by reference, see § 430.3) except for sections 7.1, 7.2.2.2, 7.2.2.5, 7.2.3.1, and 7.8; and as specified in sections 6.1 through 6.5 of this appendix.

#### 6.1 *General*.

a. Install the furnace or boiler in the test room in accordance with the I&O manual, as defined in section 2.6 of this appendix, except that if provisions within this appendix are specified, then the provisions herein drafted and prescribed by DOE govern. If the I&O manual and any additional provisions of this appendix are not sufficient for testing a furnace or boiler, the manufacturer must request a waiver from the test procedure pursuant to 10 CFR 430.27.

b. If the I&O manual indicates the unit should not be installed with a return duct, then the return (inlet) duct specified in section 7.2.1 of ASHRAE 103–1993 (incorporated by reference, see § 430.3) is not required.

c. Test multi-position furnaces in the least efficient configuration. Testing of multi-position furnaces in other configurations is permitted if energy use or efficiency is represented pursuant to the requirements in 10 CFR part 429.

d. The apparatuses described in section 6 of this appendix are used in conjunction with the furnace or boiler during testing. Each piece of apparatus shall conform to material and construction specifications listed in this appendix and in ASHRAE 103–1993

(incorporated by reference, see § 430.3), and the reference standards cited in this appendix and in ASHRAE 103–1993.

e. Test rooms containing equipment must have suitable facilities for providing the utilities (including but not limited to environmental controls, sufficient fluid source(s), applicable measurement equipment, and any other technology or tools) necessary for performance of the test and must be able to maintain conditions within the limits specified in section 6 of this appendix.

#### 6.2 *Forced-air central furnaces (direct vent and direct exhaust)*.

a. Units not equipped with a draft hood or draft diverter must be provided with the minimum-length vent configuration recommended in the I&O manual or a 5-ft flue pipe if there is no recommendation provided in the I&O manual (see Figure 4 of ASHRAE 103–1993 (incorporated by reference, see § 430.3)). For a direct exhaust system, insulate the minimum-length vent configuration or the 5-ft flue pipe with insulation having an R-value not less than 7 and an outer layer of aluminum foil. For a direct vent system, see section 7.5 of ASHRAE 103–1993 for insulation requirements.

b. For units with power burners, cover the flue collection box with insulation having an R-value of not less than 7 and an outer layer of aluminum foil before the cool-down and heat-up tests described in sections 9.5 and 9.6 of ASHRAE 103–1993 (incorporated by reference, see § 430.3), respectively. However, do not apply the insulation for the jacket loss test (if conducted) described in section 8.6 of ASHRAE 103–1993 or the steady-state test described in section 9.1 of ASHRAE 103–1993.

c. For power-vented units, insulate the shroud surrounding the blower impeller with insulation having an R-value of not less than 7 and an outer layer of aluminum foil before the cool-down and heat-up tests described in sections 9.5 and 9.6, respectively, of ASHRAE 103–1993 (incorporated by reference, see § 430.3). Do not apply the insulation for the jacket loss test (if conducted) described in section 8.6 of ASHRAE 103–1993 or the steady-state test described in section 9.1 of ASHRAE 103–1993. Do not insulate the blower motor or block the airflow openings that facilitate the cooling of the combustion blower motor or bearings.

6.3 *Downflow furnaces*. Install an internal section of vent pipe the same size as the flue collar for connecting the flue collar to the top of the unit, if not supplied by the manufacturer. Do not insulate the internal vent pipe during the jacket loss test (if conducted) described in section 8.6 of ASHRAE 103–1993 (incorporated by reference, see § 430.3) or the steady-state test described in section 9.1 of ASHRAE 103–1993. Do not insulate the internal vent pipe before the cool-down and heat-up tests described in sections 9.5 and 9.6, respectively, of ASHRAE 103–1993. If the vent pipe is surrounded by a metal jacket, do not insulate the metal jacket. Install a 5-ft test stack of the same cross-sectional area or perimeter as the vent pipe above the top of

the furnace. Tape or seal around the junction connecting the vent pipe and the 5-ft test stack. Insulate the 5-ft test stack with insulation having an R-value not less than 7 and an outer layer of aluminum foil. (See Figure 3–E of ASHRAE 103–1993.)

6.4 *Units with draft hoods or draft diverters*. Install the stack damper in accordance with the I&O manual. Install 5 feet of stack above the damper.

a. For units with an integral draft diverter, cover the 5-ft stack with insulation having an R-value of not less than 7 and an outer layer of aluminum foil.

b. For units with draft hoods, insulate the flue pipe between the outlet of the furnace and the draft hood with insulation having an R-value of not less than 7 and an outer layer of aluminum foil.

c. For units with integral draft diverters that are mounted in an exposed position (not inside the overall unit cabinet), cover the diverter boxes (excluding any openings through which draft relief air flows) before the beginning of any test (including jacket loss test) with insulation having an R-value of not less than 7 and an outer layer of aluminum foil.

d. For units equipped with integral draft diverters that are enclosed within the overall unit cabinet, insulate the draft diverter box with insulation as described in section 6.4.c before the cool-down and heat-up tests described in sections 9.5 and 9.6, respectively, of ASHRAE 103–1993 (incorporated by reference, see § 430.3). Do not apply the insulation for the jacket loss test (if conducted) described in section 8.6 of ASHRAE 103–1993 or the steady-state test described in section 9.1 of ASHRAE 103–1993.

6.5 *Condensate collection*. Attach condensate drain lines to the unit as specified in the I&O manual. Maintain a continuous downward slope of drain lines from the unit. Additional precautions (such as eliminating any line configuration or position that would otherwise restrict or block the flow of condensate or checking to ensure a proper connection with condensate drain spout that allows for unobstructed flow) must be taken to facilitate uninterrupted flow of condensate during the test. Collection containers must be glass or polished stainless steel to facilitate removal of interior deposits. The collection container must have a vent opening to the atmosphere.

7.0 *Testing conditions*. The testing conditions must be as specified in section 8 of ASHRAE 103–1993 (incorporated by reference, see § 430.3), except for section 8.2.1.3, 8.3.3.1, 8.4.1.1, 8.4.1.1.2, 8.4.1.2, 8.4.2.1.4, 8.4.2.1.6, 8.6.1.1, 8.7.2, and 8.8.3; and as specified in sections 7.1 to 7.10 of this appendix, respectively.

7.1 *Fuel supply, gas*. In conducting the tests specified herein, gases with characteristics as shown in Table 1 of ASHRAE 103–1993 (incorporated by reference, see § 430.3) shall be used. Maintain the gas supply, ahead of all controls for a furnace, at a test pressure between the normal and increased values shown in Table 1 of ASHRAE 103–1993. Maintain the regulator outlet pressure at a level approximating that recommended in the I&O



manual, as defined in section 2.6 of this appendix, or, in the absence of such recommendation, to the nominal regulator settings used when the product is shipped by the manufacturer. Use a gas having a specific gravity as shown in Table 1 of ASHRAE 103–1993 and with a higher heating value within  $\pm 5\%$  of the higher heating value shown in Table 1 of ASHRAE 103–1993. Determine the actual higher heating value in Btu per standard cubic foot for the gas to be used in the test within an error no greater than 1%.

**7.2 Installation of piping.** Install piping equipment in accordance with the I&O manual. In the absence of such specification, install piping in accordance with section 8.3.1.1 of ASHRAE 103–1993 (incorporated by reference, see § 430.3).

**7.3 Gas burner.** Adjust the burners of gas-fired furnaces and boilers to their maximum Btu input ratings at the normal test pressure specified by section 7.1 of this appendix. Correct the burner input rate to reflect gas characteristics at a temperature of 60 °F and atmospheric pressure of 30 in of Hg and adjust down to within  $\pm 2$  percent of the hourly Btu nameplate input rating specified by the manufacturer as measured during the steady-state performance test in section 8 of this appendix. Set the primary air shutters in accordance with the I&O manual to give a good flame at this condition. If, however, the setting results in the deposit of carbon on the burners during any test specified herein, the tester shall adjust the shutters and burners until no more carbon is deposited and shall perform the tests again with the new settings (see Figure 9 of ASHRAE 103–1993 (incorporated by reference, see § 430.3)). After the steady-state performance test has been started, do not make additional adjustments to the burners during the required series of performance tests specified in section 9 of ASHRAE 103–1993. If a vent-limiting means is provided on a gas pressure regulator, keep it in place during all tests.

**7.4 Modulating gas burner adjustment at reduced input rate.** For gas-fired furnaces and boilers equipped with modulating-type controls, adjust the controls to operate the unit at the nameplate minimum input rate. If the modulating control is of a non-automatic type, adjust the control to the setting recommended in the I&O manual. In the absence of such recommendation, the midpoint setting of the non-automatic control shall be used as the setting for determining the reduced fuel input rate. Start the furnace or boiler by turning the safety control valve to the “ON” position. For boilers, use a supply water temperature that will allow for continuous operation without shutoff by the control. If necessary to achieve such continuous operation, supply water may be increased above 120 °F; in such cases, gradually increase the supply water temperature to determine what minimum supply water temperature, with a 20 °F temperature rise across the boiler, will be needed to adjust for the minimum input rate at the reduced input rate control setting. Monitor regulated gas pressure out of the modulating control valve (or entering the burner) to determine when no further reduction of gas pressure results. The flow rate of water through the boiler shall be adjusted to achieve a 20 °F temperature rise.

**7.5 Oil burner.** Adjust the burners of oil-fired furnaces or boilers to give a CO<sub>2</sub> reading specified in the I&O manual and an hourly Btu input during the steady-state performance test described in section 8 of this appendix. Ensure the hourly BTU input is within  $\pm 2\%$  of the normal hourly Btu input rating as specified in the I&O manual. Smoke in the flue may not exceed a No. 1 smoke during the steady-state performance test as measured by the procedure in ASTM D2156R13 (incorporated by reference, see § 430.3). Maintain the average draft over the fire and in the flue during the steady-state performance test at the value specified in the I&O manual. Do not allow draft fluctuations exceeding 0.005 in. water. Do not make additional adjustments to the burner during the required series of performance tests. The instruments and measuring apparatus for this test are described in section 6 of this appendix and shown in Figure 8 of ASHRAE 103–1993 (incorporated by reference, see § 430.3).

**7.6** Adjust air throughputs to achieve a temperature rise that is the higher of a and b, below, unless c applies. A tolerance of  $\pm 2$  °F is permitted.

a. 15 °F less than the nameplate maximum temperature rise or

b. 15 °F higher than the minimum temperature rise specified in the I&O manual.

c. A furnace with a non-adjustable air temperature rise range and an automatically controlled airflow that does not permit a temperature rise range of 30°F or more must be tested at the midpoint of the rise range.

**7.7** Establish the temperature rise specified in section 7.6 of this appendix by adjusting the circulating airflow. This adjustment must be accomplished by symmetrically restricting the outlet air duct and varying blower speed selection to obtain the desired temperature rise and minimum external static pressure, as specified in Table 4 of ASHRAE 103–1993 (incorporated by reference, see § 430.3). If the required temperature rise cannot be obtained at the minimum specified external static pressure by adjusting blower speed selection and duct outlet restriction, then the following applies.

a. If the resultant temperature rise is less than the required temperature rise, vary the blower speed by gradually adjusting the blower voltage so as to maintain the minimum external static pressure listed in Table 4 of ASHRAE 103–1993 (incorporated by reference, see § 430.3). The airflow restrictions shall then remain unchanged. If static pressure must be varied to prevent unstable blower operation, then increase the static pressure until blower operation is stabilized, except that the static pressure must not exceed the maximum external static pressure as specified by the manufacturer in the I&O manual.

b. If the resultant temperature rise is greater than the required temperature rise, then the unit can be tested at a higher temperature rise value, but one not greater than nameplate maximum temperature rise. In order not to exceed the maximum temperature rise, the speed of a direct-driven blower may be increased by increasing the circulating air blower motor voltage.

**7.8 Measurement of jacket surface temperature.** Divide the jacket of the furnace

or boiler into 6-inch squares when practical, and otherwise into 36-square-inch regions comprising 4 inch by 9 inch or 3 inch by 12 inch sections, and determine the surface temperature at the center of each square or section with a surface thermocouple. Record the surface temperature of the 36-square-inch areas in groups where the temperature differential of the 36-square-inch areas is less than 10 °F for temperature up to 100 °F above room temperature, and less than 20 °F for temperatures more than 100 °F above room temperature. For forced-air central furnaces, the circulating air blower compartment is considered as part of the duct system, and no surface temperature measurement of the blower compartment needs to be recorded for the purpose of this test. For downflow furnaces, measure all cabinet surface temperatures of the heat exchanger and combustion section, including the bottom around the outlet duct and the burner door, using the 36-square-inch thermocouple grid. The cabinet surface temperatures around the blower section do not need to be measured (See Figure 3–E of ASHRAE 103–1993 (incorporated by reference, see § 430.3)).

**7.9 Installation of vent system.** Keep the vent or air intake system supplied by the manufacturer in place during all tests. Test units intended for installation with a variety of vent pipe lengths with the minimum vent length as specified in the I&O manual, or a 5-ft. flue pipe if there are no recommendations in the I&O manual. Do not connect a furnace or boiler employing a direct vent system to a chimney or induced-draft source. Vent combustion products solely by using the venting incorporated in the furnace or boiler and the vent or air intake system supplied by the manufacturer. For units that are not designed to significantly preheat the incoming air, see section 7.5 of this appendix and Figure 4a or 4b of ASHRAE 103–1993 (incorporated by reference, see § 430.3). For units that do significantly preheat the incoming air, see Figure 4c or 4d of ASHRAE 103–1993.

**7.10 Additional optional method of testing for determining  $D_F$  and  $D_F$  for furnaces and boilers.** On units whose design is such that there is no measurable airflow through the combustion chamber and heat exchanger when the burner(s) is (are) off as determined by the optional test procedure in section 7.10.1 of this appendix,  $D_F$  and  $D_F$  may be set equal to 0.05.

**7.10.1 Optional test method for indicating the absence of flow through the heat exchanger.** Manufacturers may use the following test protocol to determine whether air flows through the combustion chamber and heat exchanger when the burner(s) is (are) off. The minimum default draft factor (as allowed per sections 8.8.3 and 9.10 of ASHRAE 103–1993 (incorporated by reference, see § 430.3)) may be used only for units determined pursuant to this protocol to have no airflow through the combustion chamber and heat exchanger.

**7.10.1.1 Test apparatus.** Use a smoke stick that produces smoke that is easily visible and has a density less than or approximately equal to air. Use a smoke stick that produces smoke that is non-toxic to the test personnel and produces gas that is

unreactive with the environment in the test chamber.

7.10.1.2 *Test conditions.* Minimize all air currents and drafts in the test chamber, including turning off ventilation if the test chamber is mechanically ventilated. Wait at least two minutes following the termination of the furnace or boiler on-cycle before beginning the optional test method for indicating the absence of flow through the heat exchanger.

7.10.1.3 *Location of the test apparatus.* After all air currents and drafts in the test chamber have been eliminated or minimized, position the smoke stick based on the following equipment configuration: (a) For horizontal combustion air intakes, approximately 4 inches from the vertical plane at the termination of the intake vent and 4 inches below the bottom edge of the combustion air intake; or (b) for vertical combustion air intakes, approximately 4 inches horizontal from vent perimeter at the termination of the intake vent and 4 inches down (parallel to the vertical axis of the vent). In the instance where the boiler combustion air intake is closer than 4 inches to the floor, place the smoke device directly on the floor without impeding the flow of smoke.

7.10.1.4 *Duration of test.* Establish the presence of smoke from the smoke stick and then monitor the direction of the smoke flow for no less than 30 seconds.

7.10.1.5 *Test results.* During visual assessment, determine whether there is any draft of smoke into the combustion air intake vent.

If absolutely no smoke is drawn into the combustion air intake, the furnace or boiler meets the requirements to allow use of the minimum default draft factor pursuant to section 8.8.3 and/or section 9.10 of ASHRAE 103–1993 (incorporated by reference, see § 430.3).

If there is any smoke drawn into the intake, proceed with the methods of testing as prescribed in section 8.8 of ASHRAE 103–1993.

8.0 *Test procedure.* Conduct testing and measurements as specified in section 9 of ASHRAE 103–1993 (incorporated by reference, see § 430.3) except for sections 9.1.2.2.1, 9.1.2.2.2, 9.5.1.1.1, 9.5.1.2.1, 9.5.1.2.2, 9.5.2.1, 9.7.4, and 9.10; and as specified in sections 8.1 through 8.11 of this appendix. Section 8.4 of this appendix may be used in lieu of section 9.2 of ASHRAE 103–1993.

8.1 *Fuel input.* For gas units, measure and record the steady-state gas input rate in Btu/hr, including pilot gas, corrected to standard conditions of 60 °F and 30 in. Hg. Use measured values of gas temperature and pressure at the meter and barometric pressure to correct the metered gas flow rate to the above standard conditions. For oil units, measure and record the steady-state fuel input rate.

8.2 *Electrical input.* For furnaces and boilers, during the steady-state test, perform a single measurement of all of the electrical power involved in burner operation (PE), including energizing the ignition system, controls, gas valve or oil control valve, and draft inducer, if applicable. For boilers, the

measurement of PE must include the boiler pump if so equipped. If the boiler pump does not operate during the measurement of PE, add the boiler pump nameplate power to the measurement of PE. If the boiler pump nameplate power is not available, use 0.13 kW.

For furnaces, during the steady-state test, perform a single measurement of the electrical power to the circulating air blower (BE). For hot water boilers, use the circulating water pump nameplate power for BE, or if the pump nameplate power is not available, use 0.13 kW.

8.3 *Input to interrupted ignition device.* For burners equipped with an interrupted ignition device, record the nameplate electric power used by the ignition device,  $PE_{IG}$ , or record that  $PE_{IG} = 0.4$  kW if no nameplate power input is provided. Record the nameplate ignition device on-time interval,  $t_{IG}$ , or, if the nameplate does not provide the ignition device on-time interval, measure the on-time interval with a stopwatch at the beginning of the test, starting when the burner is turned on. Set  $t_{IG} = 0$  and  $PE_{IG} = 0$  if the device on-time interval is less than or equal to 5 seconds after the burner is on.

8.4 *Optional test procedures for condensing furnaces and boilers, measurement of condensate during the establishment of steady-state conditions.* For units with step-modulating or two-stage controls, conduct the test at both the maximum and reduced inputs. In lieu of collecting the condensate immediately after the steady state conditions have been reached as required by section 9.2 of ASHRAE 103–1993 (incorporated by reference, see § 430.3), condensate may be collected during the establishment of steady state conditions as defined by section 9.1.2.1 of ASHRAE 103–1993. Perform condensate collection for at least 30 minutes. Measure condensate mass immediately at the end of the collection period to prevent evaporation loss from the sample. Record fuel input for the 30-minute condensate collection test period. Observe and record fuel higher heating value (HHV), temperature, and pressures necessary for determining fuel energy input ( $Q_{c,ss}$ ). Measure the fuel quantity and HHV with errors no greater than 1%. The humidity for the room air shall at no time exceed 80%. Determine the mass of condensate for the establishment of steady state conditions ( $M_{c,ss}$ ) in pounds by subtracting the tare container weight from the total container and condensate weight measured at the end of the 30-minute condensate collection test period.

8.5 *Cool-down test for gas- and oil-fueled gravity and forced-air central furnaces without stack dampers.* Turn off the main burner after completing steady-state testing, and measure the flue gas temperature by means of the thermocouple grid described in section 7.6 of ASHRAE 103–1993 (incorporated by reference, see § 430.3) at 1.5 minutes ( $T_{F,OFF}(t_3)$ ) and 9 minutes ( $T_{F,OFF}(t_4)$ ) after shutting off the burner. When taking these temperature readings, the integral draft diverter must remain blocked and insulated, and the stack restriction must remain in place. On atmospheric systems with an integral draft diverter or draft hood and equipped with either an electromechanical

inlet damper or an electromechanical flue damper that closes within 10 seconds after the burner shuts off to restrict the flow through the heat exchanger in the off-cycle, bypass or adjust the control for the electromechanical damper so that the damper remains open during the cool-down test.

For furnaces that employ post-purge, measure the length of the post-purge period with a stopwatch. Record the time from burner “OFF” to combustion blower “OFF” (electrically de-energized) as  $t_p$ . If the measured  $t_p$  is less than or equal to 30 seconds, set  $t_p$  at 0 and conduct the cool-down test as if there is no post-purge. If  $t_p$  is prescribed by the I&O manual or measured to be greater than 180 seconds, stop the combustion blower at 180 seconds and use that value for  $t_p$ . Measure the flue gas temperature by means of the thermocouple grid described in section 7.6 of ASHRAE 103–1993 at the end of the post-purge period,  $t_p(T_{F,OFF}(t_p))$ , and at the time  $(1.5 + t_p)$  minutes ( $T_{F,OFF}(t_3)$ ) and  $(9.0 + t_p)$  minutes ( $T_{F,OFF}(t_4)$ ) after the main burner shuts off.

8.6 *Cool-down test for gas- and oil-fueled gravity and forced-air central furnaces without stack dampers and with adjustable fan control.* For a furnace with adjustable fan control, measure the time delay between burner shutdown and blower shutdown,  $t^+$ . This time delay,  $t^+$ , will be 3.0 minutes for non-condensing furnaces or 1.5 minutes for condensing furnaces or until the supply air temperature drops to a value of 40 °F above the inlet air temperature, whichever results in the longest fan on-time. For a furnace without adjustable fan control or with the type of adjustable fan control whose range of adjustment does not allow for the time delay,  $t^+$ , specified above, bypass the fan control and manually control the fan to allow for the appropriate delay time as specified in section 9.5.1.2 of ASHRAE 103–1993 (incorporated by reference, see § 430.3). For a furnace that employs a single motor to drive both the power burner and the indoor air circulating blower, the power burner and indoor air circulating blower must be stopped at the same time.

8.7 *Cool-down test for gas- and oil-fueled boilers without stack dampers.* After steady-state testing has been completed, turn the main burner(s) “OFF” and measure the flue gas temperature at 3.75 minutes (temperature designated as  $T_{F,OFF}(t_3)$ ) and 22.5 minutes (temperature designated as  $T_{F,OFF}(t_4)$ ) after the burner shut-off using the thermocouple grid described in section 7.6 of ASHRAE 103–1993 (incorporated by reference, see § 430.3).

a. During this off-period, for units that do not have pump delay after shut-off, do not allow any water to circulate through the hot water boilers.

b. For units that have pump delay on shut-off, except those having pump controls sensing water temperature, the unit control must stop the pump. Measure and record the time between burner shut-off and pump shut-off ( $t^+$ ) to the nearest second.

c. For units having pump delay controls that sense water temperature, operate the pump for 15 minutes and record  $t^+$  as 15 minutes. While the pump is operating, maintain the inlet water temperature and

flow rate at the same values as used during the steady-state test, as specified in sections 9.1 and 8.4.2.3 of ASHRAE 103–1993 (incorporated by reference, see § 430.3).

d. For boilers that employ post-purge, measure the length of the post-purge period with a stopwatch. Record the time from burner “OFF” to combustion blower “OFF” (electrically de-energized) as  $t_P$ . If  $t_P$  is prescribed by the I&O manual or measured to be greater than 180 seconds, stop the combustion blower at 180 seconds and use that value for  $t_P$ . Measure the flue gas temperature by means of the thermocouple grid described in section 7.6 of ASHRAE 103–1993 at the end of the post-purge period  $t_P$  ( $T_{F,OFF}(t_P)$ ) and at  $(3.75 + t_P)$  minutes ( $T_{F,OFF}(t_3)$ ) and  $(22.5 + t_P)$  minutes ( $T_{F,OFF}(t_4)$ ) after the main burner shuts off. If the measured  $t_P$  is less than or equal to 30 seconds, record  $t_P$  as 0 and conduct the cool-down test as if there is no post-purge.

8.8 *Direct measurement of off-cycle losses testing method.* [Reserved.]

8.9 *Calculation options.* The rate of the flue gas mass flow through the furnace and the factors  $D_P$ ,  $D_F$ , and  $D_S$  are calculated by the equations in sections 11.6.1, 11.6.2, 11.6.3, 11.6.4, 11.7.1, and 11.7.2 of ASHRAE 103–1993 (incorporated by reference, see § 430.3). On units whose design is such that there is no measurable airflow through the combustion chamber and heat exchanger when the burner(s) is (are) off (as determined by the optional test procedure in section 7.10 of this appendix),  $D_F$  and  $D_P$  may be set equal to 0.05.

8.10 *Optional test procedures for condensing furnaces and boilers that have no off-period flue losses.* For units that have applied the test method in section 7.10 of this appendix to determine that no measurable airflow exists through the combustion chamber and heat exchanger during the burner off-period and having post-purge periods of less than 5 seconds, the cool-down and heat-up tests specified in sections 9.5 and 9.6 of ASHRAE 103–1993 (incorporated by reference, see § 430.3) may be omitted. In lieu of conducting the cool-down and heat-up tests, the tester may use the losses determined during the steady-state test described in section 9.1 of ASHRAE 103–1993 when calculating heating seasonal efficiency,  $Eff_{yHS}$ .

8.11 *Measurement of electrical standby and off mode power.*

8.11.1 *Standby power measurement.* With all electrical auxiliaries of the furnace or boiler not activated, measure the standby power ( $P_{W,SB}$ ) in accordance with the procedures in IEC 62301 (incorporated by reference, see § 430.3), except that section 8.5, *Room Ambient Temperature*, of ASHRAE 103–1993 (incorporated by reference, see § 430.3) and the voltage

provision of section 8.2.1.4, *Electrical Supply*, of ASHRAE 103–1993 shall apply in lieu of the corresponding provisions of IEC 62301 at section 4.2, *Test room*, and the voltage specification of section 4.3, *Power supply*. Frequency shall be 60Hz. Clarifying further, IEC 62301 section 4.4, *Power measurement instruments*, and section 5, *Measurements*, apply in lieu of ASHRAE 103–1993 section 6.10, *Energy Flow Rate*. Measure the wattage so that all possible standby mode wattage for the entire appliance is recorded, not just the standby mode wattage of a single auxiliary. Round the recorded standby power ( $P_{W,SB}$ ) to the second decimal place, except for loads greater than or equal to 10W, which must be recorded to at least three significant figures.

8.11.2 *Off mode power measurement.* If the unit is equipped with an off switch or there is an expected difference between off mode power and standby mode power, measure off mode power ( $P_{W,OFF}$ ) in accordance with the standby power procedures in IEC 62301 (incorporated by reference, see § 430.3), except that section 8.5, *Room Ambient Temperature*, of ASHRAE 103–1993 (incorporated by reference, see § 430.3) and the voltage provision of section 8.2.1.4, *Electrical Supply*, of ASHRAE 103–1993 shall apply in lieu of the corresponding provisions of IEC 62301 at section 4.2, *Test room*, and the voltage specification of section 4.3, *Power supply*. Frequency shall be 60Hz. Clarifying further, IEC 62301 section 4.4, *Power measurement instruments*, and section 5, *Measurements*, apply for this measurement in lieu of ASHRAE 103–1993 section 6.10, *Energy Flow Rate*. Measure the wattage so that all possible off mode wattage for the entire appliance is recorded, not just the off mode wattage of a single auxiliary. If there is no expected difference in off mode power and standby mode power, let  $P_{W,OFF} = P_{W,SB}$ , in which case no separate measurement of off mode power is necessary. Round the recorded off mode power ( $P_{W,OFF}$ ) to the second decimal place, except for loads greater than or equal to 10W, in which case round the recorded value to at least three significant figures.

9.0 *Nomenclature.* Nomenclature includes the nomenclature specified in section 10 of ASHRAE 103–1993 (incorporated by reference, see § 430.3) and the following additional variables:

$Eff_{motor}$  = Efficiency of power burner motor  
 $PE_{IG}$  = Electrical power to the interrupted ignition device, kW  
 $R_{T,a}$  =  $R_{T,F}$  if flue gas is measured  
 =  $R_{T,S}$  if stack gas is measured  
 $R_{T,F}$  = Ratio of combustion air mass flow rate to stoichiometric air mass flow rate

$R_{T,S}$  = Ratio of the sum of combustion air and relief air mass flow rate to stoichiometric air mass flow rate

$t_{IG}$  = Electrical interrupted ignition device on-time, min.

$T_{a,ss,x}$  =  $T_{F,ss,x}$  if flue gas temperature is measured, °F  
 =  $T_{s,ss,x}$  if stack gas temperature is measured, °F

$y_{IG}$  = Ratio of electrical interrupted ignition device on-time to average burner on-time

$y_P$  = Ratio of power burner combustion blower on-time to average burner on-time

$E_{SO}$  = Average annual electric standby mode and off mode energy consumption, in kilowatt-hours

$P_{W,OFF}$  = Furnace or boiler off mode power, in watts

$P_{W,SB}$  = Furnace or boiler standby mode power, in watts

10.0 *Calculation of derived results from test measurements.* Perform calculations as specified in section 11 of ASHRAE 103–1993 (incorporated by reference, see § 430.3), except for sections 11.5.11.1, 11.5.11.2, and appendices B and C; and as specified in sections 10.1 through 10.11 and Figure 1 of this appendix.

10.1 *Annual fuel utilization efficiency.* The annual fuel utilization efficiency (AFUE) is as defined in sections 11.2.12 (non-condensing systems), 11.3.12 (condensing systems), 11.4.12 (non-condensing modulating systems) and 11.5.12 (condensing modulating systems) of ASHRAE 103–1993 (incorporated by reference, see § 430.3), except for the definition for the term  $Eff_{yHS}$  in the defining equation for AFUE.  $Eff_{yHS}$  is defined as:

$Eff_{yHS}$  = heating seasonal efficiency as defined in sections 11.2.11 (non-condensing systems), 11.3.11 (condensing systems), 11.4.11 (non-condensing modulating systems) and 11.5.11 (condensing modulating systems) of ASHRAE 103–1993, except that for condensing modulating systems sections 11.5.11.1 and 11.5.11.2 are replaced by sections 10.2 and 10.3 of this appendix.  $Eff_{yHS}$  is based on the assumptions that all weatherized warm air furnaces or boilers are located outdoors, that non-weatherized warm air furnaces are installed as isolated combustion systems, and that non-weatherized boilers are installed indoors.

10.2 *Part-load efficiency at reduced fuel input rate.* If the option in section 8.10 of this appendix is not employed, calculate the part-load efficiency at the reduced fuel input rate,  $Eff_{yU,R}$ , for condensing furnaces and boilers equipped with either step-modulating or two-stage controls, expressed as a percent and defined as:

$$Eff_{yU,H} = 100 - L_{L,A} + L_G - L_C - C_J L_J - \left[ \frac{t_{ON}}{t_{ON} + \left( \frac{Q_P}{Q_{IN}} \right) t_{OFF}} \right] (L_{S,ON} + L_{S,OFF} + L_{I,ON} + L_{I,OFF})$$

If the option in section 8.10 of this appendix is employed, calculate  $Effy_{U,R}$  as follows:

$$Effy_{U,H} = 100 - L_{L,A} + L_G - L_C - C_J L_J - \left[ \frac{t_{ON}}{t_{ON} + \left( \frac{Q_P}{Q_{IN}} \right) t_{OFF}} \right] (C_S)(L_{S,SS})$$

Where:

$L_{L,A}$  = value as defined in section 11.2.7 of ASHRAE 103–1993 (incorporated by reference, see § 430.3)

$L_G$  = value as defined in section 11.3.11.1 of ASHRAE 103–1993, at reduced input rate,

$L_C$  = value as defined in section 11.3.11.2 of ASHRAE 103–1993 at reduced input rate,

$L_J$  = value as defined in section 11.4.8.1.1 of ASHRAE 103–1993 at maximum input rate,

$t_{ON}$  = value as defined in section 11.4.9.11 of ASHRAE 103–1993,

$Q_P$  = pilot fuel input rate determined in accordance with section 9.2 of ASHRAE 103–1993 in Btu/h,

$Q_{IN}$  = value as defined in section 11.4.8.1.1 of ASHRAE 103–1993,

$t_{OFF}$  = value as defined in section 11.4.9.12 of ASHRAE 103–1993 at reduced input rate,

$L_{S,ON}$  = value as defined in section 11.4.10.5 of ASHRAE 103–1993 at reduced input rate,

$L_{S,OFF}$  = value as defined in section 11.4.10.6 of ASHRAE 103–1993 at reduced input rate,

$L_{I,ON}$  = value as defined in section 11.4.10.7 of ASHRAE 103–1993 at reduced input rate,

$L_{I,OFF}$  = value as defined in section 11.4.10.8 of ASHRAE 103–1993 at reduced input rate,

$C_J$  = jacket loss factor and equal to:  
= 0.0 for furnaces or boilers intended to be installed indoors

= 1.7 for furnaces intended to be installed as isolated combustion systems

= 2.4 for boilers (other than finned-tube boilers) intended to be installed as isolated combustion systems

= 3.3 for furnaces intended to be installed outdoors

= 4.7 for boilers (other than finned-tube boilers) intended to be installed outdoors  
= 1.0 for finned-tube boilers intended to be installed outdoors

= 0.5 for finned-tube boilers intended to be installed in isolated combustion system applications

$L_{S,SS}$  = value as defined in section 11.4.6 of ASHRAE 103–1993 at reduced input rate,

$C_S$  = value as defined in section 11.3.10.1 of ASHRAE 103–1993 at reduced input rate.

10.3 *Part-Load Efficiency at Maximum Fuel Input Rate.* If the option in section 8.10 of this appendix is not employed, calculate the part-load efficiency at maximum fuel input rate,  $Effy_{U,H}$ , for condensing furnaces and boilers equipped with two-stage controls, expressed as a percent and defined as:

$$Effy_{U,R} = 100 - L_{L,A} + L_G - L_C - C_J L_J - \left[ \frac{t_{ON}}{t_{ON} + \left( \frac{Q_P}{Q_{IN}} \right) t_{OFF}} \right] (L_{S,ON} + L_{S,OFF} + L_{I,ON} + L_{I,OFF})$$

If the option in section 8.10 of this appendix is employed, calculate  $Effy_{U,H}$  as follows:

$$Effy_{U,R} = 100 - L_{L,A} + L_G - L_C - C_J L_J - \left[ \frac{t_{ON}}{t_{ON} + \left( \frac{Q_P}{Q_{IN}} \right) t_{OFF}} \right] (C_S)(L_{S,SS})$$

Where:

$L_{L,A}$  = value as defined in section 11.2.7 of ASHRAE 103–1993 (incorporated by reference, see § 430.3),

$L_G$  = value as defined in section 11.3.11.1 of ASHRAE 103–1 at maximum input rate,

$L_C$  = value as defined in section 11.3.11.2 of ASHRAE 103–1993 at maximum input rate,

$L_J$  = value as defined in section 11.4.8.1.1 of ASHRAE 103–1993 at maximum input rate,

$t_{ON}$  = value as defined in section 11.4.9.11 of ASHRAE 103–1993,

$Q_P$  = pilot fuel input rate determined in accordance with section 9.2 of ASHRAE 103–1993 in Btu/h,

$Q_{IN}$  = value as defined in section 11.4.8.1.1 of ASHRAE 103–1993,

$t_{OFF}$  = value as defined in section 11.4.9.12 of ASHRAE 103–1993 at maximum input rate,

$L_{S,ON}$  = value as defined in section 11.4.10.5 of ASHRAE 103–1993 at maximum input rate,

$L_{S,OFF}$  = value as defined in section 11.4.10.6 of ASHRAE 103–1993 at maximum input rate,

$L_{I,ON}$  = value as defined in section 11.4.10.7 of ASHRAE 103–1993 at maximum input rate,

$L_{I,OFF}$  = value as defined in section 11.4.10.8 of ASHRAE 103–1993 at maximum input rate,

$C_J$  = value as defined in section 10.2 of this appendix,

$L_{S,SS}$  = value as defined in section 11.4.6 of ASHRAE 103–1993 at maximum input rate,

$C_S$  = value as defined in section 11.4.10.1 of ASHRAE 103–1993 at maximum input rate.

10.4 *National average burner operating hours, average annual fuel energy consumption, and average annual auxiliary electrical energy consumption for gas or oil furnaces and boilers.*

10.4.1 *National average number of burner operating hours.* For furnaces and boilers equipped with single-stage controls, the national average number of burner operating hours is defined as:

$BOH_{SS} = 2,080 (0.77) (A) DHR - 2,080 (B)$

Where:

2,080 = national average heating load hours  
0.77 = adjustment factor to adjust the calculated design heating requirement and heating load hours to the actual heating load experienced by the heating system

$A = 100,000/[341,300 (y_P PE + y_{IG} PE_{IG} + y BE) + (Q_{IN} - Q_P) Eff_{yHS}]$ , for forced draft unit, indoors  
 $= 100,000/[341,300 (y_P PE Eff_{motor} + y_{IG} PE_{IG} + y BE) + (Q_{IN} - Q_P) Eff_{yHS}]$ , for forced draft unit, isolated combustion system,  
 $= 100,000/[341,300 (y_P PE (1 - Eff_{motor}) + y_{IG} PE_{IG} + y BE) + (Q_{IN} - Q_P) Eff_{yHS}]$ , for induced draft unit, indoors, and  
 $= 100,000/[341,300 (y_{IG} PE_{IG} + y BE) + (Q_{IN} - Q_P) Eff_{yHS}]$ , for induced draft unit, isolated combustion system.

DHR = typical design heating requirements as listed in Table 8 (in kBtu/h) of ASHRAE 103–1993 (incorporated by reference, see § 430.3), using the proper value of  $Q_{OUT}$  defined in 11.2.8.1 of ASHRAE 103–1993.

$B = 2 Q_P (Eff_{yHS}) (A)/100,000$

Where:

$Eff_{motor}$  = nameplate power burner motor efficiency provided by the manufacturer, = 0.50, an assumed default power burner efficiency if not provided by the manufacturer.

100,000 = factor that accounts for percent and kBtu

$y_P$  = ratio of induced or forced draft blower on-time to average burner on-time, as follows:

- 1 for units without post-purge;
- $1 + (t_p/3.87)$  for single stage furnaces with post purge;
- $1 + (t_p/10)$  for two-stage and step modulating furnaces with post purge;
- $1 + (t_p/9.68)$  for single stage boilers with post purge; or
- $1 + (t_p/15)$  for two stage and step modulating boilers with post purge.

PE = all electrical power related to burner operation at full load steady-state operation, including electrical ignition device if energized, controls, gas valve or oil control valve, draft inducer, and boiler pump, as determined in section 8.2 of this appendix.

$y_{IG}$  = ratio of burner interrupted ignition device on-time to average burner on-time, as follows:

- 0 for burners not equipped with interrupted ignition device;
- $(t_{IG}/3.87)$  for single-stage furnaces or boilers;
- $(t_{IG}/10)$  for two-stage and step modulating furnaces;
- $(t_{IG}/9.68)$  for single stage boilers; or
- $(t_{IG}/15)$  for two stage and step modulating boilers.

$PE_{IG}$  = electrical input rate to the interrupted ignition device on burner (if employed), as defined in section 8.3 of this appendix

y = ratio of blower or pump on-time to average burner on-time, as follows:

- 1 for furnaces without fan delay or boilers without a pump delay;
- $1 + (t^+ - t^-)/3.87$  for single-stage furnaces with fan delay;

$1 + (t^+ - t^-)/10$  for two-stage and step modulating furnaces with fan delay;

$1 + (t^+/9.68)$  for single-stage boilers with pump delay;

$1 + (t^+/1.5)$  for two-stage and step modulating boilers with pump delay.

BE = circulating air fan or water pump electrical energy input rate at full-load steady-state operation as defined in section 8.2 of this appendix.

$t_p$  = post-purge time as defined in section 8.5 (furnace) or section 8.7 (boiler) of this appendix

= 0 if  $t_p$  is equal to or less than 30 second  
 $t_{IG}$  = on-time of the burner interrupted ignition device, as defined in section 8.3 of this appendix

$Q_{IN}$  = as defined in section 11.2.8.1 of ASHRAE 103–1993

$Q_P$  = as defined in section 11.2.11 of ASHRAE 103–1993

$Eff_{yHS}$  = as defined in section 11.2.11 (non-condensing systems) or section 11.3.11.3 (condensing systems) of ASHRAE 103–1993, percent, and calculated on the basis of:

- isolated combustion system installation, for non-weatherized warm air furnaces; indoor installation, for non-weatherized boilers; or
- outdoor installation, for furnaces and boilers that are weatherized.

2 = ratio of the average length of the heating season in hours to the average heating load hours

$t^+$  = delay time between burner shutoff and the blower or pump shutoff measured as defined in section 9.5.1.2 of ASHRAE 103–1993 (furnace) or section 8.7 of this appendix (boiler).

$t^-$  = as defined in section 9.6.1 of ASHRAE 103–1993

10.4.1.1 For furnaces and boilers equipped with two stage or step modulating controls the average annual energy used during the heating season,  $E_M$ , is defined as:  
 $E_M = (Q_{IN} - Q_P) BOH_{SS} + (8,760 - 4,600) Q_P$

Where:

$Q_{IN}$  = as defined in 11.4.8.1.1 of ASHRAE 103–1993 (incorporated by reference, see § 430.3)

$Q_P$  = as defined in 11.4.12 of ASHRAE 103–1993

$BOH_{SS}$  = as defined in section 10.4.1 of this appendix, in which the weighted  $Eff_{yHS}$  as defined in 11.4.11.3 or 11.5.11.3 of ASHRAE 103–1993 is used for calculating the values of A and B, the term DHR is based on the value of  $Q_{OUT}$  defined in 11.4.8.1.1 or 11.5.8.1.1 of ASHRAE 103–1993, and the term  $(y_P PE + y_{IG} PE_{IG} + y BE)$  in the factor A is increased by the factor R, which is defined as:

- R = 2.3 for two stage controls
- = 2.3 for step modulating controls when the ratio of minimum-to-maximum output is greater than or equal to 0.5
- = 3.0 for step modulating controls when the ratio of minimum-to-maximum output is less than 0.5

$A = 100,000/[341,300 (y_P PE + y_{IG} PE_{IG} + y BE) R + (Q_{IN} - Q_P) Eff_{yHS}]$ , for forced draft unit, indoors

$= 100,000/[341,300 (y_P PE Eff_{motor} + y_{IG} PE_{IG} + y BE) R + (Q_{IN} - Q_P) Eff_{yHS}]$ , for forced draft unit, isolated combustion system,

$= 100,000/[341,300 (y_P PE (1 - Eff_{motor}) + y_{IG} PE_{IG} + y BE) R + (Q_{IN} - Q_P) Eff_{yHS}]$ , for induced draft unit, indoors, and  
 $= 100,000/[341,300 (y_{IG} PE_{IG} + y BE) R + (Q_{IN} - Q_P) Eff_{yHS}]$ , for induced draft unit, isolated combustion system.

Where:

$Eff_{motor}$  = nameplate power burner motor efficiency provided by the manufacturer, = 0.50, an assumed default power burner efficiency if not provided by the manufacturer.

$Eff_{yHS}$  = as defined in 11.4.11.3 or 11.5.11.3 of ASHRAE 103–1993, and calculated on the basis of:

- isolated combustion system installation, for non-weatherized warm air furnaces; indoor installation, for non-weatherized boilers; or
- outdoor installation, for furnaces and boilers that are weatherized.

8,760 = total number of hours per year

4,600 = as defined in 11.4.12 of ASHRAE 103–1993

10.4.1.2 For furnaces and boilers equipped with two-stage or step-modulating controls, the national average number of burner operating hours at the reduced operating mode ( $BOH_R$ ) is defined as:

$BOH_R = X_R E_M / Q_{IN,R}$

Where:

$X_R$  = as defined in 11.4.8.7 of ASHRAE 103–1993 (incorporated by reference, see § 430.3)

$E_M$  = as defined in section 10.4.1.1 of this appendix

$Q_{IN,R}$  = as defined in 11.4.8.1.2 of ASHRAE 103–1993

10.4.1.3 For furnaces and boilers equipped with two-stage controls, the national average number of burner operating hours at the maximum operating mode ( $BOH_H$ ) is defined as:

$BOH_H = X_H E_M / Q_{IN}$

Where:

$X_H$  = as defined in 11.4.8.6 of ASHRAE 103–1993 (incorporated by reference, see § 430.3)

$E_M$  = as defined in section 10.4.1.1 of this appendix

$Q_{IN}$  = as defined in section 11.4.8.1.1 of ASHRAE 103–1993

10.4.1.4 For furnaces and boilers equipped with step-modulating controls, the national average number of burner operating hours at the modulating operating mode ( $BOH_M$ ) is defined as:

$BOH_M = X_H E_M / Q_{IN,M}$

Where:

$X_H$  = as defined in 11.4.8.6 of ASHRAE 103–1993 (incorporated by reference, see § 430.3)

$E_M$  = as defined in section 10.4.1.1 of this appendix

$Q_{IN,M} = Q_{OUT,M} / (Eff_{ySS,M} / 100)$

$Q_{OUT,M}$  = as defined in 11.4.8.10 or 11.5.8.10 of ASHRAE 103–1993, as appropriate

$Eff_{ySS,M}$  = as defined in 11.4.8.8 or 11.5.8.8 of ASHRAE 103–1993, as appropriate, in percent

100 = factor that accounts for percent

10.4.2 *Average annual fuel energy consumption for gas or oil fueled furnaces or boilers.* For furnaces or boilers equipped with single-stage controls, the average annual fuel energy consumption ( $E_F$ ) is expressed in Btu per year and defined as:

$$E_F = BOH_{SS} (Q_{IN} - Q_P) + 8,760 Q_P$$

Where:

$BOH_{SS}$  = as defined in section 10.4.1 of this appendix

$Q_{IN}$  = as defined in section 11.2.8.1 of ASHRAE 103–1993 (incorporated by reference, see § 430.3)

$Q_P$  = as defined in section 11.2.11 of ASHRAE 103–1993

8,760 = as defined in section 10.4.1.1 of this appendix

10.4.2.1 For furnaces or boilers equipped with either two-stage or step modulating controls,  $E_F$  is defined as:

$$E_F = E_M + 4,600 Q_P$$

Where:

$E_M$  = as defined in section 10.4.1.1 of this appendix

4,600 = as defined in section 11.4.12 of ASHRAE 103–1993

$Q_P$  = as defined in section 11.2.11 of ASHRAE 103–1993

10.4.3 *Average annual auxiliary electrical energy consumption for gas or oil-fueled furnaces or boilers.* For furnaces and boilers equipped with single-stage controls, the average annual auxiliary electrical consumption ( $E_{AE}$ ) is expressed in kilowatt-hours and defined as:

$$E_{AE} = BOH_{SS} (y_P PE + y_{IG} PE_{IG} + y_{BE}) + E_{SO}$$

Where:

$BOH_{SS}$  = as defined in section 10.4.1 of this appendix

$y_P$  = as defined in section 10.4.1 of this appendix

$PE$  = as defined in section 10.4.1 of this appendix

$y_{IG}$  = as defined in section 10.4.1 of this appendix

$PE_{IG}$  = as defined in section 10.4.1 of this appendix

$y$  = as defined in section 10.4.1 of this appendix

$BE$  = as defined in section 10.4.1 of this appendix

$E_{SO}$  = as defined in section 10.11 of this appendix

10.4.3.1 For furnaces or boilers equipped with two-stage controls,  $E_{AE}$  is defined as:

$$E_{AE} = BOH_R (y_P PE_R + y_{IG} PE_{IG} + y_{BE_R}) + BOH_H (y_P PE_H + y_{IG} PE_{IG} + y_{BE_H}) + E_{SO}$$

Where:

$BOH_R$  = as defined in section 10.4.1.2 of this appendix

$y_P$  = as defined in section 10.4.1 of this appendix

$PE_R$  = as defined in section 8.2 of this appendix and measured at the reduced fuel input rate

$y_{IG}$  = as defined in section 10.4.1 of this appendix

$PE_{IG}$  = as defined in section 10.4.1 of this appendix

$y$  = as defined in section 10.4.1 of this appendix

$BE_R$  = as defined in section 8.2 of this appendix and measured at the reduced fuel input rate

$BOH_H$  = as defined in section 10.4.1.3 of this appendix

$PE_H$  = as defined in section 8.2 of this appendix and measured at the maximum fuel input rate

$BE_H$  = as defined in section 8.2 of this appendix and measured at the maximum fuel input rate

$E_{SO}$  = as defined in section 10.11 of this appendix

10.4.3.2 For furnaces or boilers equipped with step-modulating controls,  $E_{AE}$  is defined as:

$$E_{AE} = BOH_R (y_P PE_R + y_{IG} PE_{IG} + y_{BE_R}) + BOH_M (y_P PE_H + y_{IG} PE_{IG} + y_{BE_H}) + E_{SO}$$

Where:

$BOH_R$  = as defined in section 10.4.1.2 of this appendix

$y_P$  = as defined in section 10.4.1 of this appendix

$PE_R$  = as defined in section 8.2 of this appendix and measured at the reduced fuel input rate

$y_{IG}$  = as defined in section 10.4.1 of this appendix

$PE_{IG}$  = as defined in section 10.4.1 of this appendix

$y$  = as defined in section 10.4.1 of this appendix

$BE_R$  = as defined in section 8.2 of this appendix and measured at the reduced fuel input rate

$BOH_M$  = as defined in 10.4.1.4 of this appendix

$PE_H$  = as defined in section 8.2 of this appendix and measured at the maximum fuel input rate

$BE_H$  = as defined in section 8.2 of this appendix and measured at the maximum fuel input rate

$E_{SO}$  = as defined in section 10.11 of this appendix

10.5 *Average annual electric energy consumption for electric furnaces or boilers.* For electric furnaces and boilers, the average annual electrical energy consumption ( $E_E$ ) is expressed in kilowatt-hours and defined as:

$$E_E = 100 (2,080) (0.77) DHR (3.412 AFUE) + E_{SO}$$

Where:

100 = to express a percent as a decimal

2,080 = as defined in section 10.4.1 of this appendix

0.77 = as defined in section 10.4.1 of this appendix

DHR = as defined in section 10.4.1 of this appendix

3.412 = conversion factor from watt-hours to Btu

AFUE = as defined in section 11.1 of ASHRAE 103–1993 (incorporated by reference, see § 430.3), in percent, and calculated on the basis of:

isolated combustion system installation, for non-weatherized warm air furnaces;

indoor installation, for non-weatherized boilers; or

outdoor installation, for furnaces and boilers that are weatherized.

$E_{SO}$  = as defined in section 10.11 of this appendix.

10.6 *Energy factor.*

10.6.1 *Energy factor for gas or oil furnaces and boilers.* Calculate the energy factor, EF, for gas or oil furnaces and boilers defined as, in percent:

$$EF = (E_F - 4,600 (Q_P)) (Eff_{yHS}) / (E_F + 3,412 (E_{AE}))$$

Where:

$E_F$  = average annual fuel consumption as defined in section 10.4.2 of this appendix

4,600 = as defined in section 11.4.12 of ASHRAE 103–1993 (incorporated by reference, see § 430.3)

$Q_P$  = pilot fuel input rate determined in accordance with section 9.2 of ASHRAE 103–1993 in Btu/h

$Eff_{yHS}$  = annual fuel utilization efficiency as defined in sections 11.2.11, 11.3.11, 11.4.11 or 11.5.11 of ASHRAE 103–1993, in percent, and calculated on the basis of:

isolated combustion system installation, for non-weatherized warm air furnaces; indoor installation, for non-weatherized boilers; or outdoor installation, for furnaces and boilers that are weatherized.

3,412 = conversion factor from kW to Btu/h

$E_{AE}$  = as defined in section 10.4.3 of this appendix

10.6.2 *Energy factor for electric furnaces and boilers.* The energy factor, EF, for electric furnaces and boilers is defined as:

$$EF = AFUE$$

Where:

AFUE = annual fuel utilization efficiency as defined in section 10.4.3 of this appendix, in percent

10.7 *Average annual energy consumption for furnaces and boilers located in a different geographic region of the United States and in buildings with different design heating requirements.*

10.7.1 *Average annual fuel energy consumption for gas or oil-fueled furnaces and boilers located in a different geographic region of the United States and in buildings with different design heating requirements.*

For gas or oil-fueled furnaces and boilers, the average annual fuel energy consumption for a specific geographic region and a specific typical design heating requirement ( $E_{FR}$ ) is expressed in Btu per year and defined as:

$$E_{FR} = (E_F - 8,760 Q_P) (HLH/2,080) + 8,760 Q_P$$

Where:

$E_F$  = as defined in section 10.4.2 of this appendix

8,760 = as defined in section 10.4.1.1 of this appendix

$Q_P$  = as defined in section 11.2.11 of ASHRAE 103–1993 (incorporated by reference, see § 430.3)

HLH = heating load hours for a specific geographic region determined from the heating load hour map in Figure 1 of this appendix

2,080 = as defined in section 10.4.1 of this appendix

10.7.2 *Average annual auxiliary electrical energy consumption for gas or oil-fueled furnaces and boilers located in a different geographic region of the United States and in*

buildings with different design heating requirements. For gas or oil-fueled furnaces and boilers, the average annual auxiliary electrical energy consumption for a specific geographic region and a specific typical design heating requirement ( $E_{AER}$ ) is expressed in kilowatt-hours and defined as:

$$E_{AER} = (E_{AE} - E_{SO}) (HLH/2080) + E_{SOR}$$

Where:

$E_{AE}$  = as defined in section 10.4.3 of this appendix

$E_{SO}$  = as defined in section 10.11 of this appendix

HLH = as defined in section 10.7.1 of this appendix

2,080 = as defined in section 10.4.1 of this appendix

$E_{SOR}$  = as defined in section 10.7.3 of this appendix.

10.7.3 *Average annual electric energy consumption for electric furnaces and boilers located in a different geographic region of the United States and in buildings with different design heating requirements.* For electric furnaces and boilers, the average annual electric energy consumption for a specific geographic region and a specific typical design heating requirement ( $E_{ER}$ ) is expressed in kilowatt-hours and defined as:

$$E_{ER} = 100 (0.77) DHR HLH / (3.412 AFUE) + E_{SOR}$$

Where:

100 = as defined in section 10.4.3 of this appendix

0.77 = as defined in section 10.4.1 of this appendix

DHR = as defined in section 10.4.1 of this appendix

HLH = as defined in section 10.7.1 of this appendix

3.412 = as defined in section 10.4.3 of this appendix

AFUE = as defined in section 10.4.3 of this appendix

$E_{SOR}$  =  $E_{SO}$  as defined in section 10.11 of this appendix, except that in the equation for  $E_{SO}$ , the term BOH is multiplied by the expression (HLH/2080) to get the appropriate regional accounting of standby mode and off mode loss.

10.8 *Annual energy consumption for mobile home furnaces*

10.8.1 *National average number of burner operating hours for mobile home furnaces ( $BOH_{SS}$ ).*  $BOH_{SS}$  is the same as in section

10.4.1 of this appendix, except that the value of  $E_{FF}_{HS}$  in the calculation of the burner operating hours,  $BOH_{SS}$ , is calculated on the basis of a direct vent unit with system number 9 or 10.

10.8.2 *Average annual fuel energy for mobile home furnaces ( $E_F$ ).*  $E_F$  is same as in section 10.4.2 of this appendix except that the burner operating hours,  $BOH_{SS}$ , is calculated as specified in section 10.8.1 of this appendix.

10.8.3 *Average annual auxiliary electrical energy consumption for mobile home furnaces ( $E_{AE}$ ).*  $E_{AE}$  is the same as in section 10.4.3 of this appendix, except that the burner operating hours,  $BOH_{SS}$ , is calculated as specified in section 10.8.1 of this appendix.

10.9 *Calculation of sales weighted average annual energy consumption for mobile home furnaces.* To reflect the distribution of mobile homes to geographical regions with average  $HLH_{MHF}$  values different from 2,080, adjust the annual fossil fuel and auxiliary electrical energy consumption values for mobile home furnaces using the following adjustment calculations.

10.9.1 For mobile home furnaces, the sales weighted average annual fossil fuel energy consumption is expressed in Btu per year and defined as:

$$E_{F,MHF} = (E_F - 8,760 Q_P) HLH_{MHF} / 2,080 + 8,760 Q_P$$

Where:

$E_F$  = as defined in section 10.8.2 of this appendix

8,760 = as defined in section 10.4.1.1 of this appendix

$Q_P$  = as defined in section 10.2 of this appendix

$HLH_{MHF}$  = 1880, sales weighted average heating load hours for mobile home furnaces

2,080 = as defined in section 10.4.1 of this appendix

10.9.2 For mobile home furnaces, the sales-weighted-average annual auxiliary electrical energy consumption is expressed in kilowatt-hours and defined as:

$$E_{AE,MHF} = E_{AE} HLH_{MHF} / 2,080$$

Where:

$E_{AE}$  = as defined in section 10.8.3 of this appendix

$HLH_{MHF}$  = as defined in section 10.9.1 of this appendix

2,080 = as defined in section 10.4.1 of this appendix

10.10 *Direct determination of off-cycle losses for furnaces and boilers equipped with thermal stack dampers.* [Reserved.]

10.11 *Average annual electrical standby mode and off mode energy consumption.* Calculate the annual electrical standby mode and off mode energy consumption ( $E_{SO}$ ) in kilowatt-hours, defined as:

$$E_{SO} = (P_{W,SB} (4160 - BOH) + 4600 P_{W,OFF}) / K$$

Where:

$P_{W,SB}$  = furnace or boiler standby mode power, in watts, as measured in section 8.11.1 of this appendix

4,160 = average heating season hours per year

BOH = total burner operating hours as calculated in section 10.4 of this appendix for gas or oil-fueled furnaces or boilers. Where for gas or oil-fueled furnaces and boilers equipped with single-stage controls,  $BOH = BOH_{SS}$ ; for gas or oil-fueled furnaces and boilers equipped with two-stage controls,  $BOH = (BOH_R + BOH_H)$ ; and for gas or oil-fueled furnaces and boilers equipped with step-modulating controls,  $BOH = (BOH_R + BOH_M)$ . For electric furnaces and boilers,  $BOH = 100(2080)(0.77)DHR / (E_{in} 3.412(AFUE))$

4,600 = as defined in section 11.4.12 of ASHRAE 103–1993 (incorporated by reference, see § 430.3)

$P_{W,OFF}$  = furnace or boiler off mode power, in watts, as measured in section 8.11.2 of this appendix

$K = 0.001$  kWh/Wh, conversion factor from watt-hours to kilowatt-hours

Where:

100 = to express a percent as a decimal

2,080 = as defined in section 10.4.1 of this appendix

0.77 = as defined in section 10.4.1 of this appendix

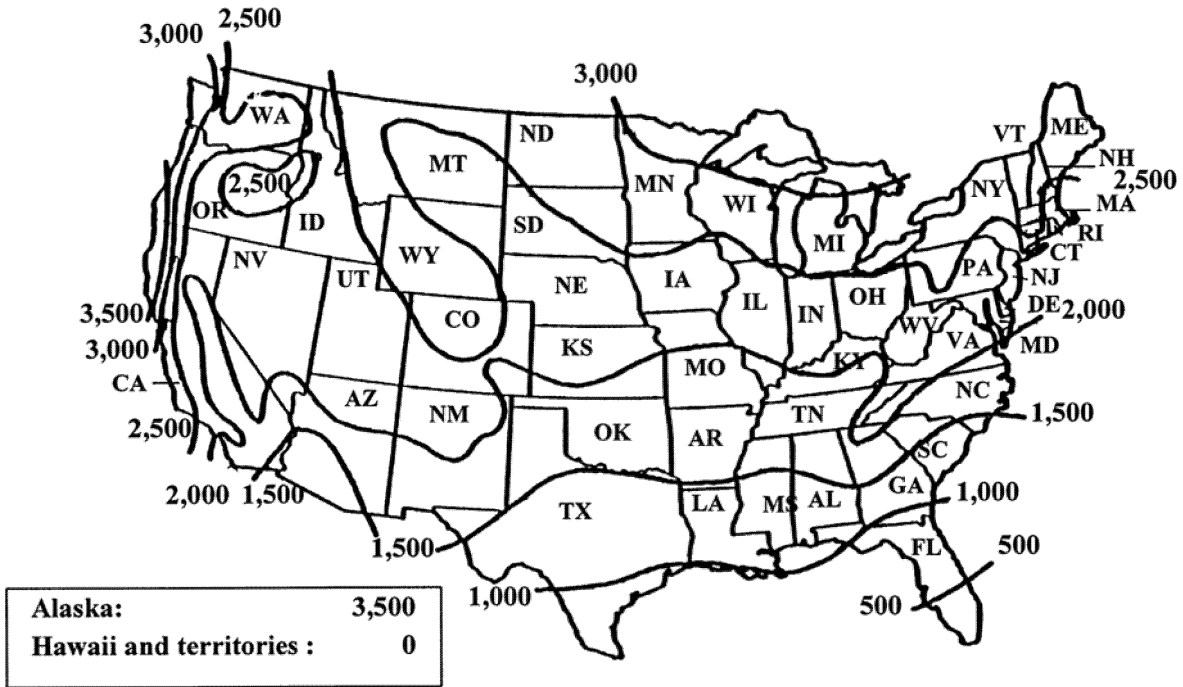
DHR = as defined in section 10.4.1 of this appendix

$E_{in}$  = steady-state electric rated power, in kilowatts, from section 9.3 of ASHRAE 103–1993

3.412 = as defined in section 10.4.3 of this appendix

AFUE = as defined in section 11.1 of ASHRAE 103–1993 in percent





This map is reasonably accurate for most parts of the United States but is necessarily generalized, and consequently not too accurate in mountainous regions, particularly in the Rockies.

FIGURE 1- HEATING LOAD HOURS (HLH) FOR THE UNITED STATES