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DEPARTMENT OF ENERGY

10 CFR Parts 429 and 431

Docket No. EERE-2014-BT-TP-0006

RIN 1904-AD16

Energy Conservation Program: Test Procedure for Commercial Packaged Boilers

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

ACTION: Final rule.

SUMMARY: On March 17, 2016, the U.S. Department of Energy (DOE) issued a notice of proposed rulemaking (NOPR) to amend the test procedure for commercial packaged boilers. That proposed rulemaking serves as the basis for the final rule. DOE incorporates by reference certain sections of the American National Standards Institute (ANSI)/Air-Conditioning, Heating, and Refrigeration Institute (AHRI) Standard 1500, "2015 Standard for Performance Rating of Commercial Space Heating Boilers." In addition, this final rule incorporates amendments that clarify the coverage for field-constructed commercial packaged boilers and the applicability of DOE's test procedure and standards for this category of commercial packaged boilers, provide an optional field test for commercial packaged boilers with fuel input rate greater than 5,000,000 Btu/h, provide a conversion method to calculate thermal efficiency based on combustion efficiency testing for steam commercial packaged boilers with fuel input rate greater than

5,000,000 Btu/h, modify the inlet water temperatures during tests of hot water commercial packaged boilers, establish limits on the ambient temperature during testing, modify setup and instrumentation requirements to remove ambiguity, and standardize terminology and provisions for "rated input" and "fuel input rate."

DATES: The effective date of this rule is [**INSERT DATE 30 DAYS AFTER DATE OF PUBLICATION IN THE FEDERAL REGISTER**]. The final rule changes will be mandatory for representations related to energy efficiency or energy use starting [**INSERT DATE 360 DAYS AFTER DATE OF PUBLICATION IN THE FEDERAL REGISTER**]. The incorporation by reference of certain publications listed in this rule is approved by the Director of the Federal Register on **[INSERT DATE 30 DAYS AFTER DATE OF PUBLICATION IN THE FEDERAL REGISTER].**

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. All documents in the docket are listed in the www.regulations.gov index. However, some documents listed in the index, such as those containing information that is exempt from public disclosure, may not be publicly available.

A link to the docket web page can be found at https://www.regulations.gov/docket?D=EERE-2014-BT-TP-0006. The docket web page will contain simple instructions on how to access all documents, including public comments, in the docket.

For further information on how to review the docket, contact the Appliance and Equipment Standards Program Staff, at (202) 586-6636 or by email: ApplianceStandardsQuestions@EE.DOE.Gov

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SUPPLEMENTARY INFORMATION:

This final rule incorporates by reference into 10 CFR parts 429 and 431 the testing methods contained in the following commercial standard:

Part 429 – ANSI/AHRI Standard 1500-2015, ("ANSI/AHRI Standard 1500-2015"), "2015 Standard for Performance Rating of Commercial Space Heating Boilers," ANSI approved November 28, 2014: Figure C9, Suggested Piping Arrangement for Hot Water Boilers.

Part 431 - ANSI/AHRI Standard 1500-2015, ("ANSI/AHRI Standard 1500-2015"), "2015 Standard for Performance Rating of Commercial Space Heating Boilers," Section 3 "Definitions," Section 5 "Rating Requirements," Appendix C "Methods of Testing for Rating Commercial Space Heating Boilers – Normative," Appendix D "Properties of Saturated Steam – Normative," and Appendix E "Correction Factors for Heating Values of Fuel Gases – Normative," ANSI approved November 28, 2014.

Copies of AHRI standards may be purchased from the Air-Conditioning, Heating, and Refrigeration Institute, 2111 Wilson Blvd., Suite 500, Arlington, VA 22201, or by visiting http://www.ahrinet.org/site/686/Standards/HVACR-Industry-Standards/Search-Standards.

See section IV.N for additional information about this standard.

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I. Authority and Background

Packaged boilers are included in the list of "covered equipment" for which the U.S. Department of Energy (DOE) is authorized to establish and amend energy conservation standards and test procedures. (42 U.S.C. 6311(1)(J)) DOE's energy conservation standards and test procedure for commercial packaged boilers, a subset of packaged boilers, are currently prescribed at 10 CFR 431.87 and 10 CFR 431.86, respectively. The following sections discuss DOE's authority to establish test procedures for commercial packaged boilers and relevant background information regarding DOE's consideration of test procedures for this equipment.

A. Authority

Title III of the Energy Policy and Conservation Act of 1975 (42 U.S.C. 6291, et seq.; "EPCA" or, "the Act")[1] sets forth a variety of provisions designed to improve energy efficiency. Part C of title III, which for editorial reasons was redesignated as Part A-1 upon incorporation into the U.S. Code (42 U.S.C. 6311–6317, as codified),

[1] All references to EPCA refer to the statute as amended through the Energy Efficiency Improvement act of 2015, Public Law 114-11 (April 30, 2015).

establishes the "Energy Conservation Program for Certain Industrial Equipment." The covered industrial equipment includes packaged boilers, the subject of this document. (42 U.S.C. 6311(1)(J))

Under EPCA, the energy conservation program consists essentially 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 use as the basis for (1) certifying to DOE that their products comply with the applicable energy conservation standards adopted under EPCA, and (2) making representations about the efficiency of those products. Similarly, DOE must use these test procedures to determine whether the products comply with any relevant standards promulgated under EPCA.

Under 42 U.S.C. 6314, EPCA sets forth the criteria and procedures DOE must follow when prescribing or amending test procedures for covered equipment. EPCA provides 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 covered equipment during a representative average use cycle or period of use and shall not be unduly burdensome to conduct. (42 U.S.C. 6314(a)(2))

In addition, if DOE determines that a test procedure amendment is warranted, it must publish a proposed test procedure and offer the public an opportunity to present oral and written comments on it. (42 U.S.C. 6314(b)) Finally, in any rulemaking to amend a

test procedure, DOE must determine to what extent, if any, the proposed test procedure would alter the measured energy efficiency of the covered equipment as determined under the existing test procedure. (42 U.S.C. 6314(a)(4)(C))

With respect to commercial packaged boilers, EPCA requires DOE to use industry test procedures developed or recognized by the Air-Conditioning, Heating, and Refrigeration Institute (AHRI) or the American Society of Heating, Refrigerating, and Air-Conditioning Engineers (ASHRAE), as referenced in ASHRAE/IES Standard 90.1, "Energy Standard for Buildings Except Low-Rise Residential Buildings." (42 U.S.C. 6314(a)(4)(A)) Further, if such an industry test procedure is amended, DOE is required to amend its test procedure to be consistent with the amended industry test procedure, unless it determines, by rule published in the Federal Register and supported by clear and convincing evidence, that the amended test procedure would be unduly burdensome to conduct or would not produce test results that reflect the energy efficiency, energy use, and estimated operating costs of that equipment during a representative average use cycle. (42 U.S.C. 6314(a)(4)(B))

EPCA also requires that, at least once every 7 years, DOE evaluate test procedures for each type of covered equipment, including commercial packaged boilers, to determine whether amended test procedures would more accurately or fully comply with the requirements for test procedures to not be unduly burdensome to conduct and be reasonably designed to produce test results that reflect energy efficiency, energy use, and estimated operating costs during a representative average use cycle. (42 U.S.C. 6314(a)(1)(A)) DOE last reviewed the test procedures for commercial packaged boilers

on July 22, 2009. 74 FR 36312. Therefore, DOE is required to re-evaluate the test procedures no later than July 22, 2016, and this rulemaking has been undertaken in fulfillment of that requirement. As the industry standard for commercial packaged boilers was recently updated, this rulemaking will also fulfill DOE's statutory obligations to make its test procedure consistent with the applicable industry test procedure.

Prior to [**INSERT DATE 360 DAYS AFTER DATE OF PUBLICATION IN THE FEDERAL REGISTER**], manufacturers must make any representations with respect to the energy use or efficiency of commercial packaged boilers in accordance with the results of testing pursuant to the new appendix A to subpart E of part 431 or the existing test procedure, as it appeared in 10 CFR 431.86, revised as of January 1, 2016. After [**INSERT DATE 360 DAYS AFTER DATE OF PUBLICATION IN THE FEDERAL REGISTER**], manufacturers must make any representations with respect to energy use or efficiency in accordance with the results of testing pursuant to appendix A to subpart E of part 431.

B. Background

On September 3, 2013, DOE initiated a test procedure and energy conservation standards rulemaking for commercial packaged boilers and published a notice of public meeting and availability of the Framework document (September 2013 Framework document). 78 FR 54197. Both in the September 2013 Framework document and during the October 1, 2013 public meeting, DOE solicited public comments, data, and information on all aspects of, and any issues or problems with, the existing DOE test procedure, including whether the test procedure was in need of updates or revisions.

DOE also received comments on the test procedure in response to the notice of availability of the preliminary technical support document (TSD) for the standards rulemaking, which was published in the Federal Register on November 20, 2014 (November 2014 Preliminary Analysis). 79 FR 69066.

Additionally, on February 20, 2014, DOE published in the Federal Register a request for information (February 2014 RFI) seeking comments on the existing DOE test procedure for commercial packaged boilers, which incorporates by reference Hydronics Institute (HI)/AHRI Standard BTS–2000 (Rev 06.07), "Method to Determine Efficiency of Commercial Space Heating Boilers" (BTS–2000). 79 FR 9643. BTS–2000 provides test procedures for measuring steady-state combustion and thermal efficiency of a gas-fired or oil-fired commercial packaged boiler capable of producing hot water and/or steam and operating at full load only. In the February 2014 RFI, DOE requested comments, information, and data about a number of issues, including (1) part-load testing and part-load efficiency rating, (2) typical inlet and outlet water temperatures for hot water commercial packaged boilers, (3) the steam pressure for steam commercial packaged boilers operating at full load, and (4) design characteristics of commercial packaged boilers that are difficult to test under the existing DOE test procedure.

On April 29, 2015, AHRI, together with the American National Standards Institute (ANSI), published the "2015 Standard for Performance Rating of Commercial Space Heating Boilers" (ANSI/AHRI Standard 1500-2015). ANSI/AHRI Standard 1500-2015 states "this standard supersedes AHRI Hydronics Institute Standard BTS-2000 Rev.

06.07" in the front matter of the document. On May 29, 2015, AHRI submitted a request directly to DOE to update the incorporation by reference in the DOE test procedure to reference the new ANSI/AHRI Standard 1500-2015. (Docket EERE-2014-BT-TP-0006, AHRI, No. 29 at p. 1)[2]

Subsequently, DOE published a notice of proposed rulemaking (NOPR) on March 17, 2016, in the Federal Register (hereafter March 2016 NOPR). 81 FR 14642. DOE proposed to incorporate by reference relevant sections of ANSI/AHRI Standard 1500-2015 as a replacement for BTS–2000 in the DOE test procedure as well as several modifications to its test procedure that are not captured in ANSI/AHRI Standard 1500-2015. The additional proposed amendments included the following:

- Clarifying the coverage of field-constructed commercial packaged boilers under DOE's regulations;

- Incorporating an optional field test for commercial packaged boilers with fuel input rate greater than 5,000,000 Btu/h;

- Incorporating an optional conversion method to calculate thermal efficiency based on the combustion efficiency test for steam commercial packaged boilers with fuel input rate greater than 5,000,000 Btu/h;

[2] A notation in this form provides a reference for information that is in Docket No. EERE-2014-BT-TP-0006..., which is maintained at https://www.regulations.gov/docket?D=EERE-2014-BT-TP-0006. The references are arranged as follows: (commenter name, comment docket ID number, page of that document). This particular notation refers to a comment from AHRI on p. 1 of document number 29 in the docket.

- Modifying the inlet and outlet water temperatures required during tests of hot water commercial packaged boilers to be more representative of field conditions;

- Requiring additional limits on the room ambient temperature and relative humidity during testing;

- Modifying setup and instrumentation requirements to remove ambiguity; and

- Standardizing terminology and provisions in regulatory text related to "fuel input rate."

In this final rule, DOE is replacing BTS-2000 with the updated industry standard, ANSI/AHRI Standard 1500-2015, as the basis for the DOE test procedure. DOE is also adopting certain proposals from the March 2016 NOPR and has modified some proposals from the March 2016 NOPR in light of comments received. Section III contains a more detailed discussion of the basis for transitioning to the commercial packaged boiler test procedures outlined in ANSI/AHRI Standard 1500-2015 as well as the additional amendments being adopted.

II. Synopsis of the Final Rule

In this final rule, DOE amends subpart E of 10 CFR part 431 as follows:

- Clarifies definitions regarding commercial packaged boilers;
- Incorporates by reference certain provisions of the current revision to the applicable industry standard: ANSI/AHRI Standard 1500-2015 "2015 Standard for Performance Rating of Commercial Space Heating Boilers;"
- Provides an optional field test and an optional conversion calculation from combustion to thermal efficiency for commercial packaged boilers with rated input greater than 5,000,000 Btu/h;
- Modifies the inlet water temperature requirements for commercial packaged boilers;
- Reduces the allowable range for ambient room temperature during testing;
- Provides additional specificity in set-up and instrumentation; and
- Requires digital data acquisition for certain parameters.

The final rule also amends 10 CFR part 429 to clarify certification and enforcement procedures, specifically to provide for the verification of rated input and to accommodate certification based on the optional field test.

III. Discussion

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

Table III.1 presents the list of interested parties that submitted written comments in response to the March 2016 NOPR.

Table III.1 Interested Parties Providing Written Comment in Response to the March 2016 NOPR

Document Docket ID Number	Name	Acronym	Type
36, 46	Air-Conditioning, Heating, & Refrigeration Institute	AHRI	Trade Association
38	American Boiler Manufacturers Association	ABMA	Trade Association
42	American Gas Association and American Public Gas Association	Gas Associations (AGA and APGA)	Trade Association
45	Appliance Standards Awareness Project, Alliance to Save Energy, American Council for an Energy-Efficient Economy, and Natural Resources Defense Council	Efficiency Advocates (ASAP, ASE, ACEEE, and NRDC)	Advocate
39	Bradford White Corporation	BWC	Manufacturer
40	Burnham Holdings, Inc.	Burnham	Manufacturer
48	California Investor Owned Utilities	CA IOUs	Utility Association
35	Council of Industrial Boiler Owners	CIBO	Trade Association
43	Lochinvar, LLC	Lochinvar	Manufacturer
44	Northwest Energy Efficiency Alliance	NEEA	Advocate

47	Raypak, Inc.	Raypak	Manufacturer
31	Tahir Khan	Khan	Individual
41	Weil-McLain	Weil-McLain	Manufacturer
33	Veritatis	Veritatis	Consultant

Interested parties provided comments on a range of issues, including both issues raised by DOE for comment, as well as other issues related to the proposed changes to the test procedure. 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.

A. Scope and Definitions

In this final rule, DOE adopts several new definitions that help further clarify the scope and applicability of DOE's commercial packaged boiler test procedure. DOE notes that these amendments to DOE's definitions at 10 CFR 431.82 also apply to DOE's energy conservation standards for commercial packaged boilers.

1. Definition of Commercial Packaged Boiler

While EPCA authorizes DOE to establish, subject to certain criteria, test procedures and energy conservation standards for packaged boilers, to date, DOE has only established test procedures and standards for commercial packaged boilers, a subset of packaged boilers. In 2004, DOE published a final rule (October 2004 final rule) establishing definitions, test procedures, and energy conservation standards for

commercial packaged boilers. 69 FR 61949 (Oct. 21, 2004). In the October 2004 final rule, DOE defined "commercial packaged boiler" as a type of packaged low pressure boiler that is industrial equipment with a capacity (fuel input rate) of 300,000 Btu per hour (Btu/h) or more which, to any significant extent, is distributed in commerce: (1) for heating or space conditioning applications in buildings; or (2) for service water heating in buildings but does not meet the definition of "hot water supply boiler." 69 FR 61949, 61960. DOE also defined "packaged low pressure boiler" as a packaged boiler that is: (1) a steam boiler designed to operate at or below a steam pressure of 15 psig; or (2) a hot water commercial packaged boiler designed to operate at or below a water pressure of 160 psig and a temperature of 250 °F; or (3) a boiler that is designed to be capable of supplying either steam or hot water, and designed to operate under the conditions in paragraphs (1) and (2) of this definition. 69 FR 61949, 61960.

DOE notes that, because commercial packaged boilers are currently defined as a subset of packaged low pressure boilers, commercial packaged boilers are also defined by the pressure and temperature criteria established in the definition of a "packaged low pressure boiler." Consequently, DOE proposed in the March 2016 NOPR a definition of "commercial packaged boiler" that explicitly includes the pressure and temperature criteria established by the "packaged low pressure boiler" definition, and to remove its definitions for "packaged low pressure boiler" and "packaged high pressure boiler" as those definitions would no longer be necessary. DOE stated that it believed such a modification would clarify the characteristics of the equipment to which DOE's test procedure and energy conservation standards apply.

In response to the March 2016 NOPR, AHRI and Bradford White supported DOE's proposals to modify its commercial packaged boiler definition and to remove the extraneous definitions. (Bradford White, No. 39 at p. 2; AHRI, No. 46 at p. 8) No commenters in response to the March 2016 NOPR raised concerns over the proposal. DOE therefore adopts these proposed changes in this final rule.

DOE's amended definition for commercial packaged boilers also includes exclusionary language for field-constructed equipment (discussed in section III.A.2) as was proposed in the March 2016 NOPR. This exclusion was previously part of DOE's definition for the broader "packaged boiler" definition.

Burnham suggested that the scope of regulated commercial boilers should be limited to sizes that can be reasonably tested in a laboratory and that, in spite of backsliding concerns, to do so would acknowledge practical concerns and previous rulemaking error. (Burnham, No. 40 at p. 8) In response, DOE notes that the scope of coverage and original energy conservation standards were established by EPCA, not by a DOE rulemaking. 42 U.S.C. 6313(a)(4). Because the scope of coverage has never included a capacity limit, DOE must have a test procedure in place for all commercial packaged boilers for manufacturers to be able to certify their equipment as complying with the energy conservation standards. DOE reiterates that to establish such a rated input limit for covered equipment with existing standards would violate the anti-backsliding provisions of EPCA found at 42 U.S.C. 6313(a)(6)(B)(iii)(I) for those

equipment larger than the limit. Additionally, both BTS-2000 (incorporated by reference in the existing DOE test procedure) and ANSI/AHRI Standard 1500-2015 (being incorporated by reference in this final rule) include in their scope any commercial packaged boiler with rated input of 300,000 Btu/h or greater.

2. Field-Constructed Commercial Packaged Boilers

EPCA establishes the statutory authority by which DOE may regulate "packaged boilers" and defines a "packaged boiler" as a boiler that is shipped complete with heating equipment, mechanical draft equipment, and automatic controls; usually shipped in one or more sections. (42 U.S.C. 6311(11)(B)) In adopting the EPCA definition for a "packaged boiler," DOE amended the definition to: (1) include language to address the various ways in which packaged boilers are distributed in commerce; and (2) explicitly exclude custom-designed, field-constructed boilers. 69 FR 61949, 61952. "Custom-designed, field-constructed" boilers were excluded because DOE believed the statutory standards for "packaged boilers" were not intended to apply to these boiler systems, which generally require alteration, cutting, drilling, threading, welding or similar tasks by the installer. As a result, DOE defined a "packaged boiler" as a boiler that is shipped complete with heating equipment, mechanical draft equipment and automatic controls; usually shipped in one or more sections and does not include a boiler that is custom designed and field constructed. If the boiler is shipped in more than one section, the sections may be produced by more than one manufacturer, and may be originated or shipped at different times and from more than one location. 10 CFR 431.82. As noted in section III.A.1, DOE is moving this exclusion from the definition for "packaged boiler"

to the definition for “commercial packaged boiler” in order to clarify the applicability of its regulations.

In order to further clarify the difference between field-constructed commercial packaged boilers (which are excluded from DOE’s commercial packaged boiler regulations) and field-assembled commercial packaged boilers (which are subject to DOE’s regulations), DOE proposed the following definition for “field-constructed” in the March 2016 NOPR:

Field-constructed means custom-designed equipment that requires welding of structural components in the field during installation; for the purposes of this definition, welding does not include attachment using mechanical fasteners or brazing; any jackets, shrouds, venting, burner, or burner mounting hardware are not structural components.

DOE noted in the March 2016 NOPR that it considered structural components include heat exchanger sections, flue tube bundles and internal heat exchanger surfaces, external piping to one or more heat exchanger sections or locations, and the mechanical supporting structure the heat exchanger rests upon in the case where a support structure is not provided with the commercial packaged boiler. DOE further noted that welding does not include attachment using mechanical fasteners or brazing; and any jackets, shrouds, venting, burner, or burner mounting hardware are not structural components. Conversely, DOE stated that a field-assembled commercial packaged boiler can be assembled in the field without the welding of structural components, as previously listed.

DOE received several comments pertaining to the proposed definition for "field-constructed" in response to the March 2016 NOPR. Bradford White expressed support for the proposed definition. (Bradford White, No. 39 at p. 2) Lochinvar suggested that because DOE is proposing a field test that would be limited to commercial packaged boilers with fuel input rates greater than 5,000,000 Btu/h that the same fuel input rate limit be included in the definition for field-constructed commercial packaged boilers. (Lochinvar, No. 43 at p. 2) NEEA and Lochinvar also suggested that the definition for field-constructed should mean custom designed equipment that requires American Society of Mechanical Engineers (ASME) code stamped with the "H" (heating) or "R" (repair) designator welding in the field during installation. (NEEA, No. 44 at p.2; Lochinvar, Public Meeting Transcript, No. 34 at p. 21)

DOE notes that the field-constructed exemption for commercial packaged boilers applies to field-constructed equipment of any size; the field test methodology accommodates those commercial packaged boilers that are not field-constructed (and therefore not exempt from DOE regulations) and the size of which makes testing in a laboratory setting exceptionally difficult or cost-prohibitive. Therefore DOE is not adopting a size limitation in its definition for field-constructed as it pertains to commercial packaged boilers. With respect to Lochinvar's suggestion that the ASME code for welding could be used to limit the scope of what is considered "field-constructed," DOE does not believe the ASME stamp requirements are applied equally across all jurisdictions, making it a poor indicator that a unit meets the field-constructed definition. Therefore, DOE will not define field-constructed to include a requirement that

the ASME stamps designators for welding be used as a means of delineating field-constructed commercial packaged boilers.

DOE reiterates that field-assembled equipment is covered, is required to be tested using the DOE test procedure, and is required to comply with the existing energy conservation standards and certification requirements.

3. Other Definitions

DOE also received comments regarding other commercial packaged boilers definitions proposed in the March 2016 NOPR. In the March 2016 NOPR, DOE proposed to modify its definition for combustion efficiency. The current definition states that combustion efficiency for a commercial packaged boiler "is determined using test procedures prescribed under §431.86 and is equal to 100 percent minus percent flue loss (percent flue loss is based on input fuel energy)." 10 CFR 431.82. As noted in the March 2016 NOPR, this definition does not sufficiently describe what the metric represents, and therefore DOE proposed to define combustion efficiency for a commercial packaged boiler as "a measurement of how much of the fuel input energy is converted to useful heat in combustion and is calculated as 100-percent minus flue loss, as determined with the test procedures prescribed under §431.86."

CIBO, AERCO, and the Gas Associations suggested that DOE's proposed definition for combustion efficiency conflicted with the definition found in ANSI/AHRI

Standard 1500-2015 and that the definition found in ANSI/AHRI Standard 1500-2015 should be retained. (CIBO, No. 35 at p.2; Gas Associations, No. 42 at p. 2; AERCO, Public Meeting Transcript, No. 34 at p. 129-131) AERCO suggested that the DOE's proposed definition does not exclude jacket losses but that the definition in ANSI/AHRI Standard 1500-2015 does. (AERCO, Public Meeting Transcript, No. 34 at p. 129-131) CIBO also suggested that DOE's definition for "combustion efficiency" should use the higher heating value of the fuel in the calculation in order to account for water vapor produced during combustion.

In response, DOE notes that its combustion efficiency definition (both current and proposed) defines combustion efficiency as being measured under the DOE test procedure whereas industry definitions for the term do not. DOE believes that specifying in the definition that combustion efficiency is determined using the test procedures prescribed under §431.86 makes clear that where DOE uses the term in its regulations it is referring to the metric as determined by DOE's test procedure. The rest of the definition provides description of what combustion efficiency represents and DOE believes this descriptive portion of the proposed definition is consistent with industry definitions. In this final rule, however, DOE has modified the descriptive portion of the definition to be consistent with that found in ANSI/AHRI Standard 1500-2015. Specifically, DOE's definition now describes the combustion efficiency as being 100 percent minus the percent losses due to dry flue gas, incomplete combustion, and moisture formed by combustion of hydrogen. In response to CIBO's comment with respect to using a higher heating value, DOE notes that DOE's test method and calculations for combustion efficiency incorporate by reference the pertinent sections of

ANSI/AHRI Standard 1500-2015, specifically sections C7.2 and C7.3, which take into account the higher heating value of the fuel. Section C7.2.16 of ANSI/AHRI Standard 1500-2015 uses the measured value for Q_{IN} which is calculated using the higher heating value of the fuel.

The Efficiency Advocates suggested that DOE clarify the distinction between condensing and non-condensing boilers to ensure that proper test conditions are used for any tested commercial packaged boiler. (Efficiency Advocates, No. 45 at pp. 2-3) In the March 2016 NOPR, DOE proposed to incorporate by reference the definitions for these terms as found in ANSI/AHRI Standard 1500-2015. DOE notes that section 3.2.2 in ANSI/AHRI Standard 1500-2015 (incorporated by reference in this final rule) states that aa condensing commercial packaged boiler means a "[commercial packaged] boiler which will, during the laboratory tests prescribed in this standard, condense part of the water vapor in the flue gases and which is equipped with a means of collecting and draining this condensate from the heat exchange section." Section 3.2.5 states that a non-condensing commercial packaged boiler means a "[commercial packaged] boiler that is not a condensing [commercial packaged] boiler."[3] DOE believes that the definition for condensing commercial packaged boiler found in ANSI/AHRI Standard 1500-2015 is sufficient for distinguishing from non-condensing commercial packaged boilers.

[3] In the March 2016 NOPR and in this final rule, DOE includes language in its test procedure that clarifies that in all sections of ANSI/AHRI Standard 1500-2015 that are incorporated by reference, the term "boiler" means a commercial packaged boiler as defined in 10 CFR 431.82.

B. General Comments

AHRI, Burnham, Raypak, and the Gas Associations suggested that DOE suspend the energy conservation standards rulemaking (Docket EERE-2013-BT-STD-0030) until after the test procedure is finalized. (AHRI, No. 46 at p. 9, Public Meeting Transcript, No. 34 at p. 11; Burnham, No. 39 at p. 1; Raypak, No. 47 at p. 1; Gas Associations, No. 42 at p. 1) The Gas Associations suggested that impacts on ratings originating from the test procedure amendments must be known with certainty prior to submitting comments on the standards NOPR and that stakeholders must know with certainty that the test procedure is technically correct, provides for the repeatability of ratings, and can be performed without any excessive burden on the manufacturer/test facility. (Gas Associations, No. 42 at p. 1) Weil-McLain suggested that DOE violated the process rule at 10 CFR Part 430, Subpart C, Appendix A, and the EPCA requirement at 42 U.S.C. 6295(o)(3). (Weil-McLain, No. 41 at p. 11) Weil-McLain also suggested that simultaneous standards and test procedure rulemakings for commercial packaged boilers as well as changes to equipment classes could cause serious harm to industry, manufacturers, contractors, and consumers. They further stated that the simultaneous impact of increasing standards and lowering of ratings due to the changing test procedure will render product models unavailable, possibly resulting in building owners/consumers and contractors having to consider more expensive alternatives. (Weil-McLain, No. 41 at p. 9)

In response to the comment from Weil-McClain, 42 U.S.C. 6295(o)(3) is a provision under Part A of EPCA, "Energy Conservation Program for Consumer Products Other than Automobiles," that generally prohibits the Secretary from prescribing a new

or amended standard for a covered consumer product if a test procedure has not been prescribed for that consumer product. The test procedure provision is also generally applicable to the "Energy Conservation Program for Certain Industrial Equipment," with several exceptions, including packaged boilers, the subject of this rulemaking. (42 U.S.C. 6311(a)). Nevertheless, DOE already has a test procedure in effect for commercial packaged boilers and this rulemaking would not result in a lapse in effectiveness during which standards would be amended without having a test procedure in place. With regard to the Process Rule, DOE developed the Process Rule to establish procedures, interpretations and policies to guide DOE in the consideration and promulgation of new or revised appliance efficiency standards for consumer products under EPCA. 10 CFR part 430, Subpart C, Appendix A. However, its approach is not prescribed. See, paragraph 14 of 10 CFR part 430, Subpart C, Appendix A.

In general, 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. The March 2016 NOPR included an update to the latest industry standard (i.e., ANSI/AHRI Standard 1500-2015), which was developed by a consensus-based AHRI process and was released in April 2015. Further, in May 2015 AHRI petitioned DOE to replace BTS-2000 with ANSI/AHRI Standard 1500-2015 in the DOE test procedure for commercial packaged boilers. (AHRI, No. 29 at p. 1) DOE understands that industry was involved in developing and has experience with the changes adopted in ANSI/AHRI Standard 1500-2015. Further, DOE believes that its proposals in the March 2016 NOPR were largely consistent with the test methodology found in ANSI/AHRI Standard 1500-2015. In

response to the March 2016 NOPR, stakeholders provided detailed, insightful comments on all aspects of the proposal, including those proposals not derived from the ANSI/AHRI Standard 1500-2015. This demonstrates that industry was able to carefully consider DOE's proposed test procedure and how it compared to the current Federal test procedure. Nevertheless, DOE granted a 30-day extension of the comment period for the energy conservation standards rulemaking (Docket EERE-2013-BT-STD-0030) to ensure stakeholders had sufficient time to consider the proposed test procedure amendments in relation to the proposed standards.

C. Adoption of Certain Sections of ANSI/AHRI Standard 1500-2015

The existing DOE test procedure for commercial packaged boilers incorporates by reference BTS–2000 to determine the steady-state efficiency of steam or hot water commercial packaged boilers while operating at full load. As described in section I, on April 29, 2015, AHRI published a new ANSI/AHRI Standard 1500-2015 (ANSI approved November 28, 2014), which supersedes BTS-2000. On May 29, 2015, AHRI submitted a request directly to DOE to update the incorporation by reference in the DOE test procedure to reference the new ANSI/AHRI Standard 1500-2015. (Docket EERE-2014-BT-TP-0006, AHRI, No. 29 at p. 1) As noted in the March 2016 NOPR, DOE reviewed both standards and DOE believes that the recently published ANSI/AHRI Standard 1500-2015 standard is not unduly burdensome to conduct and represents an improvement over BTS–2000 while retaining the general testing methodology and metrics (i.e., thermal and combustion efficiency) of the existing test procedure. DOE noted that several of the changes incorporated into ANSI/AHRI Standard 1500-2015 were also suggested by interested parties in public comments responding to DOE's

September 2013 Framework document, November 2014 Preliminary Analysis, and February 2014 RFI. DOE therefore proposed to adopt certain sections of ANSI/AHRI Standard 1500-2015 in the March 2016 NOPR.

Several parties responding to the March 2016 NOPR expressed support for adopting ANSI/AHRI Standard 1500-2015. (ABMA, No. 38 at p. 1; AHRI, No. 46 at p. 2; Burnham, No. 40 at p. 1-3, 9; Raypak, No. 47 at p. 1-2; Lochinvar, No. 43 at p.1; Gas Associations; No. 42 at p. 2; NEEA, No. 44 at p. 1; Weil-McLain, No. 41 at p. 13; ABMA, Public Meeting Transcript, No. 34 at p. 12; Crown Boiler, Public Meeting Transcript, No. 34 at p. 36) However, multiple parties did not agree with DOE's additional proposals and modifications or suggested that DOE's proposals meant that DOE was not adopting ANSI/AHRI Standard 1500-2015. (AHRI, No. 46 at p. 2; Burnham, No. 40 at p. 1-3, 9; Raypak, No. 47 at p. 1-2; Lochinvar, No. 43 at p.1; Gas Associations; No. 42 at p. 2; Weil-McLain, No. 41 at p. 13) AHRI, Burnham, and Raypak suggested that DOE had not provided clear and convincing evidence pursuant to 42 U.S.C. 6314(a)(4)(B) that its proposed changes in addition to ANSI/AHRI Standard 1500-2015 were necessary. (AHRI, No. 46 at p. 2; Burnham, No. 40 at p. 1-3, 9; Raypak, No. 47 at p. 1-2)

As described in section I.A, with respect to commercial packaged boilers, EPCA requires DOE to use industry test procedures as referenced in ASHRAE/IES Standard 90.1, "Energy Standard for Buildings Except Low-Rise Residential Buildings." (42 U.S.C. 6314(a)(4)(A)) Further, if such an industry test procedure is amended, DOE is required to amend its test procedure to be consistent with the amended industry test

procedure, unless it determines, by rule published in the Federal Register and supported by clear and convincing evidence, that the amended test procedure would be unduly burdensome to conduct or would not produce test results that reflect the energy efficiency, energy use, and estimated operating costs of that equipment during a representative average use cycle. (42 U.S.C. 6314(a)(4)(B))

DOE notes that it adopts industry standards and test procedures to the extent possible while satisfying other statutory requirements (such as the aforementioned requirement for the test procedure to produce results that reflect energy efficiency, energy use, and estimated operating costs of that equipment during a representative average use cycle. (42 U.S.C. 6314(a)(4)(B)) To accomplish this, DOE often adopts certain sections of industry test procedures rather than adopting industry standards wholesale. Additionally, DOE is adopts provisions in its test procedures that provide for compliance certification and enforcement in order to integrate the industry standard into DOE regulations. In this final rule, DOE is incorporating by reference certain sections of ANSI/AHRI Standard 1500-2015 as the basis of its test procedure in satisfaction of 42 U.S.C. 6314(a)(4)(A). Similarly, DOE is removing the incorporation by reference of the previously referenced industry standard, BTS−2000, as it has been superseded.

DOE outlined its justification for each of its proposals in the March 2016 NOPR. The need and evidence for each provision adopted in this final rule is described in the subsequent sections of this final rule.

D. Fuel Input Rate Certification and Enforcement

In the March 2016 NOPR, DOE proposed to standardize its terminology by introducing a definition for "fuel input rate" and proposed provisions for measuring and certifying the value for each basic model. Specifically, DOE proposed a procedure for determining the fuel input rate, which would be certified to DOE, by using the mean of measured values rounded to the nearest 1,000 Btu/h. DOE believed it was necessary to make this clarification because the fuel input rate determines the division of equipment classes and therefore the applicable Federal energy conservation standards for commercial packaged boilers.

Bradford White recommended using the term "rated input" instead of "fuel input rate." (Bradford White, No. 39 at p. 6) AHRI suggested DOE drop its proposed definition and requirements for fuel input rate. (AHRI, No. 46 at p. 6) Lochinvar indicated that the boiler industry is not confused by the terms used for input rate and would be harmed by the DOE's proposed definition (and more significantly) use of the terms for input rate. (Lochinvar, No. 43 at p. 10)

AHRI, Burnham and Lochinvar stated that the maximum rated input is determined as part of the safety certification process, that this process occurs before efficiency testing, and that the safety certification agency requires that the maximum rated input for which the boiler is certified is used on the nameplate. (AHRI, No. 46 at p. 6; Burnham, No. 40 p. 7; Lochinvar, No. 43 at p. 10) AHRI stated that the manufacturer's first requirement is to design a model that will comply with all the safety standards and codes applicable to that boiler model, and that part of this design phase is

establishing the maximum input rate of the boiler. (AHRI, No. 46 at p. 7) They also stated that manufacturers do not conduct efficiency tests until they are certain of the model's compliance with the applicable safety requirements, and that manufacturers therefore cannot wait until their efficiency tests to determine the model's input rating. (AHRI, No. 46 at p. 7) AHRI stated that with respect to efficiency testing the role of the maximum input rating is to assure that the unit is set up to fire at the rate at which the model was designed to operate. (AHRI, No. 46 at p. 6) Lochinvar indicated that the input rate of a commercial packaged boiler is more likely to fall slightly below that found on the nameplate so as not to exceed its safety certification. (Lochinvar, Public Meeting Transcript, No. 34 at p. 117) Raypak also did not support DOE's proposed approach for the fuel input rate because the rated input is first established during safety certification testing, specifically in accordance with ANSI/CSA Z21.13 "Gas-Fired Low Pressure Steam and Hot Water Boilers." Raypak further suggested DOE accept the fuel input rate from this process for its certification reports as is currently done. (Raypak, No. 47 at p. 7)

DOE proposed a certification procedure for fuel input rate in the March 2016 NOPR to standardize and clarify the method by which the fuel input rate for a basic model is determined. However, in light of comments received, DOE recognizes the precedence of the safety certification process during the design and development of commercial packaged boilers, particularly with respect to determining the fuel input rate for a commercial packaged boiler. DOE acknowledges that in general manufacturers subject each model to testing witnessed or performed by safety certification organizations that ensure a commercial packaged boiler model fires on rate over a range of operating

conditions and ignitions. DOE also acknowledges that once the safety certification body has verified the fuel input rate of a commercial packaged boiler, the manufacturer is often obligated to use that rate on the nameplate of the commercial packaged boiler and the accompanying product literature, and that rate has been the rate used when certifying compliance to DOE.

Lochinvar stated that since the test method and efficiency metric change with the classification of the boiler, it makes sense that a fixed rating such as “rated input” would be used to determine the test that should be run. Lochinvar further commented that the DOE proposal to use the tested input rate to determine the product class creates a paradox where the necessary test is not determined until the test is done. (Lochinvar, No. 43 at p. 10)

AHRI suggested that the proposed definition for input rate would assure that the input rate of a model would change every time the efficiency test is conducted and that it also creates a paradox where the test to be conducted is based on its equipment class but that the equipment class is not determined until the test is conducted. (AHRI, No. 46 at p. 7) AHRI suggested that comparable models that could meet the same design load of a prospective customer would have different fuel input rates under DOE's proposal and that this creates a distinction without a difference. (AHRI, No. 46 at p. 7) Burnham stated that under the proposed rule the manufacturer could be required to claim two slightly different inputs for the boiler - one for safety certification and one for meeting DOE requirements - and that this is burdensome and will create confusion in the field. (Burnham, No. 40 at p. 7) Burnham suggested that a boiler could fall into different

standards categories depending on, for example, the higher heating value of the fuel used on the day the unit is tested. (Burnham, No. 40 at p. 7)

In light of the safety certification process, DOE is not adopting its proposed certification provisions for the fuel input rate. Manufacturers must use the rated input for the basic model as determined through the safety certification process, which results in the maximum rated input listed on the nameplate and in manufacturer literature for the basic model. Based on the suggestions made by Bradford White, DOE will adopt the term "rated input" to mean the maximum rate at which a commercial packaged boiler has been rated to use energy as indicated by the nameplate or in the manual shipped with the commercial packaged boiler, and will adopt "fuel input rate" to mean the rate at which any particular commercial packaged boiler uses energy and is determined using test procedures prescribed under §431.86.

DOE also proposed in the March 2016 NOPR a set of enforcement provisions to confirm that the fuel input rate of a commercial packaged boiler being tested matched the certified value for rated input for the basic model. DOE proposed these provisions to clarify its process for determining compliance, specifically for determining the equipment class and therefore applicable standard for a commercial packaged boiler if it did not fire on rate (within 2-percent of the certified rated input value). In the case that a commercial packaged boiler did not fire on rate, DOE proposed the following steps:

- DOE will attempt to adjust the gas pressure in order to increase or decrease the fuel input rate as necessary;

- If still not on rate, DOE will then attempt to modify the gas inlet orifice (e.g., drill) accordingly;

- If still not on rate, DOE will use the measured fuel input rate when determining equipment class and the associated combustion and/or thermal efficiency standard level for the basic model.

In response, Bradford White recommended that the following steps be taken: the manifold pressure is adjusted; followed by changing the gas pressure, if necessary; and lastly, modify the gas orifice(s). (Bradford White, No. 39 at p. 6) Bradford White also suggested that DOE should consult with the manufacturer on how to achieve desired conditions if adjustments do not allow a model to operate within 2-percent of its rated input. (Bradford White, No. 39 at p. 6) Similarly, AHRI suggested that if, during testing, a unit cannot be put on rate and the input rate that is achieved in that situation would put the model in a different equipment class, DOE should ask the manufacturer for the documentation that confirms that the nameplate input rate is the value certified by the testing agency which certified the model's compliance with the applicable safety standards. (AHRI, No. 46 at p. 7) Raypak opposed the proposal that DOE attempt to modify gas inlet orifices when the fuel input rate of a boiler is not within 2-percent of the certified value because several of its commercial packaged boilers use zero-governor technology that use a nozzle instead of an orifice. The nozzle cannot simply be drilled to

gain more gas flow, and drilling would damage the nozzle. Raypak suggested that DOE consult manufacturer's instructions and input before attempting to adjust the input rate. (Raypak, No. 47 at p. 7)

DOE agrees with Bradford White that adjusting the manifold pressure of a commercial packaged boiler could bring the measured fuel input rate of a unit to within 2-percent of the rated input during testing. DOE notes that its proposed regulatory text stated that it would modify "gas pressure" without specifying inlet or manifold and therefore such modification would be attempted. In this final rule, DOE clarifies that it would attempt to alter the manifold pressure and inlet pressure in order to bring the measured fuel input rate to within 2-percent of the rated input. In response to Raypak's comments, DOE agrees that manufacturer's instructions should first be consulted and therefore is adopting additional language to clarify that this would occur before any attempts at adjust the commercial packaged boiler or test set-up are made. DOE also notes, however, that its language adopted in this notice states that DOE will attempt each modification as specified in the test procedure. DOE will therefore use its discretion as well as rely on the discretion of the third-party test laboratory in attempting each modification as may be required to bring the measured fuel input rate of a gas-fired unit to within 2-percent of rated input. If a commercial packaged boiler uses a nozzle rather than an orifice, DOE would not attempt to drill the nozzle as the provision clearly states that only a gas inlet orifice would be drilled (if the unit is equipped with one). DOE also clarifies that this set of attempts to bring a tested unit on rate apply only to gas-fired

commercial packaged boilers, and that DOE would not attempt modifications for oil-fired equipment.

Raypak suggested that rounding fuel input rates to the nearest 1,000 Btu/h will create confusion and uncertainty. (Raypak, No. 47 at p. 7) BWC disagreed with the proposal that a model's measured input is to be rounded to the nearest 1,000 Btu/hr and does not see a value in rounding the input. The model, if not already, must be adjusted to achieve its rated input ± 2-percent. (BWC, No. 39 at p. 6) DOE notes that the provision requiring rounding fuel input rates to the nearest 1,000 Btu/h was associated with the certification process for fuel input rate and is not being adopted in this final rule. Raypak's and BWC's concerns are therefore now moot.

E. Testing of Large Commercial Packaged Boilers

In the March 2016 NOPR, DOE acknowledged that large commercial packaged boilers may not be fully assembled until they are installed at the field site, which may preclude them from being tested in a laboratory setting. DOE also recognized that, as the size of the equipment increases, testing costs incurred to condition the incoming water and air to the test procedure rating conditions, as well as management of the hot water generated during testing, also significantly increases. DOE therefore proposed several provisions for its commercial packaged boiler test procedure that would accommodate the testing of large units.

1. Optional Field Test

DOE proposed a field test option for commercial packaged boilers with fuel input rates greater than 5,000,000 Btu/h. If electing to use this option, a manufacturer would test the combustion efficiency of a commercial packaged boiler once assembled in the field in order to certify compliance with the applicable energy conservation standard. As discussed in the March 2016 NOPR, DOE proposed this option in response to industry concerns that the DOE test procedure was difficult or impossible to conduct for large commercial packaged boilers. DOE recognized that commercial packaged boilers with high fuel input rates (i.e., greater than 5,000,000 Btu/h) may not be fully assembled until they are installed at the field location which may preclude them from being tested in a laboratory setting. The proposed field test option would allow for compliance certification based on testing of only one unit, and would include exemptions for certain set-up, ambient condition, and water temperature requirements that would be difficult or impossible to meet in the field.

In response, Farrelly supported the field testing option while several commenters did not. (Khan, No. 31 at p. 1; ABMA, No. 38 at p. 2; Bradford White, No. 39 at p. 3; AHRI, No. 46 at p. 6; Burnham, No. 40 at p. 2; Raypak, No. 47 at p. 3; Lochinvar, No. 43 at p. 4; Weil-McLain, No. 41 at p. 6, 14; Farrelly, Public Meeting Transcript, No. 34 at p. 165) Although Bradford White did not agree with allowing commercial packaged boilers to be tested in the field, it suggested that it is already common practice to field test boilers with inputs greater than 5,000,000 Btu/h because laboratories are not able to test them. (Bradford White, No. 39 at pp. 2-3) Burnham suggested that the proposed optional field test violates 42 U.S.C. 6314(a)(4)(B). (Burnham, No. 40 at p. 2) AHRI stated that in the

field a test cannot be conducted per ANSI/AHRI Standard 1500-2015. (AHRI, Public Meeting Transcript, No. 34 at p. 144)

In response to Burnham's suggestion that the proposed optional field test violates EPCA42 U.S.C. 6314(a)(4)(B), DOE notes that under that provision DOE may, by rule published in the Federal Register and supported by clear and convincing evidence, determine that the amended test procedure would be unduly burdensome to conduct or would not produce test results that reflect the energy efficiency, energy use, and estimated operating costs of that equipment during a representative average use cycle. Further, 42 U.S.C. 6314(a)(2) requires that DOE test procedures not be unduly burdensome to conduct. As discussed in the March 2016 NOPR, DOE received input from multiple stakeholders responding to the September 2013 Framework document and November 2014 Preliminary Analysis (Docket EERE-2013-BT-STD-0030) that indicated the DOE test procedure (referencing BTS-2000) was impractical for large commercial packaged boilers not only because of the size limitation of manufacturer and laboratory facilities, but also because these commercial packaged boilers are often not fully assembled until they are on site for installation. For example, in response to the March 2016 NOPR Weil-McLain indicated that testing commercial packaged boilers with rated input 10,000,000 Btu/h boilers and higher is cost prohibitive. (Weil-McLain, No. 41 at p. 6, 15) DOE proposed the field test option using the combustion efficiency measurement because such a test would be simpler, shorter in duration, and could be conducted in the field after a commercial packaged boiler has been assembled. DOE therefore believes

that its proposal satisfied both the requirements found at 42 U.S.C. 6314(a)(2) and 42 U.S.C. 6314(a)(4)(B) to adopt a test procedure that is not unduly burdensome to conduct. Moreover, DOE solicited suggestions for alternatives to the field test option by which manufacturers could certify compliance for large commercial packaged boilers but did not receive any such suggestions.

ABMA, Lochinvar, and Crown Boiler stated that meeting the required room temperature and humidity conditions would be difficult or impossible in the proposed field test. (ABMA, No. 38 at p. 2; Lochinvar, No. 43 at p. 4; Crown Boiler, Public Meeting Transcript, No. 34 at p. 10, 151-152) (DOE notes that the proposed field test option in the March 2016 NOPR did not require ambient room temperature and relative humidity requirements to be met.) AHRI, Lochinvar and Raypak expressed concern that the field test would potentially decrease accuracy and repeatability of the test, and AHRI and Lochinvar suggested this is due to the lack of tightly controlled operating conditions. (AHRI, No. 46 at p. 6; Lochinvar, No. 47 at p. 2; Raypak, No. 47 at p. 3) Lochinvar, Weil-McLain, and AERCO suggested that the field test option would not result in comparable ratings between equipment because laboratory tests would need to meet tight operating conditions while field tests would not. (Lochinvar, No. 43 at p. 2, 4, Public Meeting Transcript, No. 34 at p. 149; Weil-McLain, No. 41 at p. 6, 14; AERCO, Public Meeting Transcript, No. 34 at p. 149-151) Weil-McLain also suggested that a commercial packaged boiler tested using the field test option could meet the standard for its equipment class but not meet the standard when tested in a laboratory environment using the proposed test conditions. (Weil-McLain, No. 41 at p. 6)

As was noted in the March 2016 NOPR, DOE agrees that a field test option will inherently be more variable than a test conducted in a laboratory environment. However, as DOE noted in this preamble, the field test option will accommodate testing of commercial packaged boilers that currently are difficult or impossible to test. Manufacturers are obligated to certify that their equipment meets DOE standards as measured according to the DOE test procedure. While manufacturers have indicated that there are certain commercial packaged boilers that cannot be tested using the current DOE test procedure, they have generally opposed the field test option and have not put forth an alternative method of test that would address this. DOE notes that manufacturers will be required to submit certain parameters including water temperatures and ambient conditions as part of the compliance report for comparison to future tests of the same unit or another unit of the same basic model. A manufacturer may continue to use the standard laboratory method if it believes such a test would be more representative of the efficiency of its equipment. Additionally, for enforcement tests, DOE recognizes that a field test could not meet the existing laboratory accreditation requirements found at 10 CFR 429.110(a)(3) and there is adopting an exception in this section specifically for field tests of commercial packaged boilers.

Raypak stated that with respect to the field test, 10 CFR 429.12(a), which requires that certification of equipment occur before distribution in commerce, would not be met if product is allowed to be advertised and sold before ratings are established. (Raypak, No. 47 at p. 3) Raypak stated that DOE must forbid the use of thermal efficiency

advertising for models using the field testing method because testing will not have been performed yet to qualify those metrics. (Raypak, No. 47 at p. 3) Lochinvar and AHRI expressed concern that with respect to field testing commercial packaged boilers could potentially be sold into commerce without having a rating beforehand. (Lochinvar, Public Meeting Transcript, No. 34 at p. 148; AHRI, Public Meeting Transcript, No. 34 at p. 161) Weil-McLain suggested that if field testing is allowed, each unit should be required to be tested and the data from a field test unit should not be used to qualify that model for future sales without field testing every installation. (Weil-McLain, No. 41 at p. 15)

In response to Raypak's concern regarding certification of equipment prior to distribution in commerce, DOE notes that in the March 2016 NOPR, DOE proposed a provision under 10 CFR 429.60 that would allow for certification of equipment not previously certified within 15 days of commissioning. This equipment-specific provision overrides the general provision of 429.12 requiring certification prior to distribution in commerce. In response to Raypak's suggestion that DOE should prohibit representations of thermal efficiency based on field testing because the field testing would not yet have been performed to substantiate the representation, DOE notes that 42 U.S.C. 6314(d)(1) requires that representations of efficiency be based on testing in accordance with the DOE test procedure. If a manufacturer wishes to make representations of efficiency, the commercial packaged boiler basic model must first be certified as having been tested and compliant with the standard, which can reflect testing either using the normal laboratory test for thermal or combustion efficiency (as applicable pursuant to 10 CFR 431.87) or using an alternative efficiency determination method (AEDM). Such an AEDM could be

based on testing for the smallest model in a basic model line and applied to the larger models in order to certify compliance. Likewise, representations for a commercial packaged boiler model that has been previously certified using field test data could be made (i.e., a subsequently distributed unit of the same basic model).

DOE does not agree with Weil-McLain's suggestion that each installation of a field tested model would always need to be tested. If a commercial packaged boiler basic model is certified using the field test method, the manufacturer is certifying that each unit of that basic model complies with the applicable energy conservation standard as is the case with any basic model that uses the laboratory method (i.e., not field tested) of testing and certification. DOE believes that requiring the testing and certification of each unit of a basic model in the field would be unduly burdensome. If the manufacturer is uncomfortable with its certification due to uncertainty whether subsequent units will comply with the standard, the manufacturer may choose to test each subsequent unit.

ABMA does not support the field test option as proposed because once a boiler leaves a manufacturer's shipping dock, ownership transfers to the purchaser of the equipment and the boiler manufacturer has no further control over it. ABMA suggested that, even if an owner is willing to allow a field test, they are likely only willing to allow testing during summer (non-heating) months; however, the heating load available on the building during the summer is insufficient to perform a test even at night. ABMA further indicated that installation of the necessary equipment and instrumentation is unlikely to be allowed by the owner, particularly stack thermocouple grids and flow meters. (ABMA, No. 38 at p. 2, Public Meeting Transcript, No. 34 at p. 140-141) Similarly,

Lochinvar indicated that conducting efficiency tests requires time and, depending on field installations, could involve some risk of damage to equipment. They suggested that building inspectors will not typically have the training to conduct the desired tests or verify proper execution of the test if they are providing oversight. Additionally, Lochinvar stated that a third-party inspector that delivers a non-compliant result might find themselves the subject of a lawsuit questioning their methodology and results. (Lochinvar, No. 43 at p. 4)

To allow for testing in factory fire test areas ABMA suggested modifying the definition of field test to mean a combustion efficiency test that is conducted in a location other than a laboratory setting. ABMA stated that doing so would reduce problems associated with field testing to a mostly manageable level. (ABMA, No. 38 at p. 2) ABMA also stated that certification after distribution in commerce may be a worthwhile course of action provided that its other concerns for the field test provisions are accounted for. (ABMA, No. 38 at p. 3)

DOE agrees with ABMA's suggestion that a test performed in a factory fire test area (i.e., a manufacturer facility or space with fewer test capabilities than a laboratory) could meet the requirements of DOE's proposed field test while alleviating concerns regarding ownership and access to the installed commercial packaged boiler for testing. The regulatory language proposed in the March 2016 NOPR and being adopted in this final rule allows for such testing.

AHRI suggested that DOE consider additional modifications to the AEDM to allow a means to certify that large input models comply with the applicable minimum efficiency standard; however, AHRI did not provide additional detail or suggest how this might be accomplished. (AHRI, No. 46 at p. 6) Lochinvar stated that, if DOE will allow the use of the ANSI/AHRI Standard 1500-2015 test method and AEDMs, there should be no need for field testing of boilers. Lochinvar further stated that it believes that the combination of testing according to ANSI/AHRI Standard 1500-2015, conversion methodology and use of the AEDM should provide manufacturers adequate options to verify their boilers' performance. Lochinvar noted that this may require production of the smallest products in a given family for "lab" testing and encouraged DOE to allow some grace period for the production of these units and the accompanying test data to minimize the burden on these manufacturers. (Lochinvar, No. 43 at p. 4, 5) Lochinvar also noted that it understands that the performance of any commercial packaged boiler is to be verified before it is introduced to commerce and encouraged DOE to apply the appropriate rules fairly to all manufacturers. (Lochinvar, No. 43 at p. 4) ACEEE commented that allowing AEDMs for the certification of commercial packaged boilers that are too large for testing in a lab may be preferable to field tests. (ACEEE, Public Meeting Transcript, No. 34 at p. 148) ACEEE and ABMA also raised a concern that the AEDM process may not be feasible for large commercial packaged boilers because AEDMs are based on testing of multiple units of the same model and that commercial packaged boilers models with rated inputs above 5,000,000 Btu/h may only ever have one unit produced. (ACEEE, Public Meeting Transcript, No. 34 at p. 156; ABMA, Public Meeting Transcript, No. 34 at p. 157)

DOE notes that representations based on the amended test procedure are not required until [**INSERT DATE 360 DAYS AFTER DATE OF PUBLICATION IN THE FEDERAL REGISTER**] which allows manufacturers time to comply with the amended test procedure. Additionally, DOE believes that its provisions for AEDMs as they pertain to commercial packaged boilers adequately address AHRI's and Lochinvar's suggestions and mitigate test burden. An AEDM may be validated based on tests of any individual models in a validation class that meet or exceed the Federal energy conservation standard regardless of size. The tests could therefore be performed on the smallest individual model in a validation class and the AEDM could then be applied to certify the compliance of all other sizes. With respect to ACEEE and ABMA's concern regarding the number of units required for validating the AEDM, DOE notes that only one unit for each basic model of a validation class is required to be tested for comparison to the AEDM pursuant to 10 CFR 429.70(c)(2)(i).

However, as noted in the March 2016 NOPR, DOE believes that field tests of commercial packaged boilers would not be a sufficient basis for AEDMs applied to models below the 5,000,000 Btu/h and therefore proposed that AEDMs validated using field test data could only be applied to commercial packaged boilers with fuel input rates greater than 5,000,000 Btu/h. In response to the concern expressed by ACEEE and ABMA regarding the ability to develop an AEDM applicable to commercial packaged boilers with rated inputs greater than 5,000,000 Btu/h, DOE notes that manufacturers could develop the AEDM based on testing of commercial packaged boilers with rated

inputs less than 5,000,000 Btu/h and applying the AEDM to larger models, thereby mitigating this concern.

ABMA believes the threshold for allowing the field test and conversion methodology should be reduced to 2,500,000 Btu/h from 5,000,000 Btu/h to match normal capacity breaks in product lines. (ABMA, No. 38 at p. 3) AHRI indicated that it is feasible to conduct the thermal efficiency test on steam commercial packaged boilers with rated inputs greater than 2,500,000 Btu/h and less than or equal to 5,000,000 Btu/h. (AHRI, No. 46 at p. 8) However, Bradford White suggested that requiring laboratory tests for commercial packaged boilers between 2,500,000 Btu/h and 5,000,000 Btu/h would require laboratory upgrades totaling $300,000. (Bradford White, No. 39 at p. 2-3) Lochinvar opposes all "field testing;" however, if allowed, Lochinvar suggested the lower limit for field constructed boilers must be no lower than 5,000,000 Btu/h because [commercial] packaged boilers are widely available in this input rate and should not be unequally tested and rated. (Lochinvar, No. 43 at p. 4) Weil-McLain suggested that if the field test option is kept that it only be available to 10,000,000 Btu/h boilers and larger because testing these boilers is cost prohibitive. (Weil-McLain, No. 41 at p. 6, 15) Weil-McLain also indicated that testing water and steam commercial packaged boilers with inputs between 2,500,000 Btu/h and 5,000,000 Btu/h is already done in many facilities. (Weil-McLain, No. 41 at p. 14)

The purpose of the field test option is to alleviate the test burden for large capacity commercial packaged boilers that is largely the result of laboratory facility limitations. As such, DOE believes that a minimum 5,000,000 Btu/h threshold for the

field test option is appropriate as indicated in Lochinvar's and AHRI's comments, as well as Weil-McLain's indication that laboratory testing for commercial packaged boilers between 2,500,000 and 5,000,000 Btu/h is already common. In response to Bradford White's indication that incorporating commercial packaged boilers with inputs greater than 2,500,000 Btu/h and 5,000,000 Btu/h would impose costs, DOE does not believe costs associated with testing such units are prohibitive, as other parties have suggested that such testing is already commonly performed. In response to ABMA's comments that the threshold should be lowered to 2,500,000 Btu/h, DOE does not agree that capacity breaks in product lines is sufficient justification for such an allowance. In response to Weil-McLain's suggestion to raise the threshold to 10,000,000 Btu/h, DOE notes that the field test is an option, not a requirement, and that raising the threshold to 10,000,000 Btu/h would likely result in manufacturers and laboratory facilities needing to make major investment in laboratory capabilities in order to be able to perform laboratory tests up to such a capacity.

2. Optional Conversion of Combustion Efficiency to Thermal Efficiency

As an additional provision for accommodating large commercial packaged boilers (rated input greater than 5,000,000 Btu/h) DOE proposed in the March 2016 NOPR a conversion from combustion efficiency to thermal efficiency for steam commercial packaged boilers. While hot water commercial packaged boilers of the same size must meet a Federal energy conservation standard using the combustion efficiency metric, steam commercial packaged boilers must meet a thermal efficiency standard. The thermal efficiency test uses a more complex set-up and instrumentation and would be difficult to conduct in the field. Under the proposal, manufacturers could test a steam

commercial packaged boiler for combustion efficiency (in a laboratory or in the field) and convert to thermal efficiency using an equation.

In response to this proposal, ABMA agreed with the concept of the conversion but did not agree that a single number (2-percent difference between combustion and thermal efficiency) is applicable across a broad range of sizes. They suggested that the difference should be capacity dependent and provided the following data for the difference between combustion and thermal efficiency: 4,185,000 Btu/h: 0.56 percent, 10,463,000 Btu/h: 0.41 percent, 31,383,000 Btu/h: 0.24 percent, and 50,220,000 Btu/h: 0.18 percent. Alternatively, ABMA suggested that a manufacturer could use size-specific data on radiation loss. (ABMA, No. 38 at p. 3, Public Meeting Transcript, No. 34 at p. 87) Bradford White stated that the 2-percent difference was not appropriate and suggested reviewing active products in the AHRI directory. (Bradford White, No. 39 at p. 3) Lochinvar stated that the proposed conversion method was appropriate; however, Lochinvar also stated that they did not agree with any attempt to convert between combustion and thermal efficiency. They further suggested that using a fixed conversion factor is not accurate or appropriate. (Lochinvar, No. 43 at p. 4-5)

Weil-McLain stated that the 2-percent difference between combustion and thermal efficiency is arbitrary and will not result in reliable thermal efficiency results. (Weil-McLain, No. 41 at p. 8) Weil-McLain also suggested that manufacturers could take advantage of the conversion by removing insulation which would increase jacket losses and combustion efficiency but not result in higher thermal efficiency. (Weil-McLain, No. 41 at p. 15) They also suggested that if thermal efficiency cannot be

directly measured or derived based on jacket loss measurements then it should not be the specified efficiency method for that equipment class. Finally, Weil-McLain stated that the range of values for the difference between combustion and thermal efficiency is much larger than the 0.5 percent to 2.0-percent cited in the March 2016 NOPR. (Weil-McLain, No. 41 at p. 15)

Relatedly, AERCO commented that, if only the combustion efficiency test were required for large commercial packaged boilers, the test burden would be manageable. They indicated that investment in water pump and heat dissipation equipment may be necessary, but that running a test may amount to $30,000 to $40,000 which is considered reasonable when compared to the cost of some large commercial packaged boilers ($100,000 to $200,000). (AERCO, Public Meeting Transcript, No. 34 at p. 154) ABMA indicated that there would still be a limit to the size of commercial packaged boilers that could be tested even if performing only the combustion efficiency test. (ABMA, Public Meeting Transcript, No. 34 at p. 154)

DOE notes that the intent of the optional combustion to thermal efficiency methodology is to reduce test burden for manufacturers that have found it difficult to test the thermal efficiency of commercial packaged boilers with rated inputs greater than 5,000,000 Btu/h. This is supported by AERCO's comment that performing a combustion test would be achievable for large commercial packaged boilers. Manufacturers have the option of continuing to use the thermal efficiency test if they believe it will result in a

more accurate representation of their equipment's efficiency. As described in the March 2016 NOPR, DOE analyzed a subset of the AHRI directory (as of January 2015)[4] in order to determine a value for the conversion; specifically, DOE considered the difference between rated combustion and thermal efficiency for all steam commercial packaged boilers with rated input larger than 5,000,000 Btu/h. DOE found 52 basic models of steam commercial packaged boilers with a rated input larger than 5,000,000 Btu/h and the difference between rated combustion and thermal efficiency ranged between 0.5 percent and 2.0-percent. DOE acknowledges that the range may be wider (and may include values for which the thermal efficiency is greater than the combustion efficiency) for other subsets of commercial packaged boilers or for all commercial packaged boilers as a whole. However, this methodology would only be available to steam commercial packaged boilers with rated input greater than 5,000,000 Btu/h and therefore DOE used only that subset of data.

Additionally, DOE used a single value of 2.0 that represents the maximum difference between combustion and thermal efficiency for those commercial packaged boilers in order to generate conservative ratings for basic models certified using this methodology. If manufacturers believe their equipment is capable of achieving a higher thermal efficiency, they may elect to use the thermal efficiency test rather than the combustion efficiency test and conversion. DOE notes that the thermal efficiency test may still be used for DOE enforcement testing; and therefore, DOE does not believe that

[4] Available at: https://www.ahridirectory.org/ahridirectory/pages/home.aspx

manufacturers would be likely to manipulate the test to achieve a better result as Weil-McLain suggests.

With respect to Weil-McLain's suggestion to use combustion efficiency as the metric for this equipment class, EPCA directs DOE to consider amending its energy conservation standards for commercial packaged boilers each time ASHRAE amends ASHRAE/IES Standard 90.1. (42 U.S.C. 6313(a)(6)(A)) Pursuant to EPCA, on July 22, 2009, DOE published a final rule adopting the thermal efficiency metric as the energy efficiency descriptor for eight of ten equipment classes of commercial packaged boilers in order to conform to ASHRAE/IES Standard 90.1–2007. 74 FR 36314. DOE is not reconsidering the efficiency metric used for any equipment class of commercial packaged boilers at this time.

F. Hot Water Temperatures

In the March 2016 NOPR, DOE proposed modifications to the water temperatures for hot water tests of commercial packaged boilers. In the current DOE test procedure (which incorporates by reference BTS-2000), inlet water temperature for a non-condensing commercial packaged boiler can be between 35 °F and 80 °F and outlet water temperature must be 180 °F ± 2 °F. For a condensing commercial packaged boiler, inlet water temperature must be 80 °F ± 5 °F and outlet water temperature must be 180 °F ± 2 °F (at Point C in). ANSI/AHRI Standard 1500-2015, which replaced BTS-2000 and was proposed for incorporation by reference in the March 2016 NOPR, did not change these temperature requirements. These inlet and outlet temperature requirements result in a temperature rise across the heat exchanger ranging from 98 °F to 147 °F for a non-

condensing commercial packaged boiler and from 93 °F to 107 °F for a condensing commercial packaged boiler. Also, BTS-2000 and ANSI/AHRI Standard 1500-2015 permit recirculating loops , allowing heated outlet water to be reintroduced into the incoming water thereby increasing the temperature of the inlet water entering the commercial packaged boiler (see further discussion in section III.F.2). As stated in the March 2016 NOPR, DOE identified several issues with these temperature requirements based on comments received in response to the October 2013 Framework document, February 2014 RFI, and the November 2014 Preliminary Analysis, as well as through manufacturer interviews and a review of the existing DOE test procedure. The issues included:

- The current temperature rise is unrepresentative of actual operating conditions;
- The current temperature rise may induce excessive stresses on some commercial packaged boilers; and
- The presence of recirculating loops during testing leads to significant variability in the actual temperature rise across the commercial packaged boiler.

DOE therefore proposed modifications to the inlet and outlet water temperature requirements that would result in a consistent 40 °F nominal temperature rise for all commercial packaged boilers. For condensing commercial packaged boilers, DOE proposed an inlet temperature of 80 °F and an outlet temperature of 120 °F, and for non-condensing commercial packaged boilers DOE proposed an inlet temperature of 140 °F

and an outlet temperature of 180 °F. Additionally, while recirculating loops could still be used, DOE proposed that the inlet temperature would be measured downstream of where the loop would reenter the incoming water stream, immediately prior to the water entering the commercial packaged boiler.

1. General Comments

Burnham, Weil-McLain, and the Efficiency Advocates agreed that the temperatures in the current test procedure (BTS-2000, or equivalently in ANSI/AHRI Standard 1500-2015) were not representative of actual installation/field conditions for commercial packaged boilers. (Burnham, No. 40 at p. 3; Efficiency Advocates, No. 45 at p. 1-2; Weil-McLain, No. 41 at p.7) Weil-McLain further suggested that BTS-2000 was not intended to simulate actual installation conditions for the boiler and that a 100 °F temperature rise would not have been used in BTS-2000 otherwise. (Weil-McLain, No. 41 at p. 17) Burnham further stated that, even though the water temperatures found in ANSI/AHRI Standard 1500-2015 are not representative of those seen in the field, this does not necessarily mean that resulting efficiency measurements are not representative of what would be found in the field. (Burnham, No. 40 at p. 3)

Bradford White, NEEA, and the Efficiency Advocates stated that DOE's proposed water temperatures would more accurately reflect operating temperatures found in the field. (Bradford White, No. 39 at p. 3; NEEA, No. 44 at p. 2; Efficiency Advocates, No. 45 at p. 1-2) AERCO also stated that continuing to use the 80 °F inlet and 180 °F outlet temperatures is unrealistic and that this should be changed even if ratings are affected. (AERCO, Public Meeting Transcript, No. 34 at p. 12) NEEA stated

that, for non-condensing commercial packaged boilers, hot water coils that provide heating are designed to provide a 20 °F temperature drop across the coil with a design supply water temperature of 180 °F on the coldest days and 160 °F on mild days. NEEA stated that the 20 °F temperature drop across the coil prevents the return water from being less than 140 °F (when the supply water temperature is 160 °F), which prevents condensing from occurring, and that the 40 °F rise proposed by DOE is more representative than the range used in ANSI/AHRI Standard 1500-2015. For condensing commercial packaged boilers, NEEA stated that the 40 °F temperature rise is also more representative of typical conditions in a commercial building, and that water is typically supplied to the building at 120 °F and returned to the commercial packaged boiler at 100 °F. (NEEA, No. 44 at pp. 1-2) The Efficiency Advocates similarly commented that return water for a non-condensing commercial packaged boiler must be at or above 140 °F to prevent condensing and possible corrosion. (Efficiency Advocates, No. 45 at pp. 1-2)

The Efficiency Advocates also suggested that the specificity of DOE's proposed inlet and outlet temperature requirements would improve consistency and repeatability across ratings and tests. (Efficiency Advocates, No. 45 at pp. 1-2) The Efficiency Advocates also supported the proposal to measure the inlet water temperature downstream of where inlet water enters the unit such that the actual temperature of the water entering the commercial packaged boiler would not be obscured. (Efficiency Advocates, No. 45 at p. 1) The CA IOUs supported DOE's proposal for a fixed inlet water temperature as opposed to the 35 °F to 80 °F range currently allowed because

consumers could more confidently compare the ratings of commercial packaged boiler models. (CA IOUs, No. 48 at p. 2)

However, several stakeholders including AHRI, Burnham, Raypak, Lochinvar and Weil-McLain, suggested that DOE's proposed water temperatures would impact ratings, and presented test results that showed a range of effects on thermal efficiency from a decrease of up to 1.4-percent to an increase of up to 1.8-percent. (AHRI, No. 46 at p. 3; Burnham, No. 40 at p. 4; Raypak, No. 47 at p. 4; Lochinvar, No. 43 at p. 7; Weil-McLain, No. 41 at p. 4, 8, 10) AHRI stated that the current water temperature conditions specified in BTS-2000 and maintained in ANSI/AHRI Standard 1500-2015 should be retained without change. (AHRI, No. 46 at p. 3) AHRI further stated that the aggregate effect on ratings is irrelevant to a commercial packaged boiler model that just complies with the standard and whose rating is lowered by the proposed test procedure. (AHRI, No. 46 at p. 3) Burnham suggested that the proposed water temperatures would trigger manufacturers to recertify and could result in non-compliance for some models, while Crown Boiler and Raypak suggested that all manufacturers would need to retest all models. (Burnham, No. 40 at p. 4, 5; Crown Boiler, Public Meeting Transcript, No. 34 at p. 10; Raypak, No. 47 at p. 4, 6) Lochinvar questioned why, if the amended test procedure is not expected to change ratings, manufacturers should be burdened with rerating their units. (Lochinvar, Public Meeting Transcript, No. 34 at p. 49) NEEA suggested that DOE create a crosswalk to convert old test data to new test data as a way of reducing testing burden. (NEEA, Public Meeting Transcript, No. 34 at p. 34) Burnham raised the concern that reducing the temperature rise would increase measurement error and therefore the thermal efficiency error by 2.5 times. (Burnham,

No. 40 at p.5) DOE believes that Burnham arrived at the factor of 2.5 by dividing a 100 °F temperature rise by the proposed 40 °F temperature rise, and that Burnham is suggesting that the measurement error would increase in the same proportion as the decrease in temperature rise. DOE notes that such a scenario would only happen in those instances where recirculating loops are not currently used during testing, e.g., cast iron sectional commercial packaged boilers.

The Gas Associations suggested that DOE document specific differences in efficiency that result from the water temperature changes as compared to ratings produced by ANSI/AHRI Standard 1500-2015 so that manufacturers could evaluate the impacts the temperature changes would have on their specific models. (Gas Associations, No. 42 at p. 2) The CA IOUs suggested that test data from Pacific Gas and Electric (PGE) showed changes in efficiency resulting from different inlet and outlet water temperatures, but that this testing was done according to a different test protocol and it remains unclear how the changes proposed in the NOPR will impact the efficiency of commercial packaged boilers on the market. (CA IOUs, No. 48 at p. 4)

DOE is sensitive to concerns regarding the impact of the test procedure amendments on ratings, particularly for commercial packaged boilers that were not previously able to use a recirculating loop for reducing the temperature rise across the unit, as there was a significant difference in inlet water temperature in the NOPR for units not using a recirculating loop as compared to the current test method. (Recirculating

loops are considered in section III.F.2.) However, DOE continues to believe that an inlet water temperature range of 35 °F to 80 °F is an unnecessarily large range due to the capabilities of current test facilities, and that lower temperatures in that range are particularly unrepresentative of water temperatures found in the field. In this final rule, DOE is therefore adopting an inlet temperature requirement of 80 °F ± 5 °F for non-condensing commercial packaged boilers that do not utilize a recirculating loop, and the outlet temperature will remain 180 °F ± 2 °F. (Note: this inlet water temperature is consistent with the existing inlet water temperature requirement for condensing commercial packaged boilers. See section III.F.3 for discussion of water temperatures for condensing commercial packaged boilers.) This range aligns with the existing allowable maximum temperature of 80 °F for the inlet water temperature but reduces the total allowable range. DOE agrees with the Efficiency Advocates and CA IOUs that the March 2016 NOPR water temperatures would improve consistency due to their specificity, would remove ambiguity concerning the temperature of water entering a unit, and would provide assurance to consumers that commercial packaged boilers were rated similarly. DOE believes that these consequences also will result from the temperatures being adopted in this final rule. DOE believes that this final rule results in a test procedure that is more representative of efficiencies found in the field by increasing the allowable inlet water temperature and more repeatable because of the narrower allowable range of inlet water temperatures, while mitigating concerns regarding the impact on ratings. DOE believes that the concerns regarding impacts on ratings due to the proposed 140 °F inlet water temperature are mitigated with the temperature requirements it is adopting in this final rule. Therefore, DOE does not believe it is necessary to produce, as

the Gas Associations and NEEA suggested, a conversion methodology between the existing and amended test procedures. Moreover, a manufacturer would only need to recertify a basic model if it determines its test results no longer represent the efficiency of the basic model as tested under the amended test procedure. Such a determination should be possible based on a review of the water temperatures used to generate prior test data and an understanding of the potential effects on the resulting efficiency.

2. Recirculating Loops

DOE noted in the March 2016 NOPR that the presence of recirculating loops during testing obscures the actual temperature rise that the commercial packaged boiler experiences. Section 8.5.1.1.1 of BTS-2000, which is incorporated by reference in the current DOE test procedure, states that such a loop may be used "for tubular boilers that require a greater flow rate to prevent boiling." In such instances, the same section also requires that the temperature rise through the boiler itself not be less than 20 °F. Section 5.3.5.3 of ANSI/AHRI Standard 1500-2015, which replaces BTS-2000, expands the use of recirculating loops by removing the requirement that a boiler be "tubular" to use a recirculating loop, such that a recirculating loop may be used "for [any] boilers that require a greater flow rate to prevent boiling." In the March 2016 NOPR, DOE proposed inlet water temperature requirements immediately preceding the commercial packaged boiler, thereby allowing all commercial packaged boiler tests to use the recirculating loop to achieve a 140 °F or 80 °F inlet water temperature for non-condensing and condensing units, respectively. (See section III.F.3 for discussion of water temperatures for condensing commercial packaged boilers.) DOE also sought comment specifically on the prevalence of recirculating loops during testing. DOE received the following feedback:

- ABMA stated that recirculating loops are used for fire-tube type boilers. (ABMA, No. 38 at p. 4)

- Bradford White stated that recirculating loops are used for low mass boilers to prevent boiling. (Bradford White, no. 39 at p. 4)

- AHRI stated that recirculating loops are used for water-tube type boilers that require forced water circulation to operate, and that the AHRI certification program is consistent with this. (AHRI, No. 46 at p. 3)

- Burnham stated that recirculation loops are not used unless absolutely necessary (though they did not indicate what conditions would require the recirculating loop) and indicated that BTS-2000 only explicitly permits recirculating loops for water-tube type boilers. (Burnham, No. 40 at p. 5)

- Raypak stated that they use a recirculating loop on all non-condensing boilers. (Raypak, No. 47 at p. 6)

- Lochinvar stated that recirculation loops are common on tube-type boilers and uncommon on cast sectional boilers but that this is not universally true. They also stated that a recirculating loop is needed for copper fin tube boilers but not stainless steel tube boilers. (Lochinvar, No. 43 at p. 7, Public Meeting Transcript, No. 34 at p. 43)

- Weil-McLain stated that it is not true that most manufacturers use a recirculation loop with sectional cast iron boilers. (Weil-McLain, No. 41 at p. 9)

- Crown Boiler stated that they do not use a recirculating loop in testing most of their boilers except for those that require a higher flow rate, and that they believe this is characteristic of most other manufacturers. (Crown Boiler, Public Meeting Transcript, No. 34 at p. 42-43)

- AERCO stated they do not use a recirculating loop unless it is during the winter and the water entering the building is 40 °F to 50 °F. (AERCO, Public Meeting Transcript, No. 34 at p. 44)

DOE notes that Raypak does not manufacture sectional cast iron commercial packaged boilers, and therefore their statement that recirculating loops are only used for their non-condensing models is consistent with the current allowance only for "tubular" or tube-type commercial packaged boilers in the DOE test procedure (BTS-2000, section 8.5.1.1.1). Raypak also stated that it specifies minimum and maximum flow rates in its installation and operation manuals to prevent boiling and erosion in the tubes, and that it uses recirculation loops to maintain these flow rates during testing. (Raypak, No. 47 at p. 6) Burnham further suggested that excessive stresses caused by the current temperature rise are not a problem because of the short duration of the test, and that recirculation loops are used only when necessary because they create additional set-up complexity and may negatively impact efficiency. (Burnham, No. 40 at p. 4-5) AHRI suggested that the

change in ANSI/AHRI Standard 1500-2015 to make recirculating loops available for all models addresses concerns for damaging the commercial packaged boiler. (AHRI, No. 46 at p. 3) In response to the March 2016 NOPR, the CA IOUs supported the proposed inlet water temperature location because it would remove ambiguity. (CA IOUs, No. 48 at p. 2)

In response to the comments, DOE continues to believe that there is sufficient variation in test set-ups and temperatures so as to warrant adopting additional specifications for water temperatures. DOE believes that the expansion of the use of recirculating loops to any commercial packaged boilers as alluded to by AHRI is further justification for moving the location of the inlet water temperature constraint to immediately preceding the commercial packaged boiler inlet. Therefore, DOE is adopting the non-condensing temperatures proposed in the March 2016 NOPR (140 °F inlet as measured immediately preceding the commercial packaged boiler and 180 °F outlet) for those commercial packaged boilers that use a recirculating loop as allowable by ANSI/AHRI Standard 1500-2015 (i.e., to prevent boiling). This will ensure that all commercial packaged boilers using a recirculating loop during testing use the same temperature rise of 40 °F and will remove ambiguity, increase consistency, and provide for a more representative test of efficiency. DOE notes that a temperature requirement at this location allows manufacturers and laboratories the flexibility of either using a recirculating loop or an external heat source (e.g., another boiler) to maintain the required inlet water temperature.

3. Condensing Commercial Packaged Boilers

Burnham suggested that DOE's proposed water temperatures make the test less representative of actual operating conditions because condensing boilers will experience an increase in efficiency due to the reduction in outlet water temperature. (Burnham, No. 40 at p.4) Raypak also stated that the proposed condensing temperatures are not representative of typical temperature rises and that these same temperatures are used in ASHRAE 155P only to provide a "boundary condition test" as part of the efficiency map that that test procedure will produce. (Raypak, No. 47 at p. 3)

Burnham and Crown Boiler also suggested that non-condensing and condensing commercial packaged boilers are often used at the same water temperatures (Burnham suggested this therefore overstates the relative efficiency of condensing commercial packaged boilers) and Raypak stated that condensing boilers will see water temperatures closer to the proposed non-condensing test temperatures and that the NOPR did not address this. (Burnham, No. 40 p 2, 4; Crown Boiler, Public Meeting Transcript, No. 34 at p. 10, 57; Weil-McLain, No. 41 at p. 4) Burnham suggested this violates 42 U.S.C. 6314(a)(4)(B), which states DOE must amend the test procedure as necessary to be consistent with the amended industry test procedure or rating procedure unless it determines that to do so, supported by clear and convincing evidence, would not meet the requirements for test procedures to be representative of energy efficiency during an average use cycle and to be not unduly burdensome to conduct. (Burnham, No. 40 p 2, 4) Weil-McLain suggested that, if the proposed water temperatures are adopted, all commercial packaged boilers (non-condensing and condensing) should be tested at the non-condensing temperatures but have the option to test at the condensing temperatures

(Weil-McLain, No. 41 at p. 5) Bradford White also suggested that different temperature conditions for condensing and non-condensing boilers would not result in fair comparisons. (Bradford White, No. 39 at p. 3)

Raypak similarly suggested that condensing boilers be tested and certified at both proposed temperature conditions (non-condensing and condensing) to provide engineers, building owners, and architects an understanding of the true efficiency that would be obtained; they also stated that separate temperature ranges for condensing and non-condensing commercial packaged boilers would introduce confusion in the market. (Raypak, No. 47 at pp. 3-4, 8) AERCO suggested rating condensing equipment at the same water temperatures as non-condensing equipment. (AERCO, Public Meeting Transcript, No. 34 at p. 44-45) PGE suggested requiring two separate metrics for condensing commercial packaged boilers, one for condensing and one for non-condensing operation. (PGE, Public Meeting Transcript, No. 34 at pp. 55-57) However, Crown Boiler, Lochinvar, and AHRI opposed this concept. (Crown Boiler, Public Meeting Transcript, No. 34 at p. 58; Lochinvar, Public Meeting Transcript, No. 34 at p. 60-61; AHRI, Public Meeting Transcript, No. 34 at p. 59) Raypak stated that not requiring condensing boilers to be certified at both conditions would give condensing boilers an unfair advantage because they are often installed in non-condensing applications or experience periods of non-condensing operation. (Raypak, No. 47 at p. 4, 8) Finally, Raypak stated that their test results indicated an 8.5-percentage point reduction in thermal efficiency when testing a condensing boiler at the non-condensing temperatures as opposed to the condensing temperatures, and that this difference needs to be addressed in DOE's test procedure. (Raypak, No. 47 at p. 4)

DOE acknowledges concerns that condensing commercial packaged boilers often in application do not experience temperatures that induce condensing operation. DOE's proposed water temperatures for condensing equipment in the March 2016 NOPR preserved the existing nominal inlet water temperature of 80 °F but reduced the outlet water temperature from 180 °F to 120 °F to achieve a more realistic temperature rise of 40 °F, consistent with the temperature rise that was proposed for non-condensing equipment. As noted by Raypak, these temperatures also aligned with the anticipated temperatures in ASHRAE Standard 155P, which several commenters have recommended DOE adopt in the future once it is published. DOE recognizes that these temperatures (80 °F inlet and 120 °F outlet), as Raypak suggested, are intended to provide a boundary condition test for ASHRAE Standard 155P – one in which a condensing commercial packaged boiler is assured to fully condense due to the average temperature between inlet and outlet water (100 °F) being well below the temperature at which condensing begins to occur (approximately 130-140 °F). Condensing commercial packaged boilers could therefore potentially gain higher efficiencies under the proposed water temperatures, and while this would not require manufacturers to rerate existing models, it may result in rated efficiencies that are not achieved in application. DOE is, therefore, maintaining the inlet and outlet water temperatures in the existing test procedure for this final rule.

4. Test Facility Water Flow Rate Capabilities

Bradford White, AHRI, Raypak, Lochinvar, and Weil-McLain suggested that the reduction in the temperature rise from 100 °F to 40 °F would reduce the capacity of laboratory facilities or that facility upgrades would be necessary because of a proportional increase in water flow rate. (Bradford White, No. 39 at p. 4; AHRI, No. 46

at p. 3; Raypak, No. 47 at p. 6; Lochinvar, No. 43 at p. 7; Weil-McLain, No. 41 at p. 14) AHRI suggested that this would be most noticeable for cast-iron and oil-fired boilers, which have not been tested with a recirculating loop. (AHRI, No. 46 at p. 4) ABMA suggested that DOE's estimated costs in the March 2016 NOPR for a 10 million Btu/h boiler were inadequate and that it is not abnormal for a boiler to be three times as large. They suggested that without an AEDM the ratio (three times) would be applied to the pump (equaling $9,000) and new weigh tanks and scales in order to accommodate a flow rate of up to 1,500 gallons per minute (gpm), as well as a new cooling tower that could reach $750,000. (ABMA, No. 38 at p. 5) AHRI stated that DOE incorrectly assumed that a recirculating loop would resolve the issue of higher water flow rates and higher total volume necessary for the proposed water temperatures. (AHRI, No. 46 at p. 3-4)

In response to concerns regarding water flow rates DOE believes that the temperatures adopted in this final rule mitigate the need for higher flow rates (and therefore additional costs, as ABMA suggests). For commercial packaged boilers that cannot utilize a recirculation loop, DOE is adopting a temperature rise that is similar to what is used currently (nominal 100 °F, whereas the current test procedure allows for a temperature rise between 98 °F and 147 °F) and therefore DOE anticipates similar flow rates will be used during testing. For commercial packaged boilers that utilize a recirculating loop to prevent boiling (in keeping with ANSI/AHRI Standard 1500-2015, incorporated by reference in this final rule), the inlet water temperature requirement, measured immediately preceding the commercial packaged boiler inlet, standardizes the temperature for these commercial packaged boilers. Currently, this temperature is not monitored and is not required to meet any specific range. However, DOE anticipates

based on product literature that the current use of recirculating loops results in a similar inlet water temperature to the 140 °F temperature requirements adopted in this final rule, and therefore does not result in any substantive change to the water flow requirements. DOE therefore does not anticipate increased water flow rates needed to meet the amended test procedure, and

5. Other Issues Related to Water Temperatures

Several commenters raised other issues associated with water temperatures for commercial packaged boilers. Bradford White stated that some commercial packaged boilers may not be capable of being tested with a 40 °F difference between inlet and outlet water temperatures and that they should instead be tested with a temperature rise as close to 40 °F as possible as allowed by manufacturer instructions. (Bradford White, No. 39 at p. 3) AHRI and Lochinvar stated that DOE already has a process in place by which instructions regarding testing of particular models could be provided. (AHRI, No. 46 at p. 8; Lochinvar, No. 43 at p. 6) Weil-McLain noted that if a boiler could previously be tested with a 100 °F temperature rise then there is no reason that it could not be tested with a 40 °F temperature rise. (Weil-McLain, No. 41 at p. 16) Raypak suggested that the proposed test procedure would allow manufacturers to select the temperature rise that works best for their product because of the proposed allowance for manufacturer instructions to specify a maximum temperature rise that would be used during testing. (Raypak, No. 47 at p. 6) DOE notes that, with the temperature requirements being adopted in this final rule, the concerns presented by these commenters apply only to commercial packaged boilers that use a recirculating loop during testing because only such units would be required to have a 40 °F temperature rise.

DOE agrees that, pursuant to 10 CFR 429.60(b)(4), manufacturers may already provide supplementary instructions for the purposes of testing a basic model. DOE therefore has determined that the test procedure proposal that addresses commercial packaged boilers that cannot be tested at the specified inlet water temperature is duplicative and DOE is not adopting those provisions. Manufacturers may continue to provide supplementary instructions pursuant to 10 CFR part 429; however, these supplementary instructions do not supplant the requirements of the DOE test procedure. Manufacturers may, however, submit a petition for waiver for any commercial packaged boilers model that cannot be tested to the DOE test procedure pursuant to 10 CFR 431.401 on the grounds that that either the basic model contains one or more design characteristics that prevent testing of the basic model according to the prescribed test procedures or cause the prescribed test procedures to evaluate the basic model in a manner so unrepresentative of its true energy or water consumption characteristics as to provide materially inaccurate comparative data.

Multiple stakeholders, including Bradford White, AHRI, Burnham, Lochinvar, Raypak, and Weil-McLain did not support DOE's proposed tolerance of ± 1 °F for the inlet and outlet water temperatures. (Bradford White, No. 39 at p. 3; AHRI, No. 46 at p. 4, Public Meeting Transcript, No. 34 at p. 47; Burnham, No. 40 at p. 5; Lochinvar, No. 43 at p. 1; Raypak, No. 47 at p. 3; Weil-McLain, No. 41 at p. 5) Burnham and Raypak suggested that the proposed tolerances would not improve the accuracy of efficiency measurements, and Weil-McLain suggested that using a tolerance of ± 2 °F would not impact the accuracy of the measurement compared to ± 1 °F because the actual temperature measured during the test is accounted for in the calculations for efficiency.

(Burnham, No. 40 at p. 5; Raypak, No. 47 at p.3; Weil-McLain, No. 41 at p. 5) Lochinvar, Weil-McLain, and Crown Boiler indicated that maintaining the water temperatures over the course of a test to within the proposed ± 1 °F band for the necessary water flow rates would be difficult or impossible. (Lochinvar, No. 43 at pp.1, 7, Public Meeting Transcript, No. 34 at p. 48; Weil-McLain, No. 41 at p. 4; Crown Boiler, Public Meeting Transcript, No. 34 at p. 48) Bradford White suggested that the average of the inlet and outlet water temperatures individually be held to a ± 1 °F tolerance through the test duration, while any given reading would have a tolerance of ± 2 °F. (Bradford White, No. 39 at p. 3) AERCO suggested allowing the temperature to vary by more than ± 1 °F but conducting the test for 2 hours so that variations from the target temperature will not bias the result. (AERCO, Public Meeting Transcript, No. 34 at p. 51)

DOE concurs with Weil-McLain's assessment that the calculations for efficiency use the actual temperature rise measured during the test and therefore maintaining the temperatures within certain tolerances is less important. DOE notes that the tolerances instead provide an additional verification that the system is operating at a steady-state. Moreover, while the water temperature immediately prior to entering the commercial packaged boiler must meet the described requirements the calculation for efficiency will continue to use the average of the water temperature measured upstream of the point at which the recirculating loop reenters the incoming water stream. The tolerance on this temperature therefore does not necessarily affect the temperature used in the efficiency calculations (unless a recirculating loop is not used). DOE is therefore not adopting the

proposed temperature tolerances of ± 1 °F and is instead adopting tolerances from ANSI/AHRI Standard 1500-2015.

AERCO stated that multipoint water temperature measurements or mixing before a single point reading is critical because a large source of error in efficiency calculations is the temperature. Measurement error can occur because of stratification of the water temperature. (AERCO, Public Meeting Transcript, No. 34 at pp. 52, 172-173) DOE acknowledges that ANSI/AHRI Standard 1500-2015 incorporated set-up changes to induce mixing at the outlet in order to prevent stratification and therefore reduce measurement error. DOE is therefore adopting similar set-up changes at the inlet of the commercial packaged boilers in order to reduce the error associated with inlet water temperature measurement. Water entering the commercial packaged boiler must first pass through two plugged tees in order to induce mixing, with the temperature measurement taking place in the plugged end of the second tee.

G. Ambient Conditions

In the March 2016 NOPR, DOE proposed new constraints on ambient temperature and relative humidity. DOE's existing test procedure limits the humidity of the room during testing of condensing boilers to 80-percent (10 CFR 431.86(c)(2)(ii)) and establishes ambient room temperature requirements. BTS-2000 (incorporated by reference) and ANSI/AHRI Standard 1500-2015 both require that test air temperature, as measured at the burner inlet, be within ±5 °F of the ambient temperature, where ambient temperature is measured within 6 feet of the front of the unit at mid-height. ANSI/AHRI Standard 1500-2015 prescribes an allowable ambient temperature during the test between

30 °F and 100 °F (section 5.3.8) with the relative humidity not exceeding 80-percent in the test room or chamber (section 5.3.9). DOE proposed to require that ambient relative humidity at all times be 60-percent ± 5-percent and ambient room temperature 75 °F ± 5 °F during thermal and combustion efficiency testing of commercial packaged boilers.[5] DOE proposed the same ambient conditions for all commercial packaged boilers (non-condensing and condensing).

In response to the March 2016 NOPR, ABMA, AHRI, Burnham, and Lochinvar indicated that current testing typically takes place in uncontrolled environments, spaces that are not sealed and tightly controlled with respect to ambient conditions, or spaces that could not be maintained within the proposed ambient parameters for all sizes of commercial packaged boilers. (ABMA, No. 38 at p. 6, Public Meeting Transcript, No. 34 at p. 75; AHRI, No. 46 at p. 4; Burnham, No. 40 at p. 6; Lochinvar, No. 43 at p. 8) Weil-McLain indicated that combustion air is typically not conditioned; that for direct exhaust systems and direct vent or sealed units, combustion air is provided directly to the unit and therefore the ambient room air is often warmer than the air used for combustion. (Weil-McLain, No. 41 at p. 2) Because the air is brought in from outside and is unconditioned, several manufacturers suggested that the proposed ambient requirements would limit the times of year during which testing could be performed. (Bradford White, No. 39 at p.4; Burnham, No. 40 at p. 6; Raypak, No. 47 at p. 5; Weil-McLain, No. 41 at p. 2)

[5] Humidity is the amount of water vapor in the air. Absolute humidity is the water content of air. Relative humidity, expressed as a percent, measures the current absolute humidity relative to the maximum for that temperature. Specific humidity is a ratio of the water vapor content of the mixture to the total air content on a mass basis.

Several commenters suggested that the proposed ambient conditions would result in additional test burden by forcing manufacturers to spend significant resources in upgrading facilities and HVAC capabilities. (ABMA, No. 38 at pp. 4, 6; Bradford White, No. 39 at p. 4; Burnham, No. 40 at p. 6; CA IOUs, No. 48 at pp. 3-4; AHRI, No. 46 at p. 4; Raypak, No. 47 at p. 5; Lochinvar, No. 43 at p. 8; Weil-McLain, No. 41 at pp. 2, 14) Weil-McLain suggested that DOE understated the costs associated with laboratory facility upgrades. (Weil-McLain, No. 41 at p.2) Bradford White estimated that the cost of an environmental chamber would be approximately $120,000; AHRI suggested the cost could be from $100,000 to over $1,000,000; Burnham suggested that the cost would be approximately $125,000 for a 20-ton cooling capacity laboratory HVAC system; and Raypak estimated that a facility capable of conditioning combustion air to support a 4,000,000 Btu/h boiler would be $500,000 to $1,500,000. (Bradford White, No. 39 at p. 4; AHRI, No. 46 at p. 4; Burnham, No. 40 at p. 6; Raypak, No. 47 at p. 6)

Multiple stakeholders suggested that DOE had not provided sufficient evidence that tighter ambient condition restrictions are justified. (Burnham, No. 40 at p. 6; AHRI, No. 46 at p. 4; Weil-McLain, No. 41 at p. 2; Bradford White, No. 39 at p. 5) ABMA acknowledged, however, that ANSI/AHRI Standard 1500-2015 was written primarily based on testing of smaller boilers and that it is possible it does not account for the sensitivity of larger boilers to certain test conditions. (ABMA, Public Meeting Transcript, No. 34 at p. 82) AHRI suggested that ambient requirements were being considered as part of the development of ASHRAE Standard 155P, particularly as they pertain to jacket losses. (AHRI, Public Meeting Transcript, No. 34 at pp. 80-81) Weil-McLain also stated that the premise that ambient temperature limits would improve

repeatability is false, while CA IOUs stated that a range of allowable ambient temperatures of 30 to 100 degrees Fahrenheit (found in ANSI/AHRI Standard 1500-2015) can result in efficiency ratings that vary because heat convection from the commercial packaged boiler to the room would increase as the ambient room temperature decreases. (Weil-McLain, No. 41 at p. 2; CA IOUs, No. 48 at p. 1). CA IOUs therefore supported the ambient room temperature requirement to be 75 °F ± 5 °F and stated that it should be achievable by most testing facilities. However, CA IOUs also suggested that variations in relative humidity have little effect on efficiency rating and therefore did not justify the added test burden. (CA IOUs, No. 48 at pp. 3-4) Similarly, Crown Boiler questioned whether the limits for relative humidity were justified, but suggested that an allowable range of 0 to 60-percent relative humidity would be more reasonable. (Crown Boiler, Public Meeting Transcript, No. 34 at pp. 74-75) Raypak stated that they concur with the conclusion reached in the residential boiler test procedure rulemaking that ambient temperature and relative humidity do not have any impact on efficiency. (Raypak, No. 47 at p. 4) Bradford White also suggested that the changes to the DOE test procedure may in fact have an effect on ratings in light of DOE's consideration that ambient temperature and relative humidity have a noticeable effect on efficiency. (Bradford White, No. 39 at pp. 4-5, 6-7)

In light of comments received DOE is maintaining the current maximum ambient relative humidity of 80-percent. At this time, DOE does not believe the added test burden of controlling ambient humidity is justified, given the amount of combustion air required for commercial packaged boilers approaching 5,000,000 Btu/h rated input (larger than this size would be eligible for the optional field test for which ambient

relative humidity would not be constrained). DOE is adopting tighter restrictions for ambient room temperature as compared to ANSI/AHRI Standard 1500-2015, as it does not believe that the incremental test burden associated with maintaining reasonable room temperatures is excessive. However, in light of the concerns raised about fluctuations in test spaces, DOE is adopting a wider range of allowable ambient room temperatures as compared to those in the March 2016 NOPR. For condensing commercial packaged boilers, room ambient temperature will be required to be between 65 °F and 85 °F and for non-condensing commercial packaged boilers ambient room temperature will be required to be between 65 °F and 100 °F. DOE believes that these temperatures are aligned with ASHRAE Standard 155P,[6] which several commenters have requested DOE adopt once it is published. DOE is also requiring that the average ambient relative humidity and average ambient room temperature be included in certification reports.

Additionally, Burnham and Raypak commented specifically that the ± 2 °F tolerance with respect to the mean ambient temperature would be difficult or impossible to maintain given the size of equipment and make-up air requirements. (Burnham, No. 40 at p. 6; Raypak, No.47 at p. 5) In light of these concerns, DOE is widening the allowable tolerance by which the room ambient temperature can vary with respect to the average ambient room temperature during the test from ± 2 °F as proposed to ± 5 °F. DOE proposed similar requirements (± 2 °F variation from average ambient room temperature) for in its test procedure NOPR for commercial water heating equipment,

[6] An Advisory Public Review Draft of ASHRAE Standard 155P was published in August 2016 and can be found at: https://osr.ashrae.org/sitepages/showdoc2.aspx/ListName/Public%20Review%20Draft%20Standards/ItemID/1542/IsAttachment/N/Standard+155P+061616+APR_chair_approved.pdf

published in the Federal Register on May 9, 2016. 81 FR 28587. In response, Bradford White, AHRI, and A.O. Smith (owner of Lochinvar) supported an allowable variation of ± 5 °F as opposed to ± 2 °F, and Bradford White and A.O. Smith suggested that maintaining temperature with such allowable variation would be achievable without additional burden to manufacturers. (Docket EERE-2014-BT-TP-0008: Bradford White, No. 19 at p. 3; AHRI, No. 26 at p. 7; A. O. Smith, No. 27 at p. 18)[7] DOE notes that Bradford White and A.O. Smith (Lochinvar) manufacturer both commercial water heating equipment and commercial packaged boilers, and DOE expects that laboratory facilities are comparable for testing both types of equipment. DOE is therefore adopting a tolerance of ± 5 °F with respect to the average room ambient temperature for commercial packaged boilers.

AERCO suggested that the altitude of a unit undergoing a field test could impact the test result, and the CA IOUs suggested that barometric pressure variation has a greater impact on test ratings than relative humidity and possibly temperature. (AERCO, Public Meeting Transcript, No. 34 at p. 160; CA IOUs, Public Meeting Transcript, No. 34 at p. 76) DOE was not provided data that indicate to what extent barometric pressure affects efficiency ratings for commercial packaged boilers. In general, DOE has not found it necessary to regulate the ambient barometric pressure of test rooms for heating products. Accordingly, DOE is not adopting barometric pressure requirements in this final rule.

[7] The rulemaking docket for the commercial water heating equipment test procedure can be found at: https://www.regulations.gov/docket?D=EERE-2014-BT-TP-0008

H. Set-up and Instrumentation

In the March 2016 NOPR, DOE proposed several clarifications to set-up and instrumentation for its commercial packaged boiler test procedure, including steam piping configuration, digital data acquisition, and calibration requirements.

In general, ACEEE suggested that DOE not specify instrumentation to the level of detail being proposed, but rather indicate only how DOE would test for enforcement cases because it is the manufacturer's responsibility to ensure the accuracy of its certifications. (ACEEE, Public Meeting Transcript, No. 34 at pp. 108-109) DOE disagrees, as manufacturers need to have test data to assess whether a product is compliant prior to distribution that is just as reliable as the test data DOE uses when bringing an enforcement case. DOE establishes test provisions that both DOE and manufacturers (as well as other stakeholders) must use when conducting an efficiency test. Although DOE does establish separate enforcement provisions, such provisions typically do not establish an alternative method of test but instead establish a methodology to grant latitude to manufacturers for key metrics such as those used to determine equipment class. Establishing a consistent test methodology, including calibration procedures, is fundamental to EPCA, as it ensures that all parties have a standardized method for assessing compliance with standards and for generating efficiency information for consumers. Therefore, DOE is adopting calibration procedures as part of its test procedure in this final rule that all parties must use when using the DOE test procedure.

1. Steam Piping

In the March 2016 NOPR DOE proposed provisions in order to clarify steam riser and header geometry. The proposed additional specifications were as follows:

- No reduction in diameter shall be made in any horizontal header piping, as a reduction in pipe diameter in the horizontal header prevents entrained water from draining properly and typically leads to non-steady-state operation. In the case of commercial packaged boilers with multiple steam risers, the cross-sectional area of the header must be no less than 80-percent of the summed total cross-sectional area of the risers, and the header pipe must be constant in diameter along its entire length.

- The diameter of the vertical portion of the steam condensate return pipe that is above the manufacturer's recommended water level may be reduced to no less than one half of the header pipe diameter to ensure adequate operation of the return loop and draining of entrained water back into the commercial packaged boiler.

In the event the manufacturer's literature does not specify necessary height and dimension characteristics for steam risers, headers, and return piping, DOE also proposed the following requirements to ensure consistent and repeatable testing:

- The header pipe diameter must be the same size as the commercial packaged boiler's steam riser (steam take-off) pipe diameter. In the case of commercial

packaged boilers with multiple steam risers, the cross-sectional area of the header must be no less than 80-percent of the summed total cross-sectional area of the risers, and the header pipe must be constant in diameter along its entire length.

- The height measured from the top of the header to the manufacturer's recommended water level must be no less than the larger of 24 inches or 6 times the header pipe diameter.

- The distance between the vertical steam riser (steam take-off) leading to the water separator and the elbow leading to the condensate return loop must be a minimum of three (3) header pipe diameters to prevent entrained water from entering the separator piping.

- If a water separator is used, piping must pitch downward to the separator at a rate of at least 1/4 inch per foot of pipe length in order to assure proper collection of moisture content and steady-state operation during testing.

- A vented water seal is required in steam moisture collection plumbing to prevent steam from escaping through the moisture collection plumbing.

In response, the CA IOUS supported the modified language for steam riser and header geometry, steam condensate return pipe and pipe installation requirements because they would improve test accuracy and quality. (CA IOUs, No. 48 at p. 3) AHRI

suggested that the test procedure should refer to manufacturer's installation instructions with regard to steam riser, header, and return water loop requirements. (AHRI, No. 46 at p. 8) Weil-McLain suggested that the steam quality requirement (98-percent per BTS-2000 and ANSI/AHRI Standard 1500-2015) is sufficient and that the proposed configuration requirements do not reflect common installation practices. (Weil-McLain, No. 41 at p. 7) Crown Boiler also suggested that the geometry requirements in ANSI/AHRI Standard 1500-2015 are sufficient because pipe sizes can vary by manufacturer and are listed in manufacturer's specifications. They also suggested that the requirement for the steam riser diameter to be half of the diameter of the header is not needed because there is generally no flow in the pipe and that the size of the pipe is sometimes determined experimentally. (Crown Boiler, Public Meeting Transcript, No. 34 at p. 85)

While DOE believes that its proposed requirements could be met in most cases, DOE cannot anticipate all commercial packaged boiler designs and configurations. For commercial packaged boiler designs for which the proposed steam piping configurations would not be feasible, manufacturers would need to seek waiver or, for commercial packaged boilers with rated inputs greater than 5,000,000 Btu/h, may need to use the field test where they otherwise could have performed a laboratory test. DOE agrees with Weil-McLain that the steam quality requirement is sufficient for ensuring steady operation of the commercial packaged boiler, in conjunction with the requirement in ANSI/AHRI Standard 1500-2015 that steam pressure not fluctuate by more than 5-percent. DOE believes that using only the steam quality and pressure measurement requirements will allow manufacturers flexibility in their set-up while ensuring tests are

conducted equivalently. DOE is therefore withdrawing these proposed steam pipe set-up provisions.

DOE also proposed insulation conductivity and thickness requirements for steam piping. AHRI commented that certifying compliance with an R-value as opposed to thickness and conductivity may be simpler. (AHRI, Public Meeting Transcript, No. 34 at p. 90) DOE notes that the proposed insulation requirements are taken from ASHRAE/IES Standard 90.1 and conversion to R-values would result in fractions which may present confusion. The proposed steam piping insulation provisions are therefore adopted in this final rule for consistency with the industry standard. The March 2016 NOPR included rows for fluid temperatures up to 250 °F; however, this final rule adopts the full table from ASHRAE/IES Standard 90.1, which include fluid temperatures up to 350 °F, in order to account for superheated steam.

2. Digital Data Acquisition

DOE proposed to require digital data acquisition at 30-second intervals in the March 2016 NOPR. Bradford White supported this proposal. (Bradford White, No. 39 at p. 5) However, AHRI, Burnham, Lochinvar, and Weil-McLain suggested that the requirement was not justified. (AHRI, No. 46 at p. 5; Burnham, No. 40 at p. 7; Lochinvar, No. 43 at pp. 6, 9; Weil-McLain, No. 41 at p. 6) ABMA suggested that digital data acquisition may have benefits. (ABMA, No. 38 at p. 5) Multiple stakeholders, including AHRI, ABMA, Lochinvar, Raypak, and Weil-Mclain, also raised concern about the cost burden of this requirement. (AHRI, No. 46 at p. 5; ABMA, No.

38 at p. 5, Public Meeting Transcript, No. 34 at p. 101; Lochinvar, No. 43 at p. 6; Raypak, No. 47 at p. 4; Weil-McLain, No. 41 at pp. 5-6)

Burnham indicated that most laboratories can log temperatures at 30-second intervals although they may not be able to do so with instrumentation having the required accuracy of ± 0.2°F. (Burnham, No. 40 at p. 7) Weil-McLain noted that DOE did not identify a calibration methodology for the digital data acquisition equipment. (Weil-McLain, No. 41 at p. 5) Raypak suggested that the data acquisition system would require costs for a flow meter, gas meter, flue gas analyzer, gas chromatograph, pressure transducers, barometric pressure and humidity interface controls and would cost four to five times DOE's estimate. (Raypak, No. 47 at p. 8) Lochinvar suggested that water temperature readings should be digitized but that higher heating value, barometric pressure, and relative humidity should not be digitized. (Lochinvar, Public Meeting Transcript, No. 34 at p. 102-103)

DOE believes digital data acquisition is a valuable tool for ensuring that the various parameters and requirements of the test procedure are met for the duration of the test. Temperatures vary over the course of a test, and DOE does not believe that 15-minute interval data as required by ANSI/AHRI Standard 1500-2015 is sufficient for verifying that the test procedure has been met or that the measured efficiency has not been influenced by variance in certain parameters. DOE considered the cost burden of adding digital data acquisition in the NOPR and has revised its estimates in section IV.B, and continues to believe that the costs are not overly burdensome in comparison to the overall cost of testing for a manufacturer's product line. DOE is therefore adopting the

requirement for obtaining data digitally for temperatures, specifically ambient room temperature, flue gas temperature, and water temperatures. Because DOE is not, at this time, adopting tighter tolerances on the ambient relative humidity, DOE also will not require digital data acquisition for this parameter and will continue to use 15-minute intervals. DOE does not believe it is necessary to specify calibration in light of the accuracy requirements already part of ANSI/AHRI Standard 1500-2015.

Weil-McLain suggested that DOE provide details on integration and averaging methods for each data type as well as rules on how to treat data points that fall outside of the requirements when the average or integrated values for the test are within requirements. (Weil-McLain, No. 41 at p. 6, Public Meeting Transcript, No. 34 at p. 65) AHRI similarly suggested DOE include a table that lists which measurements are to be averaged and which are to be totaled over the test period. (AHRI, Public Meeting Transcript, No. 34 at pp. 104-105) DOE has modified the tables in the test procedure to clarify that any individual digital reading falling out of its required range per the DOE test procedure constitutes an invalid test, . DOE is modifying the original 30-second interval to 1-minute intervals as a means of reducing the burden that the constraint may pose by invalidating a test due to one 30-second interval reading of one parameter not being within tolerance. Each 1-minute interval reading for each of the parameters required to be obtained through digital data acquisition must therefore fall within the specified range per the DOE test procedure. In this final rule, DOE has also added specificity regarding averaging and integration for each measurement, as applicable.

3. Calibration

DOE proposed in the March 2016 NOPR that instrumentation be calibrated at least once per year. Bradford White and Lochinvar expressed support for this proposal, and DOE did not receive any comments objecting. (Bradford White, No. 39 at p. 5; Lochinvar, No. 43 at p. 9) DOE is therefore adopting this requirement in this final rule. Weil-McLain, however, suggested that the proposed calibration procedures did not address whether pre-test and post-test calibration is required. For example, they suggest that it is unclear what implications, if any, there are if a previously calibrated instrument is used and on the next calibration the instrument fails or is damaged. (Weil-McLain, No. 41 at p. 18) DOE clarifies that it is not adopting provisions by which a test is invalidated because an instrument fails a subsequent calibration.

In the March 2016 NOPR, DOE proposed to require calibration of gas chemistry instrumentation using standard gases with purities of greater than 99.9995 percent for all constituents analyzed. In response, AHRI, Bradford White, Burnham, Raypak, Lochinvar, Weil-McLain, and Crown Boiler suggested that the requirement was too stringent. (AHRI, No. 46 at p. 5; Bradford White, No. 39 at p. 5; Burnham, No. 40 at p. 7; Raypak, No. 47 at pp. 7-8; Lochinvar, No. 43 at p. 9; Weil-McLain, No. 41 at p. 18; Crown Boiler, Public Meeting Transcript, No. 34 at p. 99) Raypak noted that its supplier, Airgas Specialty Gases, uses ultra-high purity gases of 99.99 percent for CO_2 and 99.5 percent for CO, and that they indicated that 99.9995 percent purity CO_2 is significantly more expensive and the maximum available for CO is 99.99 percent. (Raypak, No. 47 at p. 7) Lochinvar suggested that the excessive purity proposed in the March 2016 NOPR was both prohibitively expensive and posed significant toxicity and flammability risks.

They further suggested that calibration references should be 4 to 10 times more accurate than the required accuracy of the equipment being calibrated. (Lochinvar, No. 43 at p. 9) Bradford White suggested that a typical cylinder of calibration gas costs approximately $400 and lasts approximately 8 weeks, assuming the analyzer is calibrated daily; they also provided a sample gas calibration certificate. (Bradford White, No. 39 at p. 5 and Attachment)

After further consideration, DOE acknowledges that gas meeting the proposed ultra-high purity gas calibration standards may be difficult or expensive to obtain. Additionally, DOE recognizes that there are requirements for the accuracy of gas chemistry instrumentation found in ANSI/AHRI Standard 1500-2015 that are being adopted in this final rule. DOE believes that the requirements for gas chemistry instrumentation accuracy (specifically ±0.1 percent for CO_2 and O_2 testers and the greater of ± 10 ppm or ± 5-percent of reading for CO testers) are sufficient for the purposes of the commercial packaged boiler test procedure and that requiring a specific calibration gas purity beyond the accuracy of the instrument itself may be duplicative. Accordingly, DOE is not adopting this proposal.

4. Other Set-up and Instrumentation Comments

ABMA requested that straight vent stacks be allowed as an alternative to the double 90-degree elbow configuration in ANSI/AHRI Standard 1500-2015 to accommodate commercial packaged boilers with forced draft burners firing into combustion chambers under positive pressure. They further stated that automated draft control systems are used on installations having tall stacks, thus there is typically no dilution of flue gas in the vent system. (ABMA, No. 38 at p. 2-3) DOE agrees that such commercial packaged boilers should be permitted to test using straight vent stacks and has included a provision in this final rule accordingly.

The CA IOUs suggested that the test procedure should be revised to eliminate ambiguity in how CO_2 concentrations are measured during the test. They indicated that during tests of commercial packaged boilers conducted by PGE, the CO_2 concentration could change depending on where the CO_2 probe was placed in the flue gas stream. (CA IOUs, No. 48 at p. 2) DOE reviewed the submitted data and acknowledges that acknowledges that there appears to be an affect on the CO2 measurement based on horizontal position of the flue gas probe. Additionally, DOE notes that there is ambiguity, as CA IOUs suggest, in the placement of the flue gas probe for vent configurations like the one CA IOUs presented in their comment. Specifically, DOE believes the unit tested by PGE was an outdoor commercial packaged boilers because there was no stack attached to the unit. However, CA IOUs did not suggest which position should be used in the DOE test procedure. DOE notes that section C2.5.2 of ANSI/AHRI Standard 1500-2015 specifies that sampling from a rectangular plane be collected “using a sampling tube located so as to obtain an average flue gas sample.”

DOE agrees that this is ambiguous. DOE is therefore adopting a requirement that three samples be taken at evenly spaced intervals (¼, ½, and ¾ of the distance from one end) in the longer dimension and along the centerline halfway between the edges in the shorter dimension of the rectangle and that the average be taken.

Weil-McLain noted that ANSI/AHRI Standard 1500-2015 specifies different fuel oil analysis requirements (fuel oil grade under ASTM D396-14a, heating value under ASTM D240-09, hydrogen and carbon content under ASTM D5291-10, and density and American Petroleum Institute (API) gravity[8] under ASTM D396-14a) for commercial packaged boilers than are required for residential boilers under ASHRAE 103-1993 annual fuel utilization efficiency (AFUE) (e.g., gravity and viscosity uses ASTM D396-90A and fuel oil analysis requirements are different than for commercial). Weil-McLain suggested DOE correct this to allow the same fuel oil analysis for both residential and commercial efficiency testing. (Weil-McLain, No. 41 at p. 13) DOE reviewed the fuel oil specifications of ASTM D396-14a and the requirements found in ASHRAE Standard 103-1993 (incorporated by reference for the DOE test procedure for residential boilers found at 10 CFR part 430 subpart B appendix N). While they are similar, they are not identical and DOE could not confirm that they would yield similar results. Weil-McLain did not provide any evidence that the two methods were equivalent. Therefore, DOE is not adopting additional provisions for fuel oil analysis at this time.

[8] The American Petroleum Institute gravity, or API gravity, is a measure of how heavy or light a petroleum liquid is compared to water: if its API gravity is greater than 10, it is lighter and floats on water; if less than 10, it is heavier and sinks.

Weil-McLain noted that ANSI/AHRI Standard 1500-2015 allows for two different water meter calibrating methods, one of which does not meet certain accuracy requirements found in table C1 of ANSI/AHRI Standard 1500-2015, and therefore recommends that DOE require water meters in all cases to meet table C1 in order to avoid inaccurate efficiency results. (Weil-McLain, No. 41 at p. 13) DOE notes that the March 2016 NOPR did not propose to adopt section C2.7.2.2.2, which is the alternative water meter calibration method that Weil-Mclain referred to. This final rule adopts only the instrument accuracy requirements of Table C1 in ANSI/AHRI Standard 1500-2015 and not section C2.7.2.2.2about which Weil-McLain expressed concern.

I. Other Issues

1. Burners for Oil-Fired Commercial Packaged Boilers

In the March 2016 NOPR, DOE proposed a set of provisions for determining the burner to be used in testing an oil-fired commercial packaged boiler. DOE proposed that the unit be tested with the particular make and model of burner certified by the manufacturer. If multiple burners are specified in the installation and operation manual or in one or more certification reports, then DOE proposed that any of the listed burners may be used for testing and all must be certified to the Department.

In response, AHRI requested additional specificity in the test procedure for a situation in which manufacturer's specifications do not prescribe a specific burner or burners, particularly with respect to firing rate and/or spray geometry. (AHRI, Public Meeting Transcript, No. 34 at pp. 93-94) DOE notes that under its proposed regulations in the March 2016 NOPR, manufacturers would be required to certify the make and

model of the burner used during certification testing, and that this make and model would be used for testing. DOE believes this is sufficiently clear and is adopting the language it proposed in the March 2016 NOPR.

2. Certification and Enforcement Provisions

DOE proposed a provision in the March 2016 NOPR that it would conduct enforcement testing in both steam mode and hot water mode for those commercial packaged boilers capable of producing both and both results must demonstrate compliance with the applicable energy conservation standards. Lochinvar objected to the proposal, stating that there is already a method in place for determining hot water commercial packaged boiler efficiency based on the rating in steam mode, and that the requirement would add test burden. (Lochinvar, No. 43 at p. 11) In response, DOE notes that this is not a certification requirement for manufacturers, but is a provision that indicates the procedure DOE will follow when conducting its own enforcement testing. Namely, DOE would conduct an enforcement test in each mode (steam and hot water) for those commercial packaged boilers models capable of operating in either mode rather than using the measured efficiency for steam mode to determine compliance in hot water mode. DOE would use the appropriate result to evaluate compliance with the respective standards. DOE notes that this does not add test burden for manufacturers and is adopting this provision as part of this final rule.

3. Part-Load Testing

In the March 2016 NOPR, DOE tentatively concluded that part-load testing was not warranted and therefore did not propose any new test procedure provisions towards that end. In response, Lochinvar supported this conclusion and, along with NEEA, the Efficiency Advocates, and the CA IOUs, suggested using ASHRAE 155 in the future to capture part-load performance. (Lochinvar, No. 43 at p. 11; NEEA, No. 44 at pp.2-3; Efficiency Advocates, No. 45 at p. 3; CA IOUs, No. 48 at p. 5) Weil-McLain suggested that part-load efficiency should not be mandated, but also that it would be prudent to regulate how part-load efficiency is measured in order to ensure comparable part-load ratings. (Weil-McLain, No. 41 at p. 19) DOE does not intend to develop a test procedure at this time for the purpose of measuring part-load efficiency. DOE believes the ratings produced by its test procedure provide a sufficient basis to give the purchaser enough information when choosing between commercial packaged boilers models. DOE may in the future adopt a test procedure that includes part-load measurements.

4. Stack Temperature Adjustment

In the March 2016 NOPR, DOE proposed a calculation to adjust the stack temperature when using steam mode combustion efficiency ratings to represent the combustion efficiency in hot water mode. DOE's existing test procedure allows commercial packaged boilers with fuel input rate greater than 2,500,000 Btu/h capable of producing steam and hot water to use the combustion efficiency as measured in steam mode to represent the combustion efficiency in hot water mode. 10 CFR 431.86(c)(2)(iii)(B). DOE received waiver requests from Cleaver-Brooks, Johnston Boiler, Superior Boiler Works, and York-Shipley (AESYS) that asked to use an

adjustment to the stack temperature when using this rating method in order to more accurately reflect the combustion efficiency of a commercial packaged boiler operating in hot water mode. The adjustment is given by Equation 1:

$$T_{F,SS,adjusted} = T_{F,SS} - T_{sat} + 180 \qquad \textbf{Equation 1}$$

where $T_{F,SS,adjusted}$ is the adjusted steady-state flue temperature used for subsequent calculations of combustion efficiency, $T_{F,SS}$ is the measured steady-state flue temperature during combustion efficiency testing in steam mode, T_{sat} is the saturated steam temperature that corresponds to the measured steam pressure, and 180 is the hot water outlet temperature.

In response, Lochinvar agreed with adopting the method and indicated that the theory behind the correction is sound and results should be conservative. (Lochinvar, No. 43 at p. 10) Weil-McLain did not support adopting the method because not all boiler designs are the same and the method may not reflect accurate ratings for water mode. (Weil-McLain, No. 41 at p. 7) Crown Boiler suggested that the adjustment may be unreliable, and ABMA questioned to what extent testing was done to develop the equation. (Crown Boiler, Public Meeting Transcript, No. 34 at p. 133-135; ABMA, Public Meeting Transcript, No. 34 at p. 133-135)

DOE considered data from the AHRI directory[9] (as of May 2015) for commercial packaged boilers with rated inputs greater than 2,500,000 and for which differing combustion and thermal efficiencies were listed for the same model (57 models). DOE found that on average combustion efficiency in hot water mode was approximately 0.8-percent higher than that for steam and would anticipate a similar adjustment from the proposed methodology. However, while several manufacturers requested the adjustment methodology as part of the waiver process, no data were submitted to validate the equation. DOE is therefore not adopting this adjustment methodology. Manufacturers wishing to rate a basic model with a higher combustion efficiency in hot water mode can perform a separate combustion efficiency test in that mode.

5. Oxygen Combustion Analyzer

ANSI/AHRI Standard 1500-2015 includes a methodology for using an O_2 combustion analyzer for measurements of combustion efficiency, and DOE proposed adopting this methodology by incorporating by reference this industry standard. AHRI expressed its support for the provision because theO_2 methodology is essentially equivalent to the CO_2 methodology and that AHRI had completed analysis to verify this. (AHRI, Public Meeting Transcript, No. 34 at p. 95) DOE is adopting this provision in the final rule.

[9] Available at: https://www.ahridirectory.org/ahridirectory/pages/home.aspx

6. Rounding Requirements

DOE proposed to clarify its rounding procedures by requiring that the combustion and thermal efficiency results be rounded to the nearest tenth of one percent. In response, ACEEE suggested that reporting to such a level of precision means little to the customer, has little justification when considering the 5-percent tolerance on the final rating, and instead suggested rounding to a whole number. (ACEEE, Public Meeting Transcript, No. 34 at pp. 126-128) Bradford White similarly did not see value in rounding to the nearest tenth of a percent and instead recommended rounding to the nearest percent. (Bradford White, No. 39 at p. 6) Lochinvar, however, supported the DOE proposal to round to the nearest tenth of a percent. (Lochinvar, No. 43 at p. 10)

DOE notes that the AHRI certification program,[10] which uses BTS-2000 for certification testing, expresses thermal and combustion efficiency ratings to the nearest tenth of one percent. Also, the energy conservation standards for commercial packaged boilers at 10 CFR 431.87 are expressed to the tenth of one percent. DOE is therefore adopting a provision in this final rule to clarify that thermal and combustion efficiency ratings are to be rounded to the nearest tenth of one percent as was proposed in the March 2016 NOPR.

[10] For AHRI directory, see: https://www.ahridirectory.org/ahridirectory/pages/cblr/defaultSearch.aspx

IV. Procedural Issues and Regulatory Review

A. Review Under Executive Order 12866

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

B. Review Under the Regulatory Flexibility Act

The Regulatory Flexibility Act (5 U.S.C. 601 et seq.) requires that when an agency promulgates a final rule under 5 U.S.C. 553, after being required by that section or any other law to publish a general notice of proposed rulemaking, the agency shall prepare a final regulatory flexibility analysis (FRFA), unless the agency certifies that the rule 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 website: http://energy.gov/gc/office-general-counsel.

This final rule prescribes test procedure amendments that will be used to determine compliance with energy conservation standards for commercial packaged boilers. The amendments (1) clarify the definitions for commercial packaged boilers; (2) incorporate by reference the industry standard ANSI/AHRI Standard 1500-2015; (3) establish provisions for verifying rated input during enforcement testing; (4) adopt an optional field test and an optional metric conversion calculation; (5) modify the inlet and outlet water temperature requirements for hot water tests; (6) establish new temperature for combustion air; and (7) provide additional set-up and instrumentation requirements.

DOE reviewed this rule under the provisions of the Regulatory Flexibility Act and DOE's own procedures and policies published on February 19, 2003. 68 FR 7990. DOE has concluded that this 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). The threshold number for NAICS classification code 333414, which applies to "heating equipment (except warm air furnaces) manufacturing' and includes commercial packaged boilers, is 500 employees.

To estimate the number of companies that could be small business manufacturers of the equipment affected by this rulemaking, DOE conducted a market survey using

available public information to identify potential small manufacturers. DOE's research involved reviewing the DOE Compliance Certification Management System database (CCMS), AHRI directory (a product database), individual company websites, and marketing research tools (e.g., Hoover's reports) to create a list of all domestic small business manufacturers of equipment affected by this rulemaking. DOE identified 21[11] manufacturers of commercial packaged boilers as domestic small business manufacturers. DOE was able to discuss the DOE test procedures with 5 of these small businesses prior to publication of the March 2016 NOPR. DOE also obtained information about small businesses and potential impacts on small businesses while interviewing manufacturers in the context of the standards rulemaking. However, DOE did not receive any detailed quantifications about the incremental burden small businesses would face as compared to larger businesses in light of the proposed methods.

With respect to potential costs associated with the test procedure amendments, DOE notes that several amendments are clarifications or clerical changes that will not impose costs on small manufacturers. The clarifications made to the definitions relevant for commercial packaged boilers do not modify the scope of the test procedure nor do they impose additional test burden. DOE is not modifying the scope of coverage or substantively modifying its definitions in such a way that would result in the need to certify compliance for equipment for which certification is not already required. As a result, manufacturers that are small businesses are not expected to have to certify commercial packaged boilers for which they are not already certifying compliance.

[11] In the March 2016 NOPR, DOE identified 23 small businesses; however, of those 23, one small manufacturer left the market and another is considered large and therefore the count is now 21.

Also, updating the referenced test procedure to ANSI/AHRI Standard 1500-2015 is not anticipated to impose additional costs on manufacturers. ANSI/AHRI Standard 1500-2015 is an industry standard that replaces BTS-2000, which is currently incorporated by reference in the DOE test procedure. ANSI/AHRI Standard 1500-2015 uses essentially the same test method found in BTS-2000. While ANSI/AHRI Standard 1500-2015 removed outdated instrumentation references from BTS-2000, DOE does not believe manufacturers are using instrumentation that could not meet the requirements found in ANSI/AHRI Standard 1500-2015. ANSI/AHRI Standard 1500-2015 also increases the allowable steam pressure for steam tests as compared to BTS-2000, which accommodates testing of larger commercial packaged boilers but does not impose additional costs on manufacturers, including small manufacturers.

DOE is not adopting its proposed provisions for certification of fuel input rate, which had the potential of requiring manufacturers to re-certify previously certified commercial packaged boilers. The provisions DOE adopts in this final rule regarding rated input pertain only to the process DOE will use when conducting assessment and

enforcement testing and are for manufacturer information only. Therefore, these changes will pose no additional burden to small manufacturers of commercial packaged boilers.

DOE is adopting several provisions in this final rule that may reduce the burden associated with certifying compliance for commercial packaged boilers. Currently, laboratory testing for thermal or combustion efficiency, as applicable, is required for the certification of all commercial packaged boilers regardless of size. As described in the March 2016 NOPR and in section III.E, DOE acknowledges that some commercial packaged boilers because of their size may only be fully assembled at their site of installation and therefore the requirement to test for efficiency in a laboratory would require a manufacturer to assemble the unit at the laboratory for testing, tear it down and ship it to the site for installation, and re-build it – a process that may be expensive, if not impracticable. DOE is adopting an optional field test methodology based on the combustion efficiency test for commercial packaged boilers with rated input greater than 5,000,000 Btu/h as part of this final rule. As described in the March 2016 NOPR, the optional field test is intended to reduce test burden as compared to the existing DOE test procedure for thermal efficiency. DOE has previously noted that the combustion efficiency test is less burdensome because of its shorter duration and reduced instrumentation as compared to the thermal efficiency test. Therefore, by providing a simpler, shorter test method that only requires a unit to be assembled once, the optional field test provisions are anticipated to reduce test burden for small manufacturers that manufacturer these large commercial packaged boilers, as compared to the current test procedure.

Similarly, DOE is adopting an optional conversion calculation to obtain a thermal efficiency rating from a combustion efficiency test. The calculation allows small manufacturers to test the combustion efficiency (in a laboratory, manufacturer facility, or in the field) for steam commercial packaged boilers with rated input greater than 5,000,000 Btu/h and convert to a thermal efficiency rating. As described regarding the field test option, this optional calculation is anticipated to reduce test burden by allowing manufacturers of large equipment to use a simpler and shorter test (the combustion efficiency test, either in a laboratory or in the field).

Some test procedure amendments in this final rule may require additional costs for manufacturers, including small manufacturers. DOE is adopting more specific inlet piping provisions based on comments on the March 2016 NOPR that will increase the accuracy of the inlet water temperature measurement. The set-up change will require additional segments of pipe and tee connections, and a temperature sensor, however DOE

believes most if not all manufacturers already have these items. The set-up change may result in a longer set-up time which DOE estimates to be one additional hour per test. Based on current wage information from the Bureau of Labor Statistics (BLS) for a mechanical engineering technician[12], DOE estimates the additional cost per test (hourly labor cost multiplied by number of hours) to be $41.

DOE is also adopting water temperature limits in this final rule that will reduce ambiguity in ratings and provide for a more repeatable test. In the NOPR, DOE considered that a reduction in the temperature rise across a commercial packaged boilers would proportionally increase the water flow rate required. Such an increase may have necessitated facility improvements for manufacturer and third-party laboratories, specifically by installing larger pumps to meet the increase water demand, and DOE received several comments suggesting this would be the case in response to the March 2016 NOPR. ABMA suggested that the proposed test procedure could be particularly harmful to small entities. ABMA indicated that the example DOE provided for a 10 million Btu/h was inadequate and that it is not abnormal for a boiler to reach 3 times that size. They suggested that without an AEDM, the ratio would apply to the required larger pump size, weigh tanks, scales etc. and that applying the scaling factor of 3 to the $3,000 pump cost in the NOPR would result in a $9,000 pump. Additionally, ABMA stated that scaling the 500 gpm flow rate would yield 1,500 gpm requiring new weigh tanks and scales and possibly a new cooling tower which could reach nearly $750,000. (ABMA,

[12] Hourly labor cost is estimated by multiplying the hourly wage for a mechanical engineering technician by 1.5 to account for benefits. Based on data from the BLS, the mean hourly wage for a mechanical engineering technician (occupation code 17-3027) is $27.11. See: http://www.bls.gov/oes/current/oes173027.htm#nat

No. 38 at p. 5) However, in this final rule DOE is adopting water temperature limits that are more closely aligned with the current test procedure and reduce the allowable range of inlet water temperature for non-condensing commercial packaged boilers. For non-condensing commercial packaged boilers that already utilize a recirculating loop during testing, the amended test procedure standardizes the temperature rise across the commercial packaged boiler which may require slight adjustment of flow rates compared to current tests but does not require any additional set-up. For non-condensing commercial packaged boilers that do not currently use a recirculating loop, manufacturers may choose to use a recirculating loop in order to achieve the 80 °F ± 5 °F inlet water temperature. DOE estimates the additional set-up time required to be one hour per test, and this additional cost per test to be $41 (hourly labor cost for mechanical engineering technician multiplied by number of hours). For condensing commercial packaged boilers, DOE is not modifying the water temperature requirements.

In the March 2016 NOPR DOE proposed that steam tests occur at the lowest steam pressure at which the steam quality requirement of 98-percent is achieved by starting at atmospheric pressure and increasing incrementally. In response ABMA and Weil-McLain commented that the requirement to incrementally increase steam pressure would impose undue test burden. (ABMA, No. 38 at p. 4; Weil-McLain, No. 41 at p. 16) However, in the NOPR DOE estimated the cost of the time and fuel consumed for each test to be approximately $253 based on two additional hours of mechanical engineering

technician labor and natural gas use for a 10 million Btu/h commercial packaged boiler.[13] DOE continues to believe this amount is modest in comparison to the overall cost of product development and certification.

With respect to ambient conditions, based on comments received regarding the additional burden of tightly constraining ambient temperature and humidity, DOE is not adopting tighter restrictions on the ambient humidity and is adopting a broader range of allowable ambient temperatures as compared with the March 2016 NOPR. Several commenters suggested that the proposed ambient conditions in the March 2016 NOPR would result in additional test burden by forcing manufacturers to spend significant resources in upgrading facilities and HVAC capabilities. (ABMA, No. 38 at pp. 4, 6; Bradford White, No. 39 at p. 4; Burnham, No. 40 at p. 6; CA IOUs, No. 48 at pp. 3-4; AHRI, No. 46 at p. 4; Raypak, No. 47 at p. 5; Lochinvar, No. 43 at p. 8; Weil-McLain, No. 41 at pp. 2, 14) Weil-McLain suggested that DOE understated the costs associated with laboratory facility upgrades. (Weil-McLain, No. 41 at p.2) Bradford White estimated that the cost of an environmental chamber would be approximately $120,000; AHRI suggested the cost could be from $100,000 to over $1,000,000; Burnham suggested that the cost would be approximately $125,000 for a 20-ton cooling capacity laboratory HVAC system; and Raypak estimated that a facility capable of conditioning combustion air to support a 4,000,000 Btu/h boiler would be $500,000 to $1,500,000. (Bradford White, No. 39 at p. 4; AHRI, No. 46 at p. 4; Burnham, No. 40 at p. 6; Raypak,

[13] The price of natural gas is the 5-year average (May 2009 to May 2014) obtained from the "U.S. Price of Natural Gas Sold to Commercial Consumers" from U.S. Energy Information Administration (EIA) (Available at: http://www.eia.gov/dnav/ng/hist/n3020us3m.htm).

No. 47 at p. 6) Lochinvar indicated that adding the additional water and environmental test limitations beyond those in AHRI 1500 will have a substantial impact on all manufacturers which will be more significant for small manufacturers with less well equipped labs. (Lochinvar, No. 43 at p. 11)

However, DOE is not adopting the ambient condition requirements it proposed in the March 2016 NOPR. For ambient humidity, DOE is maintaining the current 80% maximum relative humidity requirement and is adopting a broader range of allowable ambient temperatures than proposed in the March 2016 NOPR. With regard to the ambient room temperature requirements in this final rule, DOE notes that the ranges of 65 °F to 100 °F for non-condensing commercial packaged boilers and 65 °F to 85 °F for condensing commercial packaged boilers are intended to prevent the test from being conducted in extreme ambient conditions, and that these allowable temperature ranges are typical for building heating, ventilating, and air-conditioning systems in normal operating conditions. Additionally, the temperature ranges being adopted are consistent with those found in DOE's test procedure for residential boilers (10 CFR part 430 subpart B appendix N) and in the draft version of ASHRAE Standard 155P published in August 2016 for public review, which several commenters have requested DOE adopt in the future as the basis for the DOE commercial packaged boiler test procedure. DOE does not believe that the ambient temperature requirements being adopted will require facility or equipment upgrades.

In the March 2016 NOPR, DOE proposed requiring digital data acquisition for certain parameters in the commercial packaged boilers test procedure. DOE

acknowledged that the requirement would have some one-time costs for manufacturers that do not currently have the necessary equipment. ABMA stated that digital data acquisition has its benefits, however it may create heavy financial burden for small manufacturers and should therefore be optional. (ABMA, No. 38 at p. 5) Raypak believed that the proposed digital data acquisition was too burdensome, particularly for small business manufacturers who would need to purchase data acquisition equipment at costs substantially higher than DOE estimates in the NOPR. (Raypak, No. 47 at p. 4) However, commenters did not present specific cost estimates for necessary equipment. DOE nevertheless reexamined its estimates for digital data acquisition and added instrumentation that may also be necessary to meet the requirements and the revised cost estimates are found in Table IV.1. The data acquisition system could be used by the manufacturer or laboratory to test all commercial packaged boiler models going forward.

Table IV.1 Estimated One-Time Costs Associated with Digital Data Acquisition

Description	Cost
Laptop	$1,500
Data Acquisition Module	$2,000
Data Acquisition Software	$3,000
Instrumentation (Resistance Temperature Detectors, Thermocouples)	$1,000
Initial Purchase, Installation and Setup (40 hours laboratory technician time X $41/hour)	$1,640
Total	$9,140

DOE does not believe that manufacturers are required to re-test and re-certify existing basic models that are already certified as complying with DOE's energy conservation standards as a result of this test procedure final rule. As part of its energy conservation standards rulemaking for commercial packaged boilers, DOE found that there are 595 individual models attributed to 8 small manufacturers in the CCMS database. While this results in an average of 74 individual models per small manufacturer, DOE estimates that small manufacturers on average certify 10 basic models (approximately 7 individual models per basic model). Based on discussions with third-party test laboratories, DOE estimates that a laboratory test using a third-party

laboratory would cost a manufacturer approximately $5,000. Using publicly available information from Hoovers, Manta, and Glassdoor, DOE estimated revenues for small manufacturers listed in the CCMS database. The average annual for a small manufacturer revenue was $29.6 million. If a small manufacturer were to test 7 basic models with a third-party laboratory, DOE estimates that this would cost $35,000 which represents approximately 0.1% of revenue. (Note: DOE believes this is conservative, as most manufacturers would use their own laboratories for testing at a lower cost.)

In the case of using their own facilities and conducting tests in-house, as shown in Table IV.1, DOE estimates the one-time costs associated with data acquisition to be $9,140. DOE continues to believe these costs are modest in comparison to small manufacturer revenues and to the overall cost of product development and certification. For water tests, the additional burden due to the inlet piping set-up and recirculating loop total two additional hours of mechanical engineering technician labor or $82. For steam tests, DOE estimated that two additional hours of mechanical engineering technician labor and natural gas use would cost approximately $253. DOE believes that these additional costs for each test attributable to the inlet piping set-up, recirculating loop set-up, and steam pressure adjustment to be modest in comparison to the overall cost of testing.

Further, DOE notes that manufacturers may use the AEDM process for certifying compliance in order to reduce burden. Manufacturers may develop an AEDM based on test data for smaller units in a basic model group and apply the AEDM for larger sizes of commercial packaged boilers. Additionally, the field test option adopted in this final rule

provides a test method by which a manufacturer of large equipment (i.e. greater than 5,000,000 Btu/h rated input) can test and certify such commercial packaged boilers in the field if they do not have facilities capable of meeting the requirements of the standard laboratory test method.

Additional compliance flexibilities may be available for small manufacturers through other means. EPCA provides that a manufacturer whose annual gross revenue from all of its operations does not exceed $8 million may apply for an exemption from all or part of an energy conservation standard for a period not longer than 24 months after the effective date of a final rule establishing the standard. Additionally, Section 504 of the Department of Energy Organization Act, 42 U.S.C. 7194, provides authority for the Secretary to adjust a rule issued under EPCA in order to prevent "special hardship, inequity, or unfair distribution of burdens" that may be imposed on that manufacturer as a result of such rule. Manufacturers should refer to 10 CFR part 1003 for additional details.

For the reasons stated previously, DOE concludes that this final rule will not have a significant economic impact on a substantial number of small entities, so DOE has not prepared a regulatory flexibility analysis for this rulemaking. DOE will provide its certification and supporting statement of factual basis to the Chief Counsel for Advocacy of the SBA for review under 5 U.S.C. 605(b).

C. Review Under the Paperwork Reduction Act of 1995

Manufacturers of commercial packaged boilers must certify to DOE that their equipment complies with any applicable energy conservation standards. To certify compliance, manufacturers must first obtain test data for their equipment according to the DOE test procedures, including any amendments adopted for those test procedures. DOE has established regulations for the certification and recordkeeping requirements for all covered consumer products and commercial equipment, including commercial packaged boilers. (See generally 10 CFR part 429.) The collection-of-information requirement for the certification and recordkeeping is subject to review and approval by OMB under the Paperwork Reduction Act (PRA). This requirement has been approved by OMB under OMB control number 1910-1400. Public reporting burden for the certification is estimated to average 30 hours per manufacturer, 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 commercial packaged 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 4, 1999), imposes certain requirements on agencies formulating and implementing policies or regulations that preempt State law or that have Federalism implications. The Executive Order requires agencies to examine the constitutional and statutory authority supporting any action that would limit the policymaking discretion of the States and to carefully assess the necessity for such actions. The Executive Order also requires agencies to have an accountable process to ensure meaningful and timely input by State and local officials in the development of regulatory policies that have Federalism implications. On March 14, 2000, DOE published a statement of policy describing the intergovernmental consultation process it will follow in the development of such regulations. 65 FR 13735. DOE 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; 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 (Public Law 105-277) requires Federal agencies to issue a Family Policymaking

Assessment for any rule that may affect family well-being. This final 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

DOE has determined, under Executive Order 12630, "Governmental Actions and Interference with Constitutionally Protected Property Rights" 53 FR 8859 (March 18, 1988), that this regulation 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 (Public Law 95–91; 42 U.S.C. 7101), DOE must comply with section 32 of the Federal Energy Administration Act of 1974, as amended by the Federal Energy Administration Authorization Act of 1977. (15 U.S.C. 788; FEAA) Section 32 essentially provides in relevant part that, where a proposed rule authorizes or requires use of commercial standards, the notice of proposed rulemaking must inform the public of the use and background of such standards. In addition, section 32(c) requires DOE to consult with

the Attorney General and the Chairman of the Federal Trade Commission (FTC) concerning the impact of the commercial or industry standards on competition.

The modifications to the test procedure for commercial packaged boilers adopted in this final rule incorporate testing methods contained in certain sections of the commercial standard ANSI/AHRI Standard 1500-2015. 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., whether it was developed in a manner that fully provides for public participation, comment, and review). DOE has consulted with both the Attorney General and the Chairwoman of the FTC about the impact on competition of using the methods contained in this standard and has received no comments objecting to their use.

M. Congressional Notification

As required by 5 U.S.C. 801, DOE will report to Congress on the promulgation of this rule before 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).

N. Description of Materials Incorporated by Reference

In this final rule, DOE incorporates by reference the following:

Part 429 –ANSI/AHRI Standard 1500-2015, ("ANSI/AHRI Standard 1500-2015"), "2015 Standard for Performance Rating of Commercial Space Heating Boilers,"

ANSI approved November 28, 2014: Figure C9, Suggested Piping Arrangement for Hot Water Boilers.

Part 431 - ANSI/AHRI Standard 1500-2015, ("ANSI/AHRI Standard 1500-2015"), "2015 Standard for Performance Rating of Commercial Space Heating Boilers," ANSI approved November 28, 2014: Section 3, "Definitions," Section 5, "Rating Requirements," Appendix C, "Methods of Testing for Rating Commercial Space Heating Boilers – Normative," Appendix D, "Properties of Saturated Steam – Normative," and Appendix E, "Correction Factors for Heating Values of Fuel Gases – Normative."

ANSI/AHRI Standard 1500-2015 is an industry-accepted test procedure that provides methods, requirements, and calculations for determining the thermal and/or combustion efficiency of a commercial space heating boiler. ANSI/AHRI Standard 1500-2015 is available at: http://www.ahrinet.org/App_Content/ahri/files/standards%20pdfs/ANSI%20standards%20pdfs/ANSI.AHRI_Standard_1500-2015.pdf.

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

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

10 CFR Part 431

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

Issued in Washington, DC, on October 21, 2016.

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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 431 of Chapter II 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; 28 U.S.C. 2461 note.

2. Section 429.4 is amended by adding paragraph (c)(2) to read as follows:

§ 429.4 Materials incorporated by reference.

* * * * *

(c) * * *

(2) AHRI Standard 1500-2015, ("ANSI/AHRI Standard 1500-2015"), "2015 Standard for Performance Rating of Commercial Space Heating Boilers," ANSI approved November 28, 2014: Figure C9, Suggested Piping Arrangement for Hot Water Boilers; IBR approved for §429.60.

* * * * *

3. Section 429.11 is amended by revising paragraph (b) to read as follows:

§ 429.11 General sampling requirements for selecting units to be tested.

* * * * *

(b) The minimum number of units tested shall be no less than two, except where:

(1) A different minimum limit is specified in §§429.14 through 429.65 of this subpart; or

(2) Only one unit of the basic model is produced, in which case, that unit must be tested and the test results must demonstrate that the basic model performs at or better than the applicable standard(s). If one or more units of the basic model are manufactured subsequently, compliance with the default sampling and representations provisions is required.

4. Section 429.60 is amended by:

a. Revising paragraphs (a) introductory text and (a)(1)(i);

b. Adding paragraphs (a)(3) and (4);

c. Revising paragraph (b)(2); and

d. Adding paragraphs (b)(3)(iii) and (b)(5).

The revisions and additions read as follows:

§ 429.60 Commercial packaged boilers.

(a) Determination of represented value. Manufacturers must determine the represented value, which includes the certified rating, for each basic model of commercial packaged boilers either by testing in accordance with §431.86 of this chapter, in conjunction with the applicable sampling provisions, or by applying an AEDM.

(1) * * *

(i) If the represented value is determined through testing, the general requirements of §429.11 are applicable, except that, if the represented value is determined through testing pursuant to §431.86(c) of this chapter, the number of units selected for testing may be one; and

* * * * *

(3) The rated input for a basic model reported in accordance with paragraph (b)(2) of this section must be the maximum rated input listed on the nameplate and in manufacturer literature for the commercial packaged boiler basic model.

(4) For a model of commercial packaged boiler capable of supplying either steam or hot water, representative values for steam mode must be based on performance in steam mode and representative values for hot water mode must be based on either the efficiency in hot water mode or steam mode in accordance with the test procedure in §431.86 of this chapter and the provisions of this section.

(b) * * *

(2) Pursuant to §429.12(b)(13), a certification report must include the following public, equipment-specific information:

(i) The manufacturer (including brand, if applicable) and model number of the burner;

(ii) The rated input in British thermal units per hour (Btu/h);

(iii) The representative value of combustion efficiency in percent (%) to the nearest tenth of one percent or the representative value of thermal efficiency in percent (%) to the nearest one tenth of one percent, as specified in §431.87 of this chapter; and

(iv) For a basic model of commercial packaged boiler that cannot be tested using the standard inlet temperatures required in appendix A to subpart E of part 431, the average inlet water temperature measured at Point B in Figure C9 of ANSI/AHRI Standard 1500-2015 (incorporated by reference, see §429.4) at which the model was tested.

(3) * * *

(iii) For basic models of commercial packaged boilers that have a rated input greater than 5,000,000 Btu/h, a declaration about whether the certified efficiency rating is based on testing conducted pursuant to §431.86(c) of this chapter.

* * * * *

(5) Any field tested pursuant to §431.86(c) of this chapter basic model of a commercial packaged boiler that has not been previously certified through testing or an AEDM must be certified within 15 days of commissioning.

* * * * *

5. Section 429.70 is amended by adding paragraph (c)(2)(iii)(D) to read as follows:

§ 429.70 Alternative methods for determining energy efficiency and energy use.

* * * * *

(c) * * *

(2) * * *

(iii) * * *

(D) An AEDM that is validated based on test results obtained from one or more field tests (pursuant to §431.86(c) of this chapter) can only be used to certify the performance of basic models of commercial packaged boilers with a certified rated input greater than 5,000,000 Btu/h.

* * * * *

6. Section 429.110 is amended by revising paragraph (a)(3) and adding paragraph (c)(1)(iii) to read as follows:

§ 429.110 Enforcement testing.

(a) * * *

(3) Testing will be conducted at a laboratory accredited to the International Organization for Standardization (ISO)/International Electrotechnical Commission (IEC), "General requirements for the competence of testing and calibration laboratories," ISO/IEC 17025:2005(E) (incorporated by reference; see §429.4). If testing cannot be completed at an independent laboratory, DOE, at its discretion, may allow enforcement testing at a manufacturer's laboratory, so long as the lab is accredited to ISO/IEC 17025:2005(E) and DOE representatives witness the testing. In addition, for commercial packaged boilers with rated input greater than 5,000,000 Btu/h, DOE, at its discretion, may allow enforcement testing of a commissioned commercial packaged boiler in the location in which it was commissioned for use, pursuant to the test provisions at §431.86(c) of this chapter, for which accreditation to ISO/IEC 17025:2005(E) would not be required.

* * * * *

(c) * * *

(1) * * *

(iii) Previously commissioned commercial packaged boilers with a certified rated input greater than 5,000,000 Btu/h. DOE may test a sample of at least one unit in the location in which it was commissioned for use.

* * * * *

7. Section 429.134 is amended by adding paragraph (m) to read as follows:

§ 429.134 Product-specific enforcement provisions.

* * * * *

(m) Commercial packaged boilers--(1) Verification of fuel input rate. The fuel input rate of each tested unit will be measured pursuant to the test requirements of §431.86 of this chapter. The results of the measurement(s) will be compared to the value of rated input certified by the manufacturer. The certified rated input will be considered valid only if the measurement(s) (either the measured fuel input rate for a single unit sample or the average of the measured fuel input rates for a multiple unit sample) is within two percent of the certified rated input.

(i) If the certified rated input is found to be valid, the certified rated input will serve as the basis for determination of the appropriate equipment class(es) and the mean measured fuel input rate will be used as the basis for calculation of combustion and/or thermal efficiency for the basic model.

(ii) If the certified rated input for a gas-fired commercial packaged boiler is found to be invalid, DOE will first attempt to increase or decrease the gas manifold pressure within the range specified in manufacturer's installation and operation manual shipped with the commercial packaged boiler being tested (or, if not provided in the manual, in supplemental instructions provided by the manufacturer pursuant to §429.60(b)(4) of this chapter) to achieve the certified rated input (within two-percent). If the fuel input rate is still not within two-percent of the certified rated input, DOE will attempt to increase or decrease the gas inlet pressure within the range specified in manufacturer's installation and operation manual shipped with the commercial packaged boiler being tested (or, if not provided in the manual, in supplemental instructions provided by the manufacturer pursuant to §429.60(b)(4) of this chapter) to achieve the certified rated input (within two-percent). If the fuel input rate is still not within two-percent of the certified rated input, DOE will attempt to modify the gas inlet orifice if the unit is equipped with one. If the fuel input rate still is not within two percent of the certified rated input, the mean measured fuel input rate (either for a single unit sample or the average of the measured fuel input rates for a multiple unit sample) will serve as the basis for determination of the appropriate equipment class(es) and calculation of combustion and/or thermal efficiency for the basic model.

(iii) If the certified rated input for an oil-fired commercial packaged boiler is found to be invalid, the mean measured fuel input rate will serve as the basis for determination of the appropriate equipment class(es) and calculation of combustion and/or thermal efficiency for the basic model.

(2) Models capable of producing both hot water and steam. For a model of commercial packaged boiler that is capable of producing both hot water and steam, DOE may measure the thermal or combustion efficiency as applicable (see §431.87 of this chapter) for steam and/or hot water modes. DOE will evaluate compliance based on the measured thermal or combustion efficiency in steam and hot water modes, independently.

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

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

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

9. Section 431.82 is amended by:

a. Revising the definitions of "Combustion efficiency" and "Commercial packaged boiler;"

b. Adding in alphabetical order definitions for "Field-constructed" and "Fuel input rate;"

c. Revising the definition for "Packaged boiler;"

d. Removing the definitions for "Packaged high pressure boiler" and "Packaged low pressure boiler;" and

e. Adding in alphabetical order a definition for "Rated input."

The revisions and additions read as follows:

§ 431.82 Definitions concerning commercial packaged boilers.

* * * * *

Combustion efficiency for a commercial packaged boiler is a measurement of how much of the fuel input energy is converted to useful heat in combustion and is calculated as 100-percent minus percent losses due to dry flue gas, incomplete combustion, and moisture formed by combustion of hydrogen, as determined with the test procedures prescribed under §431.86 of this chapter.

Commercial packaged boiler means a packaged boiler that meets all of the following criteria:

(1) Has rated input of 300,000 Btu/h or greater;

(2) Is, to any significant extent, distributed in commerce for space conditioning and/or service water heating in buildings but does not meet the definition of "hot water supply boiler" in this part;

(3) Does not meet the definition of "field-constructed" in this section; and

(4) Is designed to:

(i) Operate at a steam pressure at or below 15 psig;

(ii) Operate at or below a water pressure of 160 psig and water temperature of 250 °F; or

(iii) Operate at the conditions specified in both paragraphs (4)(i) and (ii) of this definition.

* * * * *

Field-constructed means custom-designed equipment that requires welding of structural components in the field during installation. For the purposes of this definition,

welding does not include attachment using mechanical fasteners or brazing; any jackets, shrouds, venting, burner, or burner mounting hardware are not structural components.

* * * * *

Fuel input rate for a commercial packaged boiler means the maximum measured rate at which the commercial packaged boiler uses energy and is determined using test procedures prescribed under §431.86 of this chapter.

* * * * *

Packaged boiler means a boiler that is shipped complete with heating equipment, mechanical draft equipment, and automatic controls and is usually shipped in one or more sections. If the boiler is shipped in more than one section, the sections may be produced by more than one manufacturer, and may be originated or shipped at different times and from more than one location.

* * * * *

Rated input means the maximum rate at which the commercial packaged boiler has been rated to use energy as indicated by the nameplate and in the manual shipped with the commercial packaged boiler.

* * * * *

10. Section 431.85 is amended by revising paragraph (b) to read as follows:

§ 431.85 Materials incorporated by reference.

* * * * *

(b) AHRI. Air-Conditioning, Heating, and Refrigeration Institute, 2111 Wilson Blvd., Suite 500, Arlington, VA 22201, (703) 524-8800, or go to: http://www.ahrinet.org.

(1) AHRI Standard 1500-2015, ("ANSI/AHRI Standard 1500-2015"), "2015 Standard for Performance Rating of Commercial Space Heating Boilers," ANSI approved November 28, 2014, IBR approved for appendix A to subpart E as follows:

(i) Section 3 – Definitions (excluding introductory text to section 3, introductory text to 3.2, 3.2.4, 3.2.7, 3.6, 3.12, 3.13, 3.20, 3.23, 3.24, 3.26, 3.27, and 3.31);

(ii) Section 5 – Rating Requirements, 5.3 Standard Rating Conditions: (excluding introductory text to section 5.3, 5.3.5, 5.3.8, and 5.3.9);

(iii) Appendix C – Methods of Testing for Rating Commercial Space Heating Boilers – Normative, excluding C2.1, C2.7.2.2.2, C3.1.3, C3.5 – C3.7, C4.1.1.1.2, C4.1.1.2.3, C4.1.2.1.5, C4.1.2.2.2, C4.1.2.2.3, C4.2, C5, C7.1, C7.2.12, C7.2.20

(iv) Appendix D. Properties of Saturated Steam – Normative.

(v) Appendix E. Correction Factors for Heating Values of Fuel Gases - Normative.

(2) [Reserved].

11. Section 431.86 is revised to read as follows:

§ 431.86 Uniform test method for the measurement of energy efficiency of commercial packaged boilers.

(a) Scope. This section provides test procedures, pursuant to the Energy Policy and Conservation Act (EPCA), as amended, which must be followed for measuring the combustion efficiency and/or thermal efficiency of a gas- or oil-fired commercial packaged boiler.

(b) Testing and Calculations. Determine the thermal efficiency or combustion efficiency of commercial packaged boilers by conducting the appropriate test procedure(s) indicated in Table 1 of this section.

Table 1 - Test Requirements for Commercial Packaged Boiler Equipment Classes

Equipment Category	Subcategory	Certified Rated Input Btu/h	Standards Efficiency Metric (§431.87)	Test Procedure (corresponding to standards efficiency metric required by §431.87)
Hot Water	Gas-fired	≥300,000 and ≤2,500,000	Thermal Efficiency	Appendix A, Section 2.
Hot Water	Gas-fired	>2,500,000	Combustion Efficiency	Appendix A, Section 3.
Hot Water	Oil-fired	≥300,000 and ≤2,500,000	Thermal Efficiency	Appendix A, Section 2.
Hot Water	Oil-fired	>2,500,000	Combustion Efficiency	Appendix A, Section 3.
Steam	Gas-fired (all*)	≥300,000 and ≤2,500,000	Thermal Efficiency	Appendix A, Section 2.
Steam	Gas-fired (all*)	>2,500,000 and ≤5,000,000	Thermal Efficiency	Appendix A, Section 2.
		>5,000,000	Thermal Efficiency	Appendix A, Section 2. OR Appendix A, Section 3 with Section 2.4.3.2.
Steam	Oil-fired	≥300,000 and ≤2,500,000	Thermal Efficiency	Appendix A, Section 2.
Steam	Oil-fired	>2,500,000 and ≤5,000,000	Thermal Efficiency	Appendix A, Section 2.
		>5,000,000	Thermal Efficiency	Appendix A, Section 2. OR Appendix A, Section 3. with Section 2.4.3.2.

*Equipment classes for commercial packaged boilers as of July 22, 2009 (74 FR 36355) distinguish between gas-fired natural draft and all other gas-fired (except natural draft). The test procedure indicated in Table 1 applies to both of

these equipment classes. If these equipment classes are amended, the test procedure will continue to apply as indicated in Table 1 to all gas-fired commercial packaged boilers.

(c) Field Tests. The field test provisions of appendix A may be used only to test a unit of commercial packaged boiler with rated input greater than 5,000,000 Btu/h.

12. Section 431.87 is revised to read as follows:

§ 431.87 Energy conservation standards and their effective dates.

(a) Each commercial packaged boiler listed in Table 1 of this section and manufactured on or after the effective date listed must meet the indicated energy conservation standard.

Table 1. Commercial Packaged Boiler Energy Conservation Standards

Equipment Category	Subcategory	Certified Rated Input	Efficiency Level—Effective Date: March 2, 2012*
Hot Water Commercial Packaged Boilers	Gas-fired	≥300,000 Btu/h and ≤2,500,000 Btu/h	80.0% E_T
Hot Water Commercial Packaged Boilers	Gas-fired	>2,500,000 Btu/h	82.0% E_C
Hot Water Commercial Packaged Boilers	Oil-fired	≥300,000 Btu/h and ≤2,500,000 Btu/h	82.0% E_T
Hot Water Commercial Packaged Boilers	Oil-fired	>2,500,000 Btu/h	84.0% E_C
Steam Commercial Packaged Boilers	Gas-fired—all, except natural draft	≥300,000 Btu/h and ≤2,500,000 Btu/h	79.0% E_T
Steam Commercial Packaged Boilers	Gas-fired—all, except natural draft	>2,500,000 Btu/h	79.0% E_T
Steam Commercial Packaged Boilers	Gas-fired—natural draft	≥300,000 Btu/h and ≤2,500,000 Btu/h	77.0% E_T
Steam Commercial Packaged Boilers	Gas-fired—natural draft	>2,500,000 Btu/h	77.0% E_T
Steam Commercial Packaged Boilers	Oil-fired	≥300,000 Btu/h and ≤2,500,000 Btu/h	81.0% E_T
Steam Commercial Packaged Boilers	Oil-fired	>2,500,000 Btu/h	81.0% E_T

*Where E_C is combustion efficiency and E_T is thermal efficiency.

(b) Each commercial packaged boiler listed in Table 2 of this section and manufactured on or after the effective date listed in Table 2 must meet the indicated energy conservation standard.

Table 2. Commercial Packaged Boiler Energy Conservation Standards

Equipment Category	Subcategory	Certified Rated Input	Efficiency Level—Effective Date: March 2, 2022*
Steam Commercial Packaged Boilers	Gas-fired—natural draft	≥300,000 Btu/h and ≤2,500,000 Btu/h	79.0% E_T
Steam Commercial Packaged Boilers	Gas-fired—natural draft	>2,500,000 Btu/h	79.0% E_T

*Where E_T is thermal efficiency.

13. Add appendix A to subpart E of part 431 to read as follows:

Appendix A to Subpart E of Part 431— Uniform Test Method for the measurement of Thermal Efficiency of Commercial Packaged Boilers

Note: Prior to [**INSERT DATE 360 DAYS AFTER DATE OF PUBLICATION IN THE FEDERAL REGISTER**], manufacturers must make any representations with respect to the energy use or efficiency of commercial packaged boilers in accordance with the results of testing pursuant to this Appendix or the test procedures as they appeared in 10 CFR 431.86 revised as of January 1, 2016. On and after [**INSERT DATE 360 DAYS AFTER DATE OF PUBLICATION IN THE FEDERAL REGISTER**], manufacturers must make any representations with respect to energy use or efficiency in accordance with the results of testing pursuant to this appendix.

1. Definitions.

For purposes of this appendix, the Department of Energy incorporates by reference the definitions established in section 3 of the American National Standards

Institute (ANSI) and Air-Conditioning, Heating, and Refrigeration Institute (AHRI) Standard 1500, "2015 Standard for Performance Rating of Commercial Space Heating Boilers," beginning with 3.1 and ending with 3.35 (incorporated by reference, see §431.85; hereafter "ANSI/AHRI Standard 1500-2015"), excluding the introductory text to section 3, the introductory text to 3.2, "Boiler"; 3.2.4, "Heating Boiler"; 3.2.7, "Packaged Boiler"; 3.6, "Combustion Efficiency"; 3.12, "Efficiency, Combustion"; 3.13, "Efficiency, Thermal"; 3.20, "Gross Output"; 3.23, "Input Rating"; 3.24, "Net Rating"; 3.26, "Published Rating"; 3.26.1 "Standard Rating"; 3.27, "Rating Conditions"; 3.27.1, "Standard Rating Conditions"; and 3.31, "Thermal Efficiency." In cases where there is a conflict, the language of the test procedure in this appendix takes precedence over ANSI/AHRI Standard 1500-2015.

1.1. In all incorporated sections of ANSI/AHRI Standard 1500-2015, references to the manufacturer's "specifications," "recommendations," "directions," or "requests" mean the manufacturer's instructions in the installation and operation manual shipped with the commercial packaged boiler being tested or in supplemental instructions provided by the manufacturer pursuant to §429.60(b)(4) of this chapter. For parameters or considerations not specified in this appendix, refer to the manual shipped with the commercial packaged boiler. Should the manual shipped with the commercial packaged boiler not provide the necessary information, refer to the supplemental instructions for the basic model pursuant to §429.60(b)(4) of this chapter. The supplemental instructions provided pursuant to §429.60(b)(4) of this chapter do not replace or alter any requirements in this appendix nor do they override the manual shipped with the commercial packaged boiler. In cases where these supplemental instructions conflict

with any instructions or provisions provided in the manual shipped with the commercial packaged boiler, use the manual shipped with the commercial packaged boiler.

1.2. Unless otherwise noted, in all incorporated sections of ANSI/AHRI Standard 1500-2015, the term "boiler" means a commercial packaged boiler as defined in §431.82.

1.3. Unless otherwise noted, in all incorporated sections of ANSI/AHRI Standard 1500-2015, the term "input rating" means "rated input" as defined in §431.82.

2. Thermal Efficiency Test.

2.1. Test Setup.

2.1.1. Instrumentation. Use instrumentation meeting the minimum requirements found in Table C1 of Appendix C of ANSI/AHRI Standard 1500-2015 (incorporated by reference, see §431.85).

2.1.2. Data collection and sampling. Record all test data in accordance with Table 2.1 and Table 2.2. Do not use Section C5 and Table C4 of Appendix C of ANSI/AHRI Standard 1500-2015.

Table 2.1. Data to be Recorded Before Testing

Item Recorded	Additional Instruction
Date of Test	
Manufacturer	
Boiler Model Number	
Burner Model Number & Manufacturer	
Nozzle description and oil pressure	
Oil Analysis - H, C, API Gravity, lb/gal and Btu/lb	
Gas Manifold Pressure	Record at start and end of test.
Gas line pressure at meter	Measurement may be made manually.
Gas temperature	Measurement may be made manually.

Item Recorded	Additional Instruction
Barometric Pressure (Steam and Natural Gas Only)	Measurement may be made manually.
Gas Heating Value, Btu/ft*	Record at start and end of test

* Multiplied by correction factors, as applicable, in accordance with Appendix E of ANSI/AHRI Standard 1500-2015.

Table 2.2. Data to be Recorded During Testing

			Record and Maintain Data		For Use in Calculations, Section 2.4	
Item Recorded		**Digital Acquisition Required?**	**Every 1 Minute**	**Every 15 Minutes**	**Average During Test Period**	**Total During Test Period**
Time, minutes/seconds		Yes	X			
Flue Gas Temperature, °F		Yes	X			
Pressure in Firebox, in H_2O (if required per Section C3.4 of ANSI/AHRI Standard 1500-2015)		No		X		
Flue Gas Smoke Spot Reading (oil)		No		X		
Room Air Temperature		Yes	X			
Fuel Weight or Volume, lb (oil) or ft^3 (gas)		Yes		X		X
Test Air Temperature, °F		Yes	X			
Draft in Vent, in H_2O (oil and non-atmospheric gas)		No		X		
Flue Gas CO_2 or O_2, %		No		X		
Flue Gas CO, ppm		No		At Least Start and End		
Relative Humidity, %		No		X		
STEAM	Separator water weight, lb	No		At Least Start and End		X
STEAM	Steam Pressure, in Hg	No		X	X	
STEAM	Steam Temperature, °F (if used)	Yes	X		X	
STEAM	Condensate collected, or water fed, lb	No		X		X
WATER	Outlet Water Temperature, °F	Yes	X		X	
WATER	Water fed, lb	No	X	X		X

			Record and Maintain Data		For Use in Calculations, Section 2.4	
Item Recorded		**Digital Acquisition Required?**	**Every 1 Minute**	**Every 15 Minutes**	**Average During Test Period**	**Total During Test Period**
	Inlet Water Temperature at Points A and B of Figure 9 of ANSI/AHRI Standard 1500-2015, °F	Yes	X		X	

2.1.3. Instrument Calibration. Instruments must be calibrated at least once per year and a calibration record containing the date of calibration and the method of calibration must be maintained as part of the data underlying each basic model certification, pursuant to §429.71 of this chapter.

2.1.4. Test Setup and Apparatus. Set up the commercial packaged boiler for thermal efficiency testing according to the provisions of Section C2 (except section C2.1) of Appendix C of ANSI/AHRI Standard 1500-2015 (incorporated by reference, see §431.85).

2.1.4.1. For tests of oil-fired commercial packaged boilers, determine the weight of fuel consumed using one of the methods specified in the following sections 2.1.4.1.1. or 2.1.4.1.2. of this appendix:

2.1.4.1.1. If using a scale, determine the weight of fuel consumed as the difference between the weight of the oil vessel before and after each measurement period, as specified in sections 2.1.4.1.3.1. or 2.1.4.1.3.2. of this appendix, determined using a scale meeting the accuracy requirements of Table C1 of Appendix C of ANSI/AHRI Standard 1500-2015.

2.1.4.1.2. If using a flow meter, first determine the volume of fuel consumed as the total volume over the applicable measurement period as specified in sections

2.1.4.1.3.1. or 2.1.4.1.3.2. of this appendix and as measured by a flow meter meeting the accuracy requirements of Table C1 of Appendix C of ANSI/AHRI Standard 1500-2015 upstream of the oil inlet port of the commercial packaged boiler. Then determine the weight of fuel consumed by multiplying the total volume of fuel over the applicable measurement period by the density of oil, in pounds per gallon, as determined pursuant to C3.2.1.1.3. of Appendix C of ANSI/AHRI Standard 1500-2015.

2.1.4.1.3. The applicable measurement period for the purposes of determining fuel input rate must be as specified in section 2.1.4.1.3.1. of this appendix for the "Warm-Up Period" or section 2.1.4.1.3.2. of this appendix for the "Test Period."

2.1.4.1.3.1. For the purposes of confirming steady-state operation during the "Warm-Up Period," the measurement period must be 15 minutes and t_T in Equation C2 in Section C7.2.3.1 of Appendix C of ANSI/AHRI Standard 1500-2015 must be 0.25 hours to determine fuel input rate.

2.1.4.1.3.2. For the purposes of determining thermal efficiency during the "Test Period," the measurement period and t_T are as specified in sections 2.3.4 and 2.3.5 of this appendix.

2.1.4.2 For tests of gas-fired commercial packaged boilers, install a volumetric gas meter meeting the accuracy requirements of Table C1 of Appendix C of ANSI/AHRI Standard 1500-2015 upstream of the gas inlet port of the commercial packaged boiler. Record the accumulated gas volume consumed for each applicable measurement period. Use Equation C7.2.3.2. of Appendix C of ANSI/AHRI Standard 1500-2015 to calculate fuel input rate.

2.1.4.2.1. The applicable measurement period for the purposes of determining fuel input rate must be as specified in section 2.1.4.2.1.1. of this appendix, for the "Warm-Up Period" and section 2.1.4.2.1.2. of this appendix, for the "Test Period."

2.1.4.2.1.1. For the purposes of confirming steady-state operation during the "Warm-Up Period," the measurement period must be 15 minutes and t_T in Equation C2 in Section C7.2.3.1 of Appendix C of ANSI/AHRI Standard 1500-2015 must be 0.25 hours to determine fuel input rate.

2.1.4.2.1.2. For the purposes of determining thermal efficiency during the "Test Period," the measurement period and t_T are as specified in sections 2.3.4 and 2.3.5 of this appendix.

2.1.4.3 In addition to the provisions of Section C2.2.1.2 of ANSI/AHRI Standard 1500-2015, vent gases may alternatively be discharged vertically into a straight stack section without elbows. R-7 minimum insulation must extend 6 stack diameters above the flue collar, the thermocouple grid must be located at a vertical distance of 3 stack diameters above the flue collar, and the sampling tubes for flue gases must be installed 1 stack diameter beyond the thermocouple grid.

2.1.5. Additional Requirements for Outdoor Commercial Packaged Boilers. If the manufacturer provides more than one outdoor venting arrangement, the outdoor commercial packaged boiler as defined in Section 3.2.6 of ANSI/AHRI Standard 1500-2015 (incorporated by reference, see §431.85) must be tested with the shortest total venting arrangement as measured by adding the straight lengths of venting supplied with the equipment. If the manufacturer does not provide an outdoor venting arrangement,

install the outdoor commercial packaged boiler venting consistent with the procedure specified in Section C2.2 of Appendix C of ANSI/AHRI Standard 1500-2015. If the vent is rectangular sample the flue gas at a location one third the distance from either side of the exhaust in its longer dimension and half the distance between its edges in the shorter dimension.

2.1.6. Additional Requirements for Steam Tests. In addition to the provisions of Section C2 of Appendix C of ANSI/AHRI Standard 1500-2015 (incorporated by reference, see §431.85), the following requirements apply for steam tests.

2.1.6.1. Insulate all steam piping from the commercial packaged boiler to the steam separator, and extend insulation at least one foot (1 ft.) beyond the steam separator, using insulation meeting the requirements specified in Table 2.3 of this appendix.

Table 2.3. Minimum Piping Insulation Thickness Requirements

Fluid Temperature Range °F	**Insulation Conductivity**		**Nominal Pipe Size Inches**				
	Conductivity BTU×in/(h×ft²×°F)	**Mean Rating Temperature °F**	**<1**	**1 to < 1-1/2**	**1-12 to < 4**	**4 to <8**	**≥ 8**
> 350°F	0.32-0.34	250	4.5	5.0	5.0	5.0	5.0
251 °F-350 °F	0.29-0.32	200	3.0	4.0	4.5	4.5	4.5
201 °F-250 °F	0.27-0.30	150	2.5	2.5	2.5	3.0	3.0
141 °F-200 °F	0.25-0.29	125	1.5	1.5	2.0	2.0	2.0
105 °F-140 °F	0.22-0.28	100	1.0	1.0	1.5	1.5	1.5

2.1.6.2. A temperature sensing device must be installed in the insulated steam piping prior to the water separator if the commercial packaged boiler produces superheated steam.

2.1.6.3. Water entrained in the steam and water condensing within the steam piping must be collected and used to calculate the quality of steam during the "Test Period." Steam condensate must be collected and measured using either a cumulative

(totalizing) flow rate or by measuring the mass of the steam condensate. Instrumentation used to determine the amount of steam condensate must meet the requirements identified in Table C1 in Appendix C of ANSI/AHRI Standard 1500-2015.

2.1.7. Additional Requirements for Water Tests. In addition to the provisions of section C2 of Appendix C of ANSI/AHRI Standard 1500-2015 (incorporated by reference, see §431.85), the following requirements apply for water tests.

2.1.7.1. Insulate all water piping between the commercial packaged boiler and the location of the temperature measuring equipment, including one foot (1 ft.) beyond the sensor, using insulation meeting the requirements specified in Table 2.2 of this appendix.

2.1.7.2. Install a temperature measuring device at Point B of Figure C9 of ANSI/AHRI Standard 1500-2015 (incorporated by reference, see §431.85). Water entering the commercial packaged boiler must first enter the run of a tee and exit from the top outlet of the tee. The remaining connection of the tee shall be plugged. Measure the inlet water temperature at Point B in the run of a second tee located 12 ± 2 pipe diameters downstream from the first tee and no more than the greater of 12 inches or 6 pipe diameters from the inlet of the commercial packaged boiler. The temperature measuring device shall extend into the water flow at the point of exit from the side outlet of the second tee. All inlet piping between the temperature measuring device and the inlet of the commercial packaged boilers must be wrapped with R-7 insulation.

2.1.7.3. Do not use Section C2.7.2.2.2 or its subsections of ANSI/AHRI Standard 1500-2015 for water meter calibration.

2.1.8. Flue Gas Sampling. In section C2.5.2 of Appendix C of ANSI/AHRI Standard 1500-2015, replace the last sentence with the following: When taking flue gas samples from a rectangular plane, collect samples at ¼, ½, and ¾ the distance from one side of the rectangular plane in the longer dimension and along the centerline midway between the edges of the plane in the shorter dimension and use the average of the three samples. The tolerance in each dimension for each measurement location is ± 1 inch.

2.2. Test Conditions.

2.2.1. General. Use the test conditions from Section 5.3 and Section C3 of Appendix C of ANSI/AHRI Standard 1500-2015 (incorporated by reference, see §431.85) for thermal efficiency testing but do not use the following sections:

(1) 5.3 Introductory text

(2) 5.3.5 (and subsections)

(3) 5.3.8

(4) 5.3.9

(5) C3.1.3

(6) C3.5 (including Table C2)

(7) C3.6

(8) C3.7

2.2.2. Burners for Oil-Fired Commercial Packaged Boilers. In addition to section C3.3 of Appendix C of ANSI/AHRI Standard 1500-2015, the following applies: for oil-fired commercial packaged boilers, test the unit with the particular make and model of burner as certified (or to be certified) by the manufacturer. If multiple burners

are specified in the certification report for that basic model, then use any of the listed burners for testing.

2.2.3. Water Temperatures. Maintain the outlet temperature measured at Point C in Figure C9 of Appendix C of ANSI/AHRI Standard 1500-2015 at 180 °F ± 2 °F and maintain the inlet temperature measured at Point B at 80 °F ± 5 °F during the "Warm-up Period" and "Test Period" as indicated by 1-minute interval data pursuant to Table 2.2 of this appendix. Each reading must meet these temperature requirements. Use the inlet temperature and flow rate measured at Point B in Figure C9 of Appendix C of ANSI/AHRI Standard 1500-2015 for calculation of thermal efficiency.

2.2.4 Exceptions to Water Temperature Requirements. For commercial packaged boilers that require a higher flow rate than that resulting from the water temperature requirements of sections 2.2.3 of this appendix to prevent boiling, use a recirculating loop and maintain the inlet temperature at Point B of Figure C9 of Appendix C of ANSI/AHRI Standard 1500-2015 at 140 °F ± 5 °F during the "Warm-up Period" and "Test Period" as indicated by 1-minute interval data pursuant to Table 2.2 of this appendix. Each reading must meet these temperature requirements. Use the inlet temperature and flow rate measured at Point A in Figure C9 of Appendix C of ANSI/AHRI Standard 1500-2015 for calculation of thermal efficiency.

2.2.5 Air Temperature. For tests of non-condensing boilers, maintain ambient room temperature between 65 °F and 100 °F at all times during the "Warm-up Period"

and “Test Period” (as described in Section C4 of Appendix C of ANSI/AHRI Standard 1500-2015) as indicated by 1-minute interval data pursuant to Table 2.2 of this appendix. For tests of condensing boilers, maintain ambient room temperature between 65 °F and 85 °F at all times during the “Warm-up Period” and “Test Period” (as described in Section C4 of Appendix C of ANSI/AHRI Standard 1500-2015) as indicated by 1-minute interval data pursuant to Table 2.2 of this appendix. The ambient room temperature may not differ by more than ± 5 °F from the average ambient room temperature during the entire “Test Period” at any reading. Measure the room ambient temperature within 6 feet of the front of the unit at mid height. The test air temperature, measured at the air inlet of the commercial packaged boiler, must be within ± 5 °F of the room ambient temperature when recorded at the 1-minute interval defined by Table 2.2.

2.2.6. Ambient Humidity. For condensing boilers, maintain ambient room relative humidity below 80-percent relative humidity at all times during both the “Warm-up Period” and “Test Period” (as described in Section C4 of Appendix C of ANSI/AHRI Standard 1500-2015) pursuant to Table 2.2 of this appendix. Measure the ambient humidity in the same location as air temperature.

2.2.7. Flue Gas Temperature. The flue gas temperature during the test must not vary from the flue gas temperature measured at the start of the Test Period (as defined in Section C4 of ANSI/AHRI Standard 1500-2015) when recorded at the interval defined in Table 2.2 of this appendix by more than the limits prescribed in Table 2.4 of this appendix.

Table 2.4 Flue Gas Temperature Variation Limits During Test Period

Fuel Type	Non-Condensing	Condensing
Gas	± 2 percent	Greater of ± 3 percent and ± 5 °F
Light Oil	± 2 percent	

Heavy Oil	Greater of ± 3 percent and ± 5 °F	

2.3. Test Method.

2.3.1. General. Conduct the thermal efficiency test as prescribed in Section C4 "Test Procedure" of Appendix C of ANSI/AHRI Standard 1500-2015 (incorporated by reference, see §431.85) excluding sections:

(1) C4.1.1.1.2

(2) C4.1.1.2.3 (see 2.3.4 of this appendix)

(3) C4.1.2.1.5

(4) C4.1.2.2.2

(5) C4.1.2.2.3 (see 2.3.5 of this appendix)

(6) C4.2

(7) C4.2.1

(8) C4.2.2

2.3.1.1. Adjust oil or non-atmospheric gas to produce the required firebox pressure and CO_2 or O_2 concentration in the flue gas, as described in Section 5.3.1 of ANSI/AHRI Standard 1500-2015. Conduct steam tests with steam pressure at the pressure specified in the manufacturer literature shipped with the commercial packaged boiler or in the manufacturer's supplemental testing instructions pursuant to §429.60(b)(4) of this chapter, but not exceeding 15 psig. If no pressure is specified in the manufacturer literature shipped with the commercial packaged boiler or in the manufacturer's supplemental testing instructions (pursuant to §429.60(b)(4)) of this chapter, or if a range of operating pressures is specified, conduct testing at a steam pressure equal to atmospheric pressure. If necessary to maintain steam quality as

required by Section 5.3.7 of ANSI/AHRI Standard 1500-2015, increase steam pressure in 1 psig increments by throttling with a valve beyond the separator until the test is completed and the steam quality requirements have been satisfied, but do not increase the steam pressure to greater than 15 psig.

2.3.2. Water Test Steady-State. Ensure that a steady-state is reached by confirming that three consecutive readings have been recorded at 15-minute intervals that indicate that the measured fuel input rate is within ± 2-percent of the rated input. Water temperatures must meet the conditions specified in sections 2.2.3 and 2.2.4 of this appendix as applicable.

2.3.3. Condensate Collection for Condensing Commercial Packaged Boilers. Collect condensate in a covered vessel so as to prevent evaporation.

2.3.4. Steam Test Duration. Replace Section C4.1.1.2.3 of ANSI/AHRI Standard 1500-2015 with the following: The test period is one hour in duration if the steam condensate is measured or two hours if feedwater is measured. The test period must end with a 15-minute reading (steam condensate or feedwater and separator weight reading) pursuant to Table 2.2 of this appendix. When feedwater is measured, the water line at the end of the test must be within 0.25 inches of the starting level.

2.3.5. Water Test Duration. Replace Section C4.1.2.2.3 of ANSI/AHRI Standard 1500-2015 with the following: The test period is one hour for condensing commercial packaged boilers and 30 minutes for non-condensing commercial packaged boilers, and ends with a 15-minute interval reading pursuant to Table 2.2 of this appendix.

2.4. Calculations.

2.4.1. General. To determine the thermal efficiency of commercial packaged boilers, use the variables in section C6 of Appendix C of ANSI/AHRI Standard 1500-2015 and calculation procedure for the thermal efficiency test specified in section C7.2 of Appendix C of ANSI/AHRI Standard 1500-2015, excluding sections C7.2.12 and C7.2.20.

2.4.2. Use of Steam Properties Table. If the average measured temperature of the steam is higher than the value in Table D1 in Appendix D of ANSI/AHRI Standard 1500-2015 that corresponds to the average measured steam pressure, then use Table 2.5 of this appendix to determine the latent heat of superheated steam in (Btu/lb). Use linear interpolation for determining the latent heat of steam in Btu/lb if the measured steam pressure is between two values listed in Table D1 in Appendix D of ANSI/AHRI Standard 1500-2015 or in Table 2.5 of this appendix.

Table 2.5. Latent Heat (Btu/lb) of Superheated Steam.

Average Measured Steam Pressure psi	**Temperature °F**							
	220	**240**	**260**	**280**	**300**	**320**	**340**	**360**
13	1155.1	1164.7	1174.3	1183.8	1193.2	1202.6	1212.0	1221.4
14	1154.6	1164.4	1174.0	1183.5	1193.0	1202.4	1211.8	1221.2
14.696	1154.4	1164.2	1173.8	1183.3	1192.8	1202.3	1211.7	1221.1
15	1154.3	1164.1	1173.7	1183.2	1192.8	1202.2	1211.7	1221.1
16	1153.8	1163.7	1173.4	1183.0	1192.5	1202.0	1211.5	1220.9
17	1153.4	1163.4	1173.1	1182.7	1192.3	1201.8	1211.3	1220.7
18		1163.0	1172.8	1182.5	1192.1	1201.6	1211.1	1220.6
19		1162.7	1172.5	1182.2	1191.9	1201.4	1210.9	1220.4
20		1162.3	1172.2	1182.0	1191.6	1201.2	1210.8	1220.3
21		1162.0	1171.9	1181.7	1191.4	1201.0	1210.6	1220.1
22		1161.6	1171.6	1181.4	1191.2	1200.8	1210.4	1219.9
23		1161.2	1171.3	1181.2	1190.9	1200.6	1210.2	1219.8
24		1160.9	1171.0	1180.9	1190.7	1200.4	1210.0	1219.6
25			1170.7	1180.6	1190.5	1200.2	1209.8	1219.4

26			1170.4	1180.4	1190.2	1200.0	1209.7	1219.3
27			1170.1	1180.1	1190.0	1199.8	1209.5	1219.1
28			1169.7	1179.8	1189.8	1199.6	1209.3	1218.9
29			1169.4	1179.6	1189.5	1199.3	1209.1	1218.8
30			1169.1	1179.3	1189.3	1199.1	1208.9	1218.6
31			1168.8	1179.0	1189.0	1198.9	1208.7	1218.4

Absolute Pressure psi	**Temperature °F**							
	380	**400**	**420**	**440**	**460**	**480**	**500**	**600**
13	1230.8	1240.2	1249.5	1258.9	1268.4	1277.8	1287.3	1334.9
14	1230.6	1240.0	1249.4	1258.8	1268.3	1277.7	1287.2	1334.8
14.696	1230.5	1239.9	1249.3	1258.8	1268.2	1277.6	1287.1	1334.8
15	1230.5	1239.9	1249.3	1258.7	1268.2	1277.6	1287.1	1334.8
16	1230.3	1239.8	1249.2	1258.6	1268.0	1277.5	1287.0	1334.7
17	1230.2	1239.6	1249.1	1258.5	1267.9	1277.4	1286.9	1334.6
18	1230.0	1239.5	1248.9	1258.4	1267.8	1277.3	1286.8	1334.6
19	1229.9	1239.4	1248.8	1258.3	1267.7	1277.2	1286.7	1334.5
20	1229.7	1239.2	1248.7	1258.2	1267.6	1277.1	1286.6	1334.4
21	1229.6	1239.1	1248.6	1258.1	1267.5	1277.0	1286.5	1334.4
22	1229.5	1239.0	1248.4	1257.9	1267.4	1276.9	1286.4	1334.3
23	1229.3	1238.8	1248.3	1257.8	1267.3	1276.8	1286.7	1334.2
24	1229.2	1238.7	1248.2	1257.7	1267.2	1276.7	1286.3	1334.2
25	1229.0	1238.5	1248.1	1257.6	1267.1	1276.6	1286.2	1334.1
26	1228.9	1238.4	1248.0	1257.5	1267.0	1276.5	1286.1	1334.0
27	1228.7	1238.3	1247.8	1257.4	1266.9	1276.4	1286.0	1334.0
28	1228.6	1238.1	1247.7	1257.2	1266.8	1276.3	1285.9	1333.9
29	1228.4	1238.0	1247.6	1257.1	1266.7	1276.2	1285.8	1333.9
30	1228.3	1237.9	1247.5	1257.0	1266.6	1276.2	1285.7	1333.8
31	1228.1	1237.7	1247.3	1256.9	1266.5	1276.1	1285.6	1333.7

Absolute Pressure psi	**Temperature °F**						
	700	**800**	**900**	**1000**	**1200**	**1400**	**1600**
13	1383.2	1432.4	1482.3	1533.2	1637.5	1745.5	1857.3
14	1383.2	1432.3	1482.3	1533.1	1637.5	1745.5	1857.3
14.696	1383.2	1432.3	1482.3	1533.1	1637.5	1745.5	1857.3
15	1383.1	1432.3	1482.3	1533.1	1637.5	1745.5	1857.3
16	1383.1	1432.3	1482.2	1533.1	1637.4	1745.5	1857.3
17	1383.0	1432.2	1482.2	1533.1	1637.4	1745.5	1857.3
18	1383.0	1432.2	1482.2	1533.0	1637.4	1745.5	1857.2
19	1382.9	1432.1	1482.1	1533.0	1637.4	1745.4	1857.2

20	1382.9	1432.1	1482.1	1533.0	1637.4	1745.4	1857.2
21	1382.8	1432.0	1482.1	1532.9	1637.3	1745.4	1857.2
22	1382.8	1432.0	1482.0	1532.9	1637.3	1745.4	1857.2
23	1382.7	1432.0	1482.0	1532.9	1637.3	1745.4	1857.2
24	1382.7	1431.9	1482.0	1532.9	1637.3	1745.4	1857.2
25	1382.6	1431.9	1481.9	1532.8	1637.3	1745.3	1857.2
26	1382.6	1431.8	1481.9	1532.8	1637.2	1745.3	1857.1
27	1382.5	1431.8	1481.9	1532.8	1637.2	1745.3	1857.1
28	1382.5	1431.8	1481.8	1532.8	1637.2	1745.3	1857.1
29	1382.4	1431.7	1481.8	1532.7	1637.2	1745.3	1857.1
30	1382.4	1431.7	1481.8	1532.7	1637.2	1745.3	1857.1
31	1382.3	1431.6	1481.7	1532.7	1637.1	1745.2	1857.1

2.4.3. Alternative Thermal Efficiency Calculation for Large Steam Commercial Packaged Boilers. To determine the thermal efficiency of commercial packaged boilers with a fuel input rate greater than 5,000,000 Btu/h according to the steam test pursuant to Section C4.1.1 of ANSI/AHRI Standard 1500-2015, either:

2.4.3.1. Calculate the thermal efficiency of commercial packaged boiler models in steam mode in accordance with the provisions of section 2.4.1. of this appendix, or

2.4.3.2. Measure and calculate combustion efficiency $\mathrm{Effy_{SS}}$ in steam mode according to Section 3. Combustion Efficiency Test of this appendix and convert to thermal efficiency using the equation:

$$\mathrm{Effy_T} = \mathrm{Effy_{SS}} - 2.0$$

where $\mathrm{Effy_T}$ is the thermal efficiency and $\mathrm{Effy_{SS}}$ is the combustion efficiency as defined in C6 of ANSI/AHRI Standard 1500-2015. The combustion efficiency $\mathrm{Effy_{SS}}$ is as calculated in Section C7.2.14 of ANSI/AHRI Standard 1500-2015.

2.4.4. Rounding. Round the final thermal efficiency value to nearest one tenth of one percent.

3. Combustion Efficiency Test.

3.1. Test Setup.

3.1.1. Instrumentation. Use instrumentation meeting the minimum requirements found in Table C1 of ANSI/AHRI Standard 1500-2015 (incorporated by reference, see §431.85).

3.1.2. Data collection and sampling. Record all test data in accordance with Table 3.1 and Table 3.2 of this appendix. Do not use Section C5 and Table C4 of Appendix C in ANSI/AHRI Standard 1500-2015.

Table 3.1. Data to be Recorded Before Testing

Item Recorded	Additional Instruction
Date of Test	
Manufacturer	
Commercial Packaged Boiler Model Number	
Burner Model Number & Manufacturer	
Nozzle description and oil pressure	
Oil Analysis - H, C, API Gravity, lb/gal and Btu/lb	
Gas Manifold Pressure	Record at start and end of test.
Gas line pressure at meter	Measurement may be made manually.
Gas temperature	Measurement may be made manually.
Barometric Pressure (Steam and Natural Gas Only)	Measurement may be made manually.
Gas Heating Value, Btu/ft*	Record at start and end of test

* Multiplied by correction factors, as applicable, in accordance with Appendix E of ANSI/AHRI Standard 1500-2015.

Table 3.2. Data to be Recorded During Testing

		Required Data Recording		For Use in Calculations, Section 2.4	
Item Recorded	**Digital Acquisition Required?**	**Every 1 Minute**	**Every 15 Minutes**	**Average During Test Period**	**Total During Test Period**

			Required Data Recording		For Use in Calculations, Section 2.4	
Item Recorded		**Digital Acquisition Required?**	**Every 1 Minute**	**Every 15 Minutes**	**Average During Test Period**	**Total During Test Period**
Time, minutes/seconds		Yes	X			
Flue Gas Temperature, °F		Yes	X		X	
Pressure in Firebox, in H_2O (if required per Section C3.4 of ANSI/AHRI Standard 1500-2015)		No		X	X	
Flue Gas Smoke Spot Reading (oil)		No		X	X	
Room Air Temperature		Yes	X			
Fuel Weight or Volume, lb (oil) or ft^3 (gas)		Yes		X		X
Test Air Temperature, °F		Yes	X			
Draft in Vent, in H_2O (oil and non-atmospheric gas)		No		X	X	
Flue Gas CO_2 or O_2, %		No		X	X	
Flue Gas CO, ppm		No		At Least Start and End	X	
Relative Humidity, %		No		X		
STEAM	Separator water weight, lb	No		At Least Start and End		X
	Steam Pressure, in Hg	No		X	X	
	Steam Temperature, °F (if used)	Yes	X		X	
	Condensate collected, or water fed, lb	No		X		X
WATER	Outlet Water Temperature, °F	Yes	X			
	Water fed, lb	No	X	X		X
	Inlet Water Temperature at Points A and B of Figure 9 of ANSI/AHRI Standard 1500-2015, °F	Yes	X			

3.1.3. Instrument Calibration. Instruments must be calibrated at least once per year and a record must be kept as part of the data underlying each basic model certification, pursuant to §429.71 of this chapter, containing, at least, the date of calibration and the method of calibration.

3.1.4. Test Setup and Apparatus. Set up the commercial packaged boiler for combustion efficiency testing according to the provisions of Section C2 (except section C2.1) of Appendix C of ANSI/AHRI Standard 1500-2015.

3.1.4.1. For tests of oil-fired commercial packaged boilers, determine the weight of fuel consumed using one of the methods specified in sections 3.1.4.1.1. or 3.1.4.1.2. of this appendix.

3.1.4.1.1. If using a scale, determine the weight of fuel consumed as the difference between the weight of the oil vessel before and after each measurement period, as specified in sections 3.1.4.1.3.1. or 3.1.4.1.3.2. of this appendix, determined using a scale meeting the accuracy requirements of Table C1 of ANSI/AHRI Standard 1500-2015.

3.1.4.1.2. If using a flow meter, first determine the volume of fuel consumed as the total volume over the applicable measurement period, as specified in sections 3.1.4.1.3.1. or 3.1.4.1.3.2. of this appendix, and as measured by a flow meter meeting the accuracy requirements of Table C1 of ANSI/AHRI Standard 1500-2015 upstream of the oil inlet port of the commercial packaged boiler. Then determine the weight of fuel consumed by multiplying the total volume of fuel over the applicable measurement

period by the density of oil, in pounds per gallon, as determined pursuant to Section C3.2.1.1.3. of ANSI/AHRI Standard 1500-2015.

3.1.4.1.3. The applicable measurement period for the purposes of determining fuel input rate must be as specified in section 3.1.4.1.3.1. of this appendix for the "Warm-Up Period" or 3.1.4.1.3.2. of this appendix for the "Test Period."

3.1.4.1.3.1. For the purposes of confirming steady-state operation during the "Warm-Up Period," the measurement period must be 15 minutes and t_T in Equation C2 in Section C7.2.3.1 of ANSI/AHRI Standard 1500-2015 must be 0.25 hours to determine fuel input rate.

3.1.4.1.3.2. For the purposes of determining combustion efficiency during the "Test Period," the measurement period and t_T are 0.5 hours pursuant to section 3.3.1.1. of this appendix.

3.1.4.2 For tests of gas-fired commercial packaged boilers, install a volumetric gas meter meeting the accuracy requirements of Table C1 of ANSI/AHRI Standard 1500-2015 upstream of the gas inlet port of the commercial packaged boiler. Record the accumulated gas volume consumed for each applicable measurement period. Use Equation C7.2.3.2. of ANSI/AHRI Standard 1500-2015 to calculate fuel input rate.

3.1.4.2.1. The applicable measurement period for the purposes of determining fuel input rate must be as specified in section 3.1.4.2.1.1. of this appendix for the "Warm-Up Period" and 3.1.4.2.1.2. of this appendix for the "Test Period."

3.1.4.2.1.1. For the purposes of confirming steady-state operation during the "Warm-Up Period," the measurement period must be 15 minutes and t_T in Equation C2 in

Section C7.2.3.1 of ANSI/AHRI Standard 1500-2015 must be 0.25 hour to determine fuel input rate.

3.1.4.2.1.2. For the purposes of determining combustion efficiency during the "Test Period," the measurement period and t_T are 0.5 hour pursuant to section 3.3.1.1.of this appendix.

3.1.4.3. In addition to the provisions of Section C2.2.1.2 of ANSI/AHRI Standard 1500-2015, vent gases may alternatively be discharged vertically into a straight stack section without elbows. R-7 minimum insulation must extend 6 stack diameters above the flue collar, the thermocouple grid must be located at a vertical distance of 3 stack diameters above the flue collar, and the sampling tubes for flue gases must be installed 1 stack diameter beyond the thermocouple grid.

3.1.5. Additional Requirements for Outdoor Commercial Packaged Boilers. If the manufacturer provides more than one outdoor venting arrangement, the outdoor commercial packaged boiler (as defined in section 3.2.6 of ANSI/AHRI Standard 1500-2015 (incorporated by reference, see §431.85)) must be tested with the shortest total venting arrangement as measured by adding the straight lengths of venting supplied with the equipment.

3.1.6. Additional Requirements for Field Tests.

3.1.6.1 Field tests are exempt from the requirements of Section C2.2 of Appendix C of ANSI/AHRI Standard 1500-2015. Measure the flue gas temperature according to Section C2.5.1 of Appendix C of ANSI/AHRI Standard 1500-2015 and the thermocouple grids identified in Figure C12 of ANSI/AHRI Standard 1500-2015, with the following

modification: the thermocouple grid may be staggered vertically by up to 1.5 inches to allow the use of instrumented rods to be inserted through holes drilled in the venting.

3.1.6.2. Field tests are exempt from the requirements of Section C2.6.3 of Appendix C of ANSI/AHRI Standard 1500-2015.

3.1.7. Additional Requirements for Water Tests. In addition to the provisions of Section C2 of Appendix C of ANSI/AHRI Standard 1500-2015 (incorporated by reference, see §431.85) the following requirements apply for water tests:

3.1.7.1. Insulate all water piping between the commercial packaged boiler and the location of the temperature measuring equipment, including one foot (1 ft.) beyond the sensor, using insulation meeting the requirements specified in Table 2.3 of this appendix.

3.1.7.2. Install a temperature measuring device at Point B of Figure C9 of ANSI/AHRI Standard 1500-2015. Water entering the commercial packaged boiler must first enter the run of a tee and exit from the top outlet of the tee. The remaining connection of the tee shall be plugged. Measure the inlet water temperature at Point B in the run of a second tee located 12 ± 2 pipe diameters downstream from the first tee and no more than the greater of 12 inches or 6 pipe diameters from the inlet of the commercial packaged boiler. The temperature measuring device shall extend into the water flow at the point of exit from the side outlet of the second tee. All inlet piping between the temperature measuring device and the inlet of the commercial packaged boilers must be wrapped with R-7 insulation. Field tests must also measure the inlet water temperature at Point B in Figure C9, however they are not required to use the temperature measurement piping described in this section 3.1.7. of this appendix.

3.1.7.3. Do not use Section C2.7.2.2.2 or its subsections of ANSI/AHRI Standard 1500-2015 for water meter calibration.

3.1.8. Flue Gas Sampling. In section C2.5.2 of Appendix C of ANSI/AHRI Standard 1500-2015, replace the last sentence with the following: When taking flue gas samples from a rectangular plane, collect samples at ¼, ½, and ¾ the distance from one side of the rectangular plane in the longer dimension and along the centerline midway between the edges of the plane in the shorter dimension and use the average of the three samples. The tolerance in each dimension for each measurement location is ± 1 inch.

3.2. Test Conditions.

3.2.1. General. Use the test conditions from Sections 5.3 and C3 of Appendix C of ANSI/AHRI Standard 1500-2015 (incorporated by reference; see §431.85) for combustion efficiency testing but do not use the following sections:

(1) 5.3 Introductory text

(2) 5.3.5

(3) 5.3.7 (excluded for field tests only)

(4) 5.3.8

(5) 5.3.9

(6) C3.1.3 (and subsections)

(7) C3.5 (including Table C2)

(8) C3.6

(9) C3.7

3.2.2. Burners for Oil-Fired Commercial Packaged Boilers. In addition to Section C3.3 of Appendix C of ANSI/AHRI Standard 1500-2015, the following applies:

for oil-fired commercial packaged boilers, test the unit with the particular make and model of burner as certified by the manufacturer. If multiple burners are specified in the certification report for that basic model, then use any of the listed burners for testing.

3.2.3. Water Temperatures. Maintain the outlet temperature measured at Point C in Figure C9 at 180 °F ± 2 °F and maintain the inlet temperature measured at Point B at 80 °F ± 5 °F during the "Warm-up Period" and "Test Period" as indicated by 1-minute interval data pursuant to Table 3.1 of this appendix. Each reading must meet these temperature requirements. Use the inlet temperature and flow rate measured at Point B in Figure C9 of Appendix C of ANSI/AHRI Standard 1500-2015 for calculation of thermal efficiency. Field tests are exempt from this requirement and instead must comply with the requirements of section 3.2.3.1 of this appendix.

3.2.3.1. For field tests, the inlet temperature measured at Point A and Point B in Figure C9 and the outlet temperature measured and Point C in Figure C9 of ANSI/AHRI Standard 1500-2015 must be recorded in the data underlying that model's certification pursuant to §429.71 of this chapter, and the difference between the inlet (measured at Point B) and outlet temperature (measured at Point C) must not be less than 20 °F at any point during the "Warm-up Period" and "Test Period," after stabilization has been achieved, as indicated by 1-minute interval data pursuant to Table 3.2 of this appendix.

3.2.3.2 For commercial packaged boilers that require a higher flow rate than that resulting from the water temperature requirements of section 3.2.3 of this appendix to prevent boiling, use a recirculating loop and maintain the inlet temperature at Point B of Figure C9 of ANSI/AHRI Standard 1500-2015 at 140 °F ± 5 °F during the "Warm-up

Period" and "Test Period" as indicated by 1-minute interval data pursuant to Table 3.2 of this appendix. Each reading must meet these temperature requirements. Use the inlet temperature and flow rate measured at Point A in Figure C9 of Appendix C of ANSI/AHRI Standard 1500-2015 for calculation of thermal efficiency.

3.2.4. Air Temperature. For tests of non-condensing boilers (except during field tests), maintain ambient room temperature between 65 °F and 100 °F at all times during the "Warm-up Period" and "Test Period" (as described in Section C4 of Appendix C of ANSI/AHRI Standard 1500-2015) as indicated by 1-minute interval data pursuant to Table 3.2 of this appendix. For tests of condensing boilers (except during field tests), maintain ambient room temperature between 65 °F and 85 °F at all times during the "Warm-up Period" and "Test Period" (as described in Section C4 of Appendix C of ANSI/AHRI Standard 1500-2015) as indicated by 1-minute interval data pursuant to Table 3.2 of this appendix. The ambient room temperature may not differ by more than ± 5 °F from the average ambient room temperature during the entire "Test Period" at any 1-minute interval reading. Measure the room ambient temperature within 6 feet of the front of the unit at mid height. The test air temperature, measured at the air inlet of the commercial packaged boiler, must be within ± 5 °F of the room ambient temperature when recorded at the 1-minute interval defined by Table 3.2. For field tests, record the ambient room temperature at 1-minute intervals in accordance with Table 3.2 of this appendix.

3.2.5. Ambient Humidity. For condensing boilers (except during field tests), maintain ambient room relative humidity below 80-percent relative humidity at all times during both the "Warm-up Period" and "Test Period" (as described in Section C4 of

Appendix C of ANSI/AHRI Standard 1500-2015) pursuant to Table 3.2 of this appendix. Measure the ambient humidity in the same location as air temperature. For field tests of condensing boilers, record the ambient room relative humidity in accordance with Table 3.2 of this appendix.

3.2.6. Flue Gas Temperature. The flue gas temperature during the test must not vary from the flue gas temperature measured at the start of the Test Period (as defined in Section C4 of ANSI/AHRI Standard 1500-2015) when recorded at the interval defined in Table 3.2 by more than the limits prescribed in Table 3.4 of this appendix. For field tests, flue gas temperature does not need to be within the limits in Table 3.3 of this appendix but must be recorded at the interval specified in Table 3.2 of this appendix.

Table 3.3 Flue Gas Temperature Variation Limits During Test Period

Fuel Type	Non-Condensing	Condensing
Gas	± 2 percent	Greater of ± 3 percent and ± 5 °F
Light Oil	± 2 percent	
Heavy Oil	Greater of ± 3 percent and ± 5 °F	

3.3. Test Method.

3.3.1. General. Conduct the combustion efficiency test using the test method prescribed in Section C4 "Test Procedure" of Appendix C of ANSI/AHRI Standard 1500-2015 excluding sections:

(1) C4.1.1.1.2

(2) C4.1.1.2.3 (see 3.3.4 of this appendix)

(3) C4.1.2.1.5

(4) C4.1.2.2.2

(5) C4.1.2.2.3 (see 3.3.5 of this appendix)

(6) C4.2

(7) C4.2.1

(8) C4.2.2

3.3.1.1. The duration of the "Test Period" outlined in sections C4.1.1.2 of Appendix C of ANSI/AHRI Standard 1500-2015 (incorporated by reference, see §431.85) and C4.1.2.2 of Appendix C of ANSI/AHRI Standard 1500-2015 is 30 minutes. For condensing commercial packaged boilers, condensate must be collected for the 30 minute Test Period.

3.3.1.2. Adjust oil or non-atmospheric gas to produce the required firebox pressure and CO_2 or O_2 concentration in the flue gas, as described in section 5.3.1 of ANSI/AHRI Standard 1500-2015. Conduct steam tests with steam pressure at the pressure specified in the manufacturer literature shipped with the commercial packaged boiler or in the manufacturer's supplemental testing instructions pursuant to §429.60(b)(4) of this chapter, but not exceeding 15 psig. If no pressure is specified in the manufacturer literature shipped with the commercial packaged boiler or in the manufacturer's supplemental testing instructions (pursuant to §429.60(b)(4)) of this chapter, or if a range of operating pressures is specified, conduct testing at a steam pressure equal to atmospheric pressure. If necessary to maintain steam quality as required by section 5.3.7 of ANSI/AHRI Standard 1500-2015, increase steam pressure in 1 psig increments by throttling with a valve beyond the separator until the test is completed and the steam quality requirements have been satisfied, but do not increase the steam pressure to greater than 15 psig.

3.3.2. Water Test Steady-State. Ensure that a steady-state is reached by confirming that three consecutive readings have been recorded at 15-minute intervals that

indicate that the measured fuel input rate is within ± 2-percent of the rated input. Water temperatures must meet the conditions specified in sections 3.2.3, 3.2.3.1, and 3.2.3.2 of this appendix as applicable.

3.3.3. Procedure for the Measurement of Condensate for a Condensing Commercial Packaged Boiler. Collect flue condensate using a covered vessel so as to prevent evaporation. Measure the condensate from the flue gas during the "Test Period." Flue condensate mass must be measured within 5 minutes after the end of the "Test Period" (defined in C4.1.1.2 and C4.1.2.2 of ANSI/AHRI Standard 1500-2015) to prevent evaporation loss from the sample. Determine the mass of flue condensate for the "Test Period" by subtracting the tare container weight from the total weight of the container and flue condensate measured at the end of the "Warm-up Period."

3.4. Calculations.

3.4.1. General. Use the variables in Section C6 and calculation procedure for the combustion efficiency test specified in Section C7.3 of Appendix C (including the specified subsections of C7.2) of ANSI/AHRI Standard 1500-2015 (incorporated by reference, see §431.85).

3.4.2. Rounding. Round combustion efficiency to nearest one tenth of a percent.

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